

WATER AND ENERGY EFFICIENCY

Domestic Water Systems

Ecosystem Service Benefits

- The domestic water systems projects save 1.5 billion gallons of water annually primarily through replacement of domestic appliances with more energy efficient models (e.g., showers, toilets, washing machines). In addition to appliance upgrades, this section also includes water savings generated from investment in advanced technologies and equipment in food processing facilities.⁹⁰
- Improved efficiency in water use results in reduced need for water supply maintenance, avoided property damage through reduced subsidence, and ecological benefits by reducing strain on the water supply needed to support river habitat.
- The potential magnitude of benefits resulting from reduced water supply maintenance needs is on the order of \$12 million per year.

OVERVIEW OF PROJECTS

Project activities

Replace appliances in underserved communities with cleaner and more energy efficient alternatives and install advanced technologies in food processing facilities to reduce energy and water usage

Implementing agencies

Department of Water Resources, Department of Community Service and Development, and the California Energy Commission

4,910 projects

across 38 counties (2016-2020)

1.5 billion

gallons of water saved annually

⁹⁰ This section excludes 14 projects funded under the SAFER program by the State Water Resources Control Board because those projects did not have quantitative data available on expected water savings (CARB 2021). Though they are excluded, these projects are expected to generate the same ecosystem service benefits as other projects included in this section.

Between 2016 and 2020, CCI invested in 4,910 water and energy efficiency projects (CARB 2021). Around 74 percent of the projects were part of the Water-Efficiency program (Department of Water Resources), 26 percent of the projects were part of the Low-Income Weatherization Program (Department of Community Services and Development). Two projects were part of the Food Production Investment Program (Energy Commission).

Project work included water and energy efficiency upgrades at residential households and food processing facilities. Upgrades at residential homes include installing more efficient toilets, sinks, showers, toilets, washing machines, among other appliances. For some programs, such as the Food Production Investment Program and the Low-Income Weatherization Program, water-savings is a secondary co-benefit to reduced energy consumption. However, the primary ecosystem service benefits considered for projects in this category are based on water savings. The projects collectively contributed to direct water savings of around 1.5 billion gallons annually across a total of 38 counties (CARB 2021). Water is a particularly scarce resource in California due to droughts, hence, water supply maintenance is an especially beneficial ecosystem service to the general public as well as industry. Increased water savings also minimizes the pressure on non-renewable water resources (i.e., fossil groundwater). In addition, reduced water use is linked to avoided property damage, as excessive groundwater pumping can lead to costly land subsidence. Finally, reducing strain on the water supply avoids the over-use of water important to river habitat in and around the Sacramento-San Joaquin Delta and relieves pressure on local water treatment systems. Appendix page A-10 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits.



Avoided water supply maintenance.

Increased efficiency of water usage leads to a reduction in water needs. CCI projects report approximately 1.5 billion gallons of water saved by these projects annually, equivalent to about 4,500 acre-feet.^{91,92}

There are various ways that these additional gallons of water can be valued. One way involves applying available data on the shadow prices of water – developed by researchers at UC Davis using a model known as the California Value Integrated Model (CALVIN) – to physical quantities of water saved in various use categories.⁹³ Shadow prices are willingness-to-pay (WTP) measures generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market.⁹⁴ Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent

⁹¹ 'Acre foot' is a term commonly used in water supply planning to describe water volume. An acre foot is approximately 326,000 gallons, which is enough water to cover an acre of land (about the size of a football field) about 1-foot deep. According to the Water Education Foundation, an average California household uses between one-half and one acre-foot of water per year for indoor and outdoor use. (Source: <https://www.watereducation.org/general-information/whats-acre-foot>)

⁹² To calculate water savings across CCI projects, we use data from CARB (2021). To remove potential duplication of reported water savings, we identified and removed water saving figures repeated across years in the same census tract with the same project ID. The water savings captured in CCIRTS for DWR projects were further adjusted downward based on an independent validation study conducted by UC Davis, which suggested an overestimate of water savings by approximately 61.2 percent.

⁹³ The CALVIN model is an economic-engineering optimization model for California specifically. Details about the model are available here: <https://calvin.ucdavis.edu/>.

⁹⁴ 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.

water shortage for urban use purposes ranges across regions in the state, varying from \$908 per acre foot in Colorado River to \$7,744 per acre foot in Central Valley North of Delta (De Souza et al. 2011). This analysis finds that the potential water savings associated with these water efficiency upgrades are valued at approximately **\$12 million per year**.

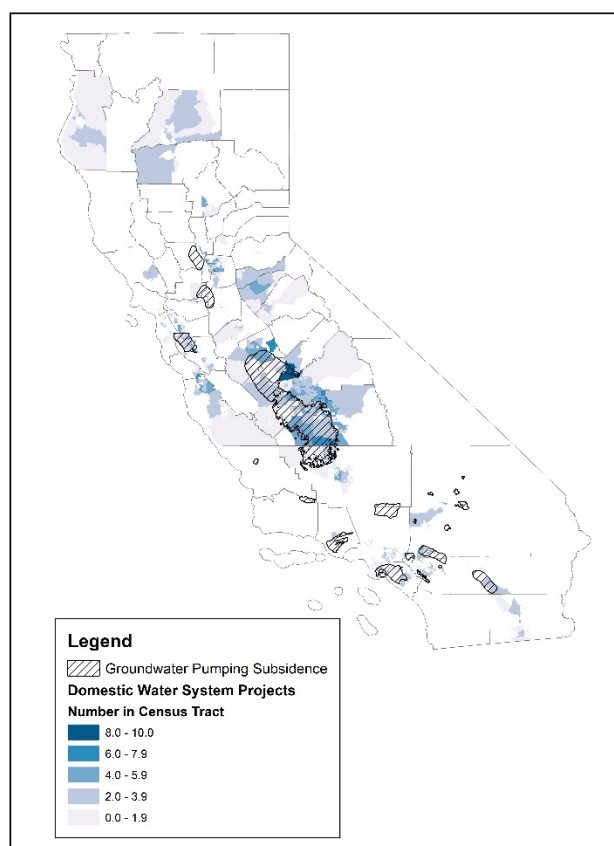
Water also has a value if left in the ground for use by future generations. Fossil groundwater is a type of groundwater located deep beneath the surface that is considered a non-renewable resource because it takes thousands of years for the groundwater in these ‘ancient aquifers’ to recharge. The Lawrence Livermore National Laboratory recently released a study that examined 2,330 drinking wells and found evidence of fossil groundwater in 22 percent of wells (de Jong et al. 2020). To the extent that CCI projects are generating water savings in areas that overlap fossil groundwater resources, the benefits of the water savings associated with such projects may be better reflected by a bequest or option value because it reduces pressure on these non-renewable groundwater resources.⁹⁵



Avoided property damage from reduced land subsidence.

For subset of projects located in the San Joaquin Valley, another potential benefit of water savings is the avoided costs associated with land subsidence, which is the gradual or sudden sinking of the land’s surface. Groundwater pumping from any aquifer “will cause some degree of land subsidence as aquifer materials adjust to new stresses” (Borchers and Carpenter 2014). Excessive groundwater pumping can cause damage to property and infrastructure. In the San Joaquin Valley, USGS has conducted subsidence studies since the 1950s and has recorded land subsidence of as much as 30 feet in some areas. The rate of subsidence, however, is increasing in some areas. For example, during the latest drought, hydrologists recorded subsidence rates in the San Joaquin Valley of more than a foot per year (McPhate 2017). Using location data contained in CARB (2021), we identified 3,859 projects located in census tracts that overlap known areas of land subsidence caused by groundwater pumping (USGS n.d.). Since we do not have sufficient information on the extent to which these projects mitigate land subsidence, we are unable to monetize this benefit.

Figure 13: CCI Project and Subsidence Locations



⁹⁵ Bequest value is the value people place on maintaining or conserving a resource for future generations. Option value is the WTP for a resource even though there is little or no likelihood the individual will use it.



Ecological and water treatment benefits from reduced strain on the water supply.

By mitigating demand for water that flows into the Sacramento-San Joaquin Delta, the domestic water systems projects may also offer ecological benefits. Bolstering the water supply supports river habitat, thereby protecting fish, plants, and other cultural and ecological resources. The projects also have the potential to reduce strain on water treatment systems, which could reduce maintenance costs. We are unable to quantify these benefits, however, because data do not exist that would allow us to quantify the change in water supply from these projects, and how those changes would then affect habitat and water treatment systems.

Table 12: Summary of Monetized Ecosystem Service Benefits for the Domestic Water Systems Projects by County (2021 dollars)

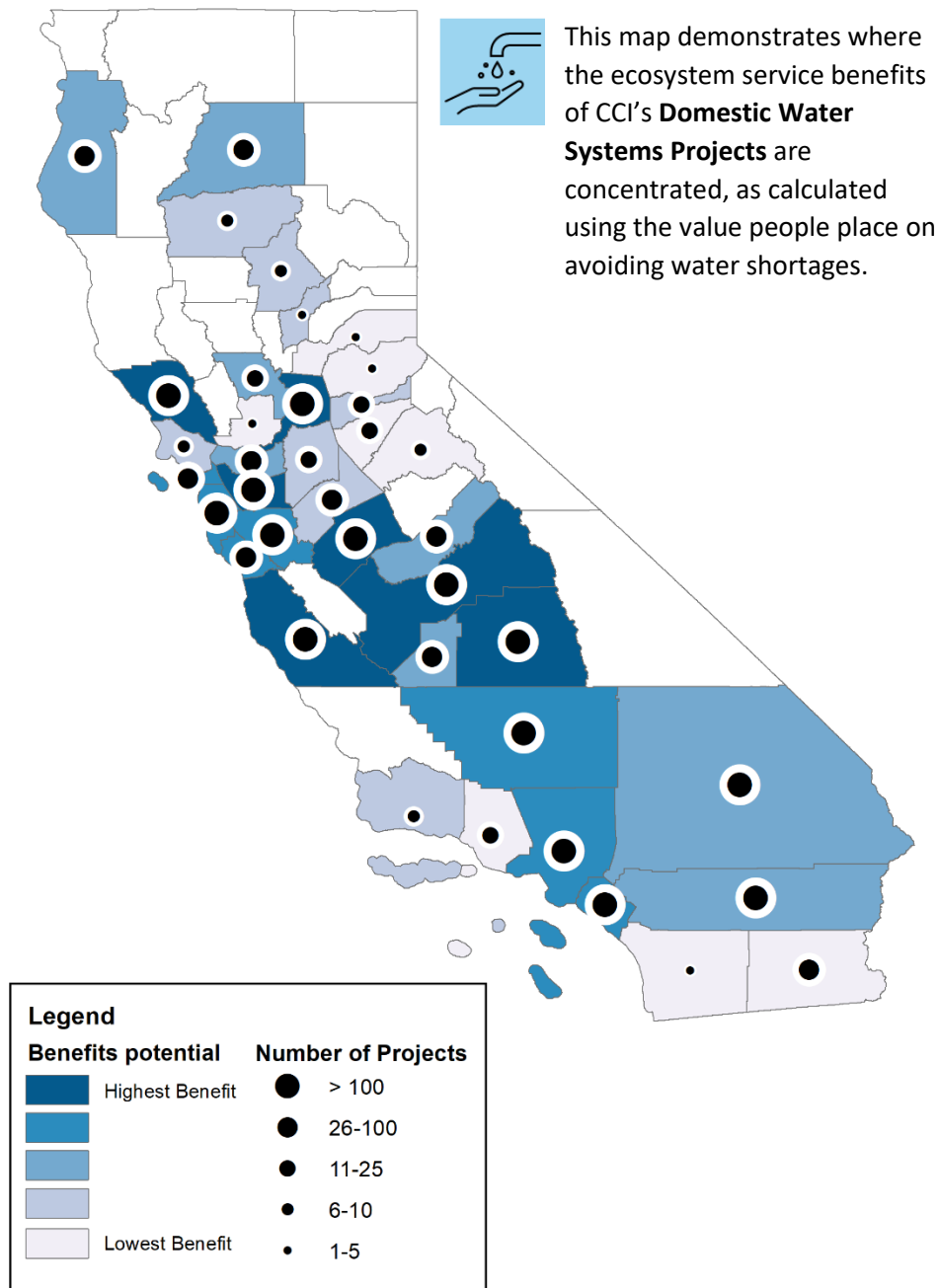
County	Acre-Feet of Water Saved (Annual) ^a	Value of Water Savings (Annual) ^b
Alameda	120	\$530,000
Amador	0.4	\$880
Butte	0.53	\$7,300
Calaveras	0.38	\$840
Contra Costa	4.8	\$51,000
El Dorado	0.027	\$210
Fresno	190	\$460,000
Humboldt	2.6	\$8,900
Imperial	0.25	\$600
Kern	55	\$120,000
Kings	12	\$38,000
Los Angeles	170	\$340,000
Madera	8.3	\$22,000
Marin	0.25	\$1,000
Merced	2,800	\$6,200,000
Monterey	100	\$370,000
Orange	65	\$120,000
Placer	0.054	\$420
Riverside	72	\$71,000
Sacramento	180	\$1,400,000
San Bernardino	120	\$110,000
San Diego	0.0012	<\$100
San Francisco	33	\$140,000
San Joaquin	0.29	\$4,600
San Mateo	73	\$310,000
Santa Barbara	0.18	\$1,600
Santa Clara	83	\$350,000
Santa Cruz	38	\$140,000
Shasta	2.2	\$17,000
Solano	0.014	\$110
Sonoma	100	\$410,000
Stanislaus	1.1	\$6,300
Tehama	0.41	\$3,100

County	Acre-Feet of Water Saved (Annual) ^a	Value of Water Savings (Annual) ^b
Tulare	180	\$410,000
Tuolumne	0.018	<\$100
Ventura	0.068	\$330
Yolo	4.9	\$40,000
Yuba	0.1	\$1,000
Statewide Total	4,500	\$12,000,000

Sources and notes:

- a. Data observed in CARB (2021) for projects implemented from 2016 to 2020.
- b. Author calculations described in this report.

Figure 14: Spatial Distribution of Ecosystem Service Benefits Potential for the Domestic Water Systems Projects



Note: The benefit potential conveyed in the public's WTP to avoid water shortages presented in Table 12.

References

- Borchers, J and M. Carpenter. 2014. "Land Subsidence from Groundwater Use in California." Available at: https://cawaterlibrary.net/wp-content/uploads/2017/04/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf.
- 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.
- De Jong, M., J.E. Moran, and A. Visser. 2020. "Identifying paleowater in California drinking water wells." *Quaternary International*, 547: 197-207.
- De Souza, S., J. Medellin-Azuara, N. Burley, J.R. Lund, R.E. Howitt. 2011. "Guidelines for Preparing Economic Analysis for Water Recycling Projects. State Water Resources Control Board." Appendix A. Prepared by the Economic Analysis Task Force for Water Recycling in California. University of California, Davis. Center for Watershed Sciences.
- McPhate, M. 2017. "The sinking of California." Accessed at <https://medium.californiasun.co/san-joaquin-valley-california-subsidence-4ae5603f717f>.
- USGS. N.d. "Areas of Land Subsidence in California." Accessed at https://ca.water.usgs.gov/land_subsidence/california-subsidence-areas.html.



WATER AND ENERGY EFFICIENCY

Woodsmoke Reduction

Ecosystem Service Benefits

- Upgrading residential woodstove reduces fine particulate matter (PM_{2.5}) and improves air quality across California as well as select counties in bordering states (Nevada and Arizona).
- Improvements in air quality may reduce the number of human health incidences by 840 to 864 cases, valued between \$170 million to \$370 million in annual avoided healthcare costs and willingness to pay (WTP) to avoid illness.
- Increased efficiency of stoves also reduces the amount of wood burned for heating purposes, thereby leaving more trees in the ground. Californians benefit from the many services provided by more vibrant forests.
- Replacing outdated stoves also decreases home fire risks, improving human safety and avoiding property damage.

OVERVIEW OF PROJECTS

Project activities

Replace residential woodburning stoves in underserved communities with cleaner and more energy efficient alternatives

Implementing agency

California Air Resources Board

826 projects

funded across 32 counties (2018-2020)

940 tons

of PM_{2.5} emissions reductions per year

Between 2018 and 2020, CCI invested in 826 projects through its Woodsmoke Reduction Program implemented by the California Air Resources Board (CARB 2021). The primary activity of these projects is replacing residential woodburning stoves in underserved communities with cleaner and more energy efficient alternatives (e.g., certified wood stove or insert, pellet stove, natural gas heating device, electric heating device).

Appendix page A-11 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Reducing woodsmoke improves indoor air quality for program participants and ambient air quality for people within their “airsheds” by reducing fine particulate matter (PM_{2.5}), black carbon, toxic air contaminants, and greenhouse gas (GHG) emissions. This analysis focuses on the benefits of PM_{2.5} reductions. Combined, these projects reduce emissions of PM_{2.5} at a rate of 940 tons per year (CARB 2021). Reductions in emissions improves air quality and human health outcomes. Replacing old woodburning stoves also improves human safety and avoids property damage by reducing fire risk. Finally, the increased efficiency of these stoves reduces the amount of wood used as a fuel source, thereby generating additional benefits associated with sustaining forestland.



Improved human health from increased air quality.

This analysis leverages the U.S. EPA’s Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to quantify the human health benefits associated with these PM_{2.5} reductions.^{96,97} COBRA uses location, time, emissions data, and a specified discount rate as inputs to estimate changes in a variety of adverse health incidences and the monetizes the benefits resulting from changes in air quality, including avoided costs of healthcare as well as WTP to avoid illness.⁹⁸ COBRA measures the changes in adverse health incidences for several health endpoints: adult and infant mortality, non-fatal heart attacks, respiratory and cardiovascular hospitalizations, acute bronchitis, upper and lower respiratory symptoms, asthma emergency room visits, and asthma exacerbation. For incidences of adult mortality and non-fatal heart attacks, COBRA provides low- and high-end estimates using different sets of assumptions from epidemiological studies that present differing magnitudes of effects for these two health endpoints due to changes in ambient PM_{2.5} levels. Since dollar value benefits are calculated using the changes in adverse health incidences, COBRA also provides low and high-end dollar benefits.

To employ this tool, we calculate the annual PM_{2.5} reductions at the county level using project reporting data assembled in CARB (2021). Our analysis assumes benefits start in 2023 and assigns a 3 percent discount rate. Though these projects were only funded in 32 counties across California, screening-level

⁹⁶ The U.S. EPA’s COBRA tool can be found online at: <https://www.epa.gov/cobra>. More details about the underlying studies, data sources, and methods is available in the user manual, available at: https://www.epa.gov/system/files/documents/2021-11/cobra-user-manual-nov-2021_4.1_0.pdf.

⁹⁷ COBRA has previously been employed to investigate the potential health effects of reducing wood heat in residential homes in the Pacific Northwest (RTF Staff 2014). However, according to the U.S. EPA, COBRA best serves as a preliminary screening tool that may benefit from further evaluation with more detailed air quality modeling approaches. That is, the estimated benefits of the Woodsmoke Reduction Program provided in this analysis are illustrative, not precise.

⁹⁸ 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.

analysis indicates that all 58 of California’s counties as well as parts of Nevada and Arizona may realize air quality benefits from the program. Approximately 3 percent of total health benefits may accrue to counties outside of California, and approximately 60 percent of total health benefits may accrue to counties without any woodsmoke reduction projects due to spillover effects. According to COBRA analysis, the reductions in ambient PM_{2.5} levels may result in an annual reduction in health incidences of 840 to 864 cases, including over 400 asthma exacerbation cases, 390 upper respiratory symptom cases, 270 lower respiratory symptom cases, and up to 65 total cases of adult and infant mortality, nonfatal heart attacks, respiratory hospital admits, cardiovascular hospital admits, and acute bronchitis.⁹⁹ In total, COBRA values these potential avoided health incidences between **\$170 million and \$370 million per year**. These types of health benefits would be most concentrated in the Northern Central Valley and Southern California.



Increased benefits associated with sustaining forest by burning less wood.

The primary activity of the Woodsmoke Reduction Program is replacing woodburning stoves in underserved communities with U.S. EPA certified stoves or other efficient replacements. An EPA-certified stove requires 33 percent less fuel to generate the same amount of heat as a typical uncertified stove (EPA 2023). Thus, by installing EPA-certified stoves throughout California, the CCI-funded woodsmoke reduction projects have significantly decreased the amount of wood burned for heating purposes, thereby leaving more trees in the ground. Since data on the amount of wood burned before and after these projects were implemented are unavailable, this analysis cannot quantify this benefit.



Avoided human safety concerns and property damage from home fires.

Replacing outdated woodburning stoves reduces the risk of home fires, which reduces the potential for human safety concerns as well as property damage. Across the entire U.S., the National Fire Protection Association estimates that that heating equipment was associated with 53,600 home fires, 400 death, 1,520 non-fatal injuries, and \$893 million in property damage in 2011 (EPA 2016). Data are not available to estimate the potential human safety and property damage benefits associated with the CCI projects.

Table 13: Summary of Monetized Ecosystem Service Benefits for the Woodsmoke Reduction Projects by County (2021 dollars)

County	Tons of PM _{2.5} Avoided (Annual) ^a	Value of Reduced Health Incidences (Annual) ^{b,c}
Alameda	--	\$2,700,000 - \$6,200,000
Alpine	1.7	\$6,700 - \$15,000
Amador	8.2	\$750,000 - \$1,700,000

⁹⁹ CARB’s Annual Report to the Legislature, supporting materials, and data dashboard utilize the CARB [Heart and Lung Health Co-benefit Assessment Methodology](#), which uses a different approach than this report to calculate health benefits. The two reports have different scopes and employs different tools. For example, while CARB finds that air pollution emission reductions from all California Climate Investments projects implemented through 2021 may prevent 324 emergency room visits for asthma. The COBRA tool used for this report finds that Woodsmoke Reduction Program projects implemented during the same time period prevent 400 asthma exacerbation cases. Emergency room visits for asthma and asthma exacerbation cases are not the same metric; based on the analyses, asthma exacerbation cases e expected to occur at a higher rate of incidence than emergency room visits for asthma.

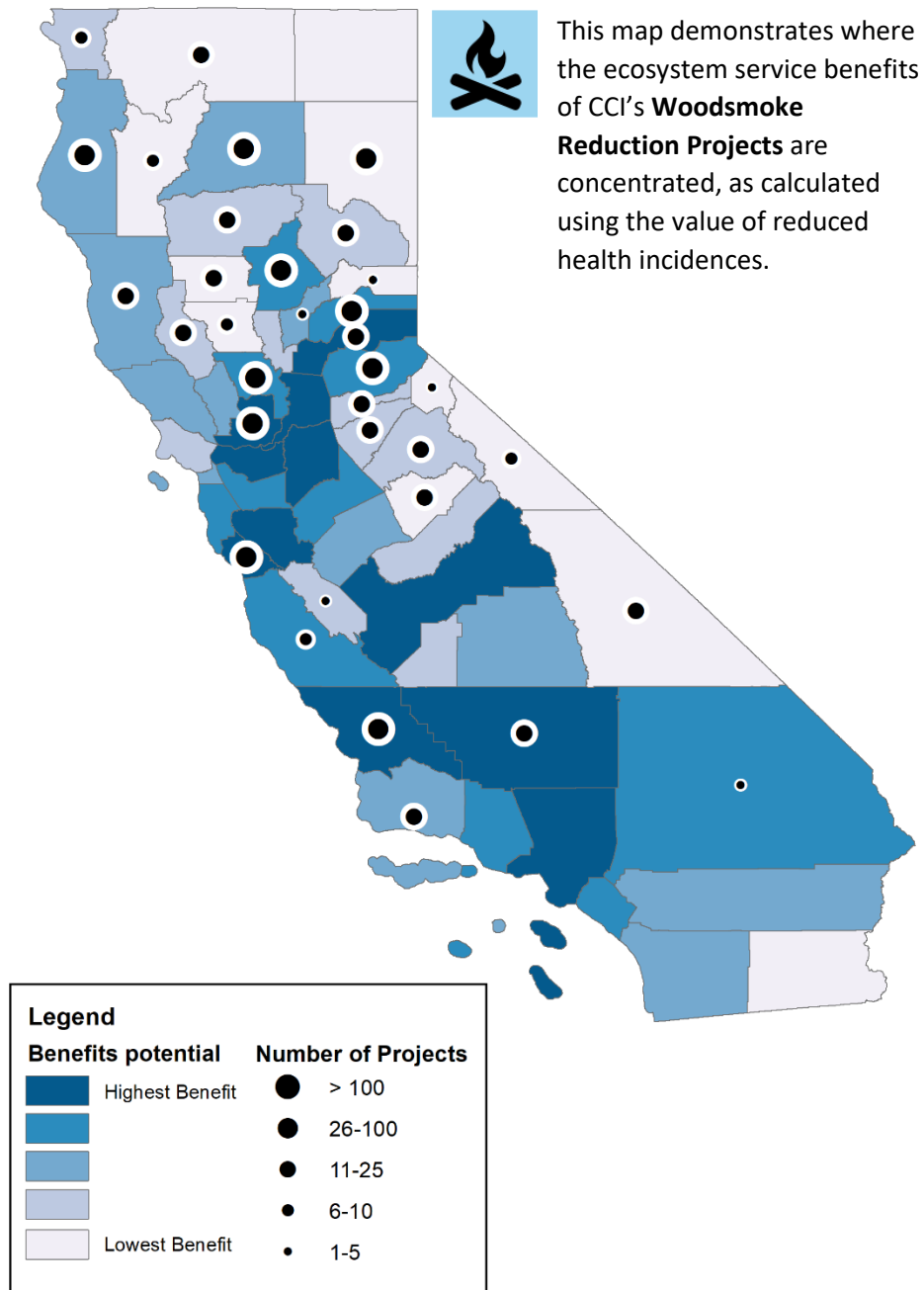
County	Tons of PM _{2.5} Avoided (Annual) ^a	Value of Reduced Health Incidences (Annual) ^{b,c}
Butte	39	\$3,600,000 - \$8,100,000
Calaveras	15	\$810,000 - \$1,800,000
Colusa	21	\$120,000 - \$260,000
Contra Costa	--	\$5,700,000 - \$13,000,000
Del Norte	2	\$200,000 - \$460,000
El Dorado	83	\$2,900,000 - \$6,500,000
Fresno	--	\$4,900,000 - \$11,000,000
Glenn	23	\$190,000 - \$440,000
Humboldt	29	\$1,200,000 - \$2,700,000
Imperial	--	\$110,000 - \$250,000
Inyo	29	\$68,000 - \$150,000
Kern	37	\$6,400,000 - \$14,000,000
Kings	--	\$760,000 - \$1,700,000
Lake	17	\$760,000 - \$1,700,000
Lassen	49	\$95,000 - \$220,000
Los Angeles	--	\$16,000,000 - \$36,000,000
Madera	--	\$540,000 - \$1,200,000
Marin	--	\$780,000 - \$1,700,000
Mariposa	19	\$110,000 - \$260,000
Mendocino	6	\$1,000,000 - \$2,300,000
Merced	--	\$1,200,000 - \$2,800,000
Modoc	--	\$14,000 - \$32,000
Mono	14	\$25,000 - \$57,000
Monterey	11	\$3,200,000 - \$7,100,000
Napa	--	\$960,000 - \$2,200,000
Nevada	27	\$2,300,000 - \$5,300,000
Orange	--	\$2,300,000 - \$5,100,000
Placer	5.3	\$7,500,000 - \$17,000,000
Plumas	11	\$260,000 - \$580,000
Riverside	--	\$2,000,000 - \$4,500,000
Sacramento	--	\$14,000,000 - \$32,000,000
San Benito	3.5	\$460,000 - \$1,000,000
San Bernardino	1	\$3,700,000 - \$8,300,000
San Diego	--	\$2,200,000 - \$5,000,000
San Francisco	--	\$1,600,000 - \$3,700,000
San Joaquin	--	\$5,100,000 - \$12,000,000
San Luis Obispo	97	\$5,100,000 - \$12,000,000
San Mateo	--	\$2,800,000 - \$6,200,000
Santa Barbara	--	\$1,600,000 - \$3,500,000
Santa Clara	--	\$11,000,000 - \$25,000,000
Santa Cruz	--	\$11,000,000 - \$25,000,000
Shasta	36	\$1,000,000 - \$2,300,000
Sierra	6.9	\$49,000 - \$110,000

County	Tons of PM _{2.5} Avoided (Annual) ^a	Value of Reduced Health Incidences (Annual) ^{b,c}
Siskiyou	34	\$140,000 - \$320,000
Solano	33	\$16,000,000 - \$36,000,000
Sonoma	--	\$1,700,000 - \$3,700,000
Stanislaus	--	\$2,300,000 - \$5,200,000
Sutter	--	\$670,000 - \$1,500,000
Tehama	27	\$330,000 - \$740,000
Trinity	4.9	\$110,000 - \$250,000
Tulare	--	\$1,700,000 - \$3,800,000
Tuolumne	53	\$620,000 - \$1,400,000
Ventura	--	\$2,300,000 - \$5,100,000
Yolo	31	\$2,300,000 - \$5,300,000
Yuba	2.4	\$960,000 - \$2,200,000
Counties in Nevada and Arizona	--	\$7,000,000 - \$16,000,000
Statewide Total (California only)	940	\$160,000,000 - \$360,000,000
Total^c	940	\$170,000,000 - \$370,000,000

Sources and notes:

- Data observed in CARB (2021). Average annual avoided PM_{2.5} emissions consider projects implemented from 2018 to 2020.
- Author calculations described in this report.
- The total row includes benefits that accrue to residents of Nevada and Arizona, in addition to California.

Figure 15: Spatial Distribution of Ecosystem Service Benefits Potential for the Woodsmoke Reduction Projects



Note: The benefit potential conveyed in the value of reduced health incidences presented in Table 13.

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.

Regional Technical Forum (RTE) Staff. 2014. Preliminary Report: Quantifying the Health Benefits of Reduced Wood Smoke from Energy Efficiency Programs in the Pacific Northwest. Accessed at <https://nwcouncil.app.box.com/s/xzv62pp132mk0ibkgmvn0upc5x9m204e>.

U.S. Environmental Protection Agency (EPA). 2016. "Burn Wise: Wood Smoke Awareness Kit" Available at: https://www.epa.gov/sites/default/files/2016-02/documents/wood_smoke_awareness_kit.pdf

U.S. Environmental Protection Agency (EPA). 2023. Energy Efficiency and Your Wood-Burning Appliance. Accessed at: <https://www.epa.gov/burnwise/energy-efficiency-and-your-wood-burning-appliance>