




Ecosystem Service Benefits of Projects Funded by California Climate Investments (CCI)

Report prepared for the California Air Resources Board
By Industrial Economics, Inc.
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Introduction

California Climate Investments (CCI) is a statewide initiative to achieve California's climate goals by directing proceeds from the state's Cap-and-Trade Program to fund projects primarily aimed at reducing greenhouse gas (GHG) emissions. In addition to emissions reductions, CCI-funded projects support the economy and improve public health and the environment. Existing efforts to describe the benefits of CCI programs largely focus on the GHG emissions-related reductions; however, CCI-funded projects also improve other environmental conditions across California communities and contribute to people's livelihood and quality of life in other ways. The contributions that healthy, functioning ecosystems make to human well-being—for example through providing opportunities for recreation, food and materials production (e.g., timber, food crops), and human health benefits—are referred to as "ecosystem service" benefits.

Between 2015 and 2020, CCI invested $5.3 billion in nearly 94,000 projects aimed at reducing GHGs. Some of these projects generate other environmental improvements that further benefit communities across California. These ecosystem service benefits are the focus of this report.

The objective of this report is to explore the diverse types of ecosystem service benefits generated by CCI-funded projects, particularly those ecosystem service benefits resulting from changes on natural and working lands. Given the considerable number and variability of projects and associated ecosystem services, a detailed, project-specific analysis of benefits is not feasible. This analysis therefore constitutes a higher-level, programmatic assessment of ecosystem service benefits associated with CCI

projects. Specifically, this analysis employs a mixed methods approach to assessing these benefits, leveraging basic project characteristics and available information on the distribution of these projects across the landscape of California. Rather than gathering new datasets or employing primary methods for valuing ecosystem service benefits, we rely on the best available models and information from existing datasets and the natural and social science literature to assess the range and potential magnitude of ecosystem service benefits that may result from these types of projects.

Scope of Projects Analyzed

Across its 77 subprograms, CCI funded nearly 94,000 unique projects between 2015 and 2020. While most projects contribute to GHG emissions reductions, a subset of projects affect ecosystem health and functioning in other ways that benefit people's well-being. At a high level, the projects most likely to generate ecosystem service benefits are those that result in landscape-level changes or other aspects of natural resources management that affect people and communities (e.g., working forests or urban planting, wetlands, agriculture, waterways).

To identify the subset of CCI projects generating ecosystem service benefits beyond reductions in GHG emissions, this analysis relies on data from the California Climate Investments Report and Tracking System (CCIRTS),[1] discussions with staff at the California Air Resources Board (CARB) and its partner organizations, and review of publicly available information on CCI programs and subprograms. Specifically, we used the following general approach for identifying relevant projects:

1. **Identify and remove *project categories* unlikely to generate ecosystem service benefits**. This involved the following two types of projects:
    - Projects with *only* emissions-based ecosystem service benefits (including GHG and criteria and toxic air pollutants);[2] and
    - Projects that do not directly affect ecosystem or resource management and, therefore, any potential environmental and ecological improvements are protracted (e.g., training, research, outreach, grant administration).[3]

    To identify groups of projects focused exclusively on emissions reduction, we used a variety of information contained in the CCIRTS database about the projects in each project category (CARB 2021). Many project categories have names or are associated with administering agencies that suggest an exclusive focus on emissions-based benefits (including GHG and criteria and toxic air pollutants) and therefore were straightforward to exclude (e.g., "Zero- and Near Zero-Emission Vehicles and Equipment"). For other project categories where project activities were less obvious, we read through project and subprogram descriptions supplemented by other publicly available information (e.g., agency websites describing the subprograms and programs) to

[1] 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.

[2] While emissions-focused projects may generate ecosystem service benefits, these types of benefits are not the focus of this effort and are accounted for in other CARB analyses.

[3] While these projects may not directly improve ecosystems or affect people's behavior, they may still contribute to environmental changes and ecosystem service benefits. For example, consider a project that funds research to improve understanding of the effectiveness of agricultural best management practices in mitigating atmospheric carbon. Information would be required then on how research ultimately influences adoption of these practices in the agricultural industry to quantify the ecosystem service benefits attributable to the research project.

determine categories associated with emissions reductions activities only.[4] As part of this step, we also isolated and excluded the projects that do not directly affect ecosystem or resource management.[5]

2. **Of the remaining project categories, determine which contain a mix of projects likely and unlikely to result in ecosystem service benefits. Then, for these project categories, identify the subset of projects that result in ecosystem service benefits**.[6] To determine projects with the potential for ecosystem service benefits, we again drew from available information in the CCIRTS database. First, we reviewed individual project descriptions for evidence of reported environmental changes (e.g., developing green space, planting trees).[7] Second, we relied on CCIRTS to identify projects that report environmental changes that improve human wellbeing (e.g., acres of land conserved, number of trees planted, tons of waste diverted). All projects that indicated an environmental change in a project description or reported non-zero values with respect to environmental changes are included in the analysis.[8]

Table 1 provides a breakdown of the 7,833 projects identified as likely to generate ecosystem service benefits based on the criteria above. As shown, the projects span activities related to agriculture, wetlands, forests, neighborhood greening, water and energy efficiency, and waste diversion. Within these broad groups, we further categorize similar projects based on activities into 12 categories. The project category with the most projects is Domestic Water Systems, followed by Woodsmoke Reduction. A total of 13 agencies are involved in the implementation of the select projects. The remainder of the report is organized around the classifications in the table below.

Of note, many of these projects are funded only partially by CCI and receive some funding from other sources. While CCI is only a partial funder, this analysis considers the ecosystem service benefits associated with projects in their entirety, not just the apportioned value of the CCI contribution of the project.

[4] For example, the project category "Improving the Energy Efficiency of Water Supply" suggested the potential for changes in water supply/availability and therefore the water on which people depend in numerous ways. However, by reading more about these projects, we learned that the energy efficiency and emissions reductions are the only changes likely to result from these activities.

[5] Examples of activities that do not directly affect ecosystems or resource management include human capital development (e.g., capacity building, job training, workforce development), operational preparations (e.g., emergency preparedness, planning), administration (e.g., grant administration and intermediary admin expenses (IAE)), analysis (e.g., research, program evaluation), and other activities with no connection to changes in natural systems (e.g., interim water delivery – i.e., bottled water).

[6] Specifically, there were two project categories containing a mix of projects with and without ecosystem service benefits: (a) Affordable Housing and (b) Energy Efficiency and Renewable Energy.

[7] Specifically, we developed a list of keywords unique to each project category to use as search terms within project descriptions.

[8] This approach may undercount the number of projects that result in ecosystem service benefits where information in CCIRTS is incomplete or vague.

Table 1: Sub-Set of CCI Projects Considered in This Report

PROJECT CATEGORY	IMPLEMENTING AGENCIES AND PROGRAMS	NO. OF PROJECTS
AGRICULTURE		
Agricultural Land Conservation	**Department of Conservation:** Sustainable Agricultural Lands Conservation Program	34
On-farm Conservation Management	**California Department of Food and Agriculture:** Healthy Soils Program **State Coastal Conservancy:** Climate Ready Program	482
Increasing Efficiency of Agricultural Irrigation	**California Department of Food and Agriculture:** State Water Efficiency and Enhancement Program	598
Alternative Manure Management	**California Department of Food and Agriculture**: • Alternative Manure Management Program • Dairy Digester Research and Development Program	210
WETLANDS		
Wetland Restoration and Management	**Department of Fish and Wildlife**: Wetlands Restoration for Greenhouse Gas Reduction Program **Wildlife Conservation Board:** Climate Adaptation and Resiliency Program **State Coastal Conservancy:** Climate Ready Program	25
FORESTS		
Fuels Management	**California Department of Forestry and Fire Prevention:** • Fire Prevention Program • Fire Prevention Grant Program • Forest Carbon Plan Implementation	275
Restoration and Reforestation	**California Department of Forestry and Fire Prevention:** • Forest Health Program • Forest Carbon Plan Implementation	83
Forest Conservation	**California Department of Forestry and Fire Prevention:** Forest Health Program **Wildfire Conservation Board:** Climate Adaptation and Resiliency Program	21
NEIGHBORHOOD GREENING		
Urban Forestry and Green Spaces	**California Department of Forestry and Fire Prevention:** Urban and Community Forestry Grant Program **Natural Resources Agency:** Urban Greening Program **Strategic Growth Council:** • Transformative Climate Communities Program • Affordable Housing and Sustainable Communities Program **State Coastal Conservancy:** Climate Ready Program	260
WATER AND ENERGY EFFICIENCY		
Domestic Water Systems	**Department of Water Resources:** Water Energy Grant Program **Department of Community Service and Development:** • Single-Family Energy Efficiency and Solar Photovoltaics Program • Farmworker Housing Grant Program • Multi-Family Energy Efficiency and Renewables Program **California Energy Commission:** Food Production Investment Program	4,910
Woodsmoke Reduction	**California Air Resources Board:** Woodsmoke Reduction Program	826
WASTE DIVERSION		
Waste Prevention and Food Rescue	**Department of Resources, Recycling, and Recovery:** • Food Waste Prevention and Rescue Grants Program • Organic Grants Program • Organics and Recycling Loan Program • Recycled Fiber, Plastic, and Glass Grant Program **Strategic Growth Council:** Transformative Climate Communities Program	112

Analysis Approach

Ecosystem services analysis is an established framework for identifying and assessing the benefits people derive from the environment. CCI projects provide ecosystem service benefits by improving or conserving many aspects of the environment in ways that contribute to human well-being. To identify the ecosystem service benefits resulting from the selected CCI projects, we developed high-level conceptual diagrams that map linkages between project activities (related to resource management exchanges), the biophysical and ecological changes resulting from those actions, and people's well-being. Importantly, our approach traces changes within ecosystems to their final impacts on people, as opposed to intermediate services that could potentially result in double-counting when quantifying or valuing these benefits.[9] To that end, we consider a range of ways in which people interact with natural systems that result in improvements to society.

Key Elements of the Analysis Approach

- Constitutes a program-level assessment
- Emphasizes explicit consideration of both ecological/environmental improvements as well as associated values
- Applies a mixed-methods approach to evaluate the diverse types of benefits
- Includes quantitative measures and qualitative descriptions of benefits for which data limitations prevent estimating a monetary value
- Focuses on average annual benefits across counties in California of CCI projects implemented between 2015 and 2020

For example, projects encouraging agricultural practices that build healthy soils reduce erosion, which reduces drinking water treatment costs. Restored wetlands are better able to capture and store water, from which people benefit. Projects that alter forests to reduce the future risk of fire avoid future costs associated with wildfire damage. Trees planted in urban spaces provide shade that reduces the need for air conditioning in warm months. Projects that replace outdated wood stoves reduce air pollution and contribute to improvements in human health.

In developing these diagrams, we grouped similar projects by common characteristics using the project categories in CCIRTS. Below is an example of the conceptual diagram developed for projects implementing more sustainable manure management practices. While these conceptual models present many possible theoretical linkages, it is unlikely that all CCI projects within a given project category will result in all of the ecosystem service benefit categories described. Instead, the models are intended to convey all possible theoretical pathways for projects within a project category.

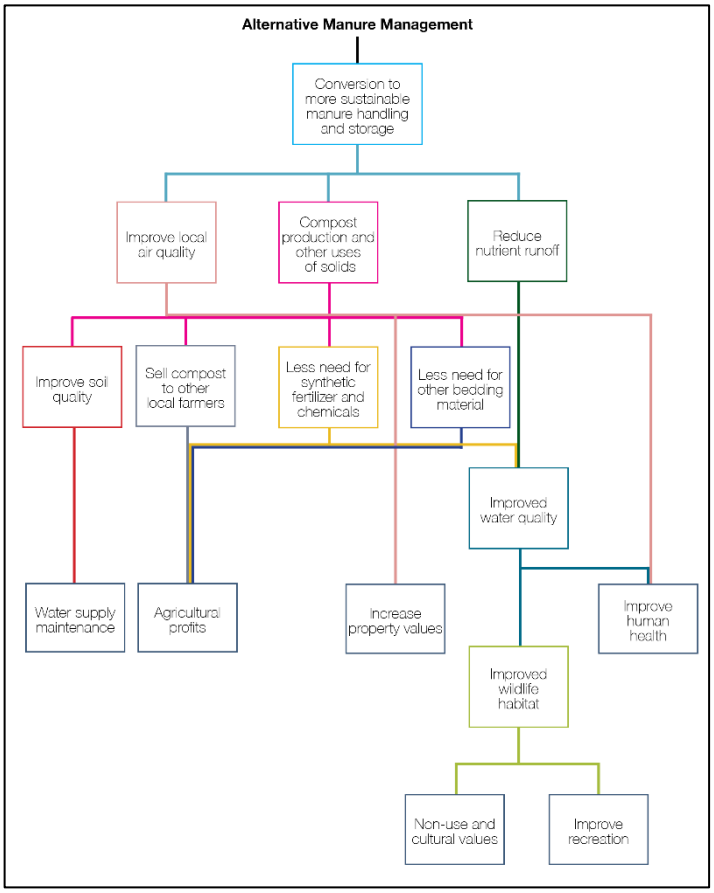
Our review of projects also highlighted various other human benefits that result from these projects that do not flow from environmental changes. For instance, many of the "Affordable Housing and Development" projects create bikeways that connect residents with recreation and clean commuting alternatives. While these project activities provide clear benefits to people beyond the primary GHG emissions reduction benefits, they are not the result of an ecosystem change, and therefore we do not include them in our conceptual diagrams.

[9] This approach is consistent with the U.S. Environmental Protection Agency's Final Ecosystem Goods and Services Classification System: https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs. However, the terminology we use borrows from several related classification systems.

The conceptual diagrams developed for each project category are included in the **Appendix**; an example is provided in **Figure 1**. As these diagrams convey, the final ecosystem service benefits associated with CCI projects are numerous and include but are not necessarily limited to the following:

- Increased water supply
- Improved or increased recreation opportunities
- Avoided property damage
- Avoided energy costs
- Avoided water treatment costs
- Increased commercial revenue
- Increased property value
- Improved human health[10]
- Improved human safety
- Improved food security
- Improved aesthetics
- Non-use and cultural values

Figure 1: Example Conceptual Flow Diagram



Biophysical and Ecological Changes

The first step in assessing ecosystem service benefits is determining the biophysical and ecological changes resulting from CCI projects. Given the breadth of CCI project activities, these changes may occur to water, air, or species habitat quality, for example.

To quantify these changes in environmental attributes, we leverage project-specific monitoring data, where possible, often captured in CCI's CCIRTS database. For instance, CARB requires state agencies to report the number of gallons of water saved as a result of project activities. Where this specific information is not available, our assessment of changes in environmental conditions draws on project-specific attributes (e.g., acres of agricultural land with improved soil health practices) but requires additional information to quantify changes in ecological conditions (e.g., increase in soil organic matter per acre associated with these practices). Given the limitations of project-specific data and to provide longer-term insights on the potential for ecological changes, this analysis draws significantly from the published literature, and interviews with state agencies, other local experts, and researchers. Where project-specific information and the literature are insufficient to offer a quantitative assessment of biophysical and ecological changes, these benefits are conveyed qualitatively.

[10] A separate effort is focused on quantifying and monetizing the health benefits of CCI projects. As a result, this report does not focus on those benefit streams. One exception is our quantification and valuation of human health benefits associated with the woodsmoke reduction projects. In this case, human health benefits are the primary ecosystem service-related benefits and are not captured elsewhere.

Ecosystem Service Benefits

For the subset of projects where quantitative data exists on biophysical and ecological changes, the next step in the analysis is to monetize how people value or benefit from these diverse types of environmental changes. Our assessment of project benefits attempts to capture as many relevant ecosystem service values as possible, though it is constrained by the availability of existing valuation research. We rely on the best available data and literature to illuminate the multiple and varied types of benefits of the CCI projects. Accordingly, the results reflect a mix of measures of economic benefits, including avoided costs, economic welfare values, and market values. The analysis therefore constitutes a mixed methods approach to evaluating the ecosystem service co-benefits of CCI projects.

Example Indicators of Ecosystem Service Values

- Results from stated preference surveys regarding people's willingness to pay for a given resource change
- Demonstrated increase in willingness to pay to participate in recreational activities at sites with specific ecological or environmental attributes
- Property value premiums resulting from changes in environmental attributes
- Changes in net revenues in commercial markets
- Avoided damages or costs relative to pre-project activities

Market-based approaches can be utilized to measure some project benefits such as increased commercial revenues or avoided costs (e.g., reduced need for water) relative to pre-project conditions. However, markets do not exist for many ecosystem services. In these cases, economists utilize nonmarket valuation techniques to measure willingness-to-pay (WTP).[11] These methods generally fall under one of two categories: stated and revealed preference. Stated preference methods utilize surveys asking respondents to consider how they value tradeoffs in the quality and quantity of particular resources. Revealed preference methods consider actual behavior that is related to an environmental change in some way. For instance, the hedonic pricing method assumes that local environmental conditions are reflected in real estate transaction prices. If a causal link can be drawn between a change in environmental conditions and property values, the magnitude of that change can be interpreted as revealing people's WTP for the change.

Interpretation of Values

Given the mix of data sources and methods this analysis incorporates, as well as the constraints associated with leveraging existing ecological and economic models without detailed monitoring data for some aspects of the projects, our results should be interpreted as best estimates that reflect the types and general magnitudes of the benefits of these projects, which are anticipated to range widely based on site-specific conditions. Where possible, we offer ranges to convey the uncertainty of our findings. Throughout our analysis, we present economic benefit estimates adjusted to 2021 dollars.

Importantly, the various monetized benefits are not necessarily additive across benefits or project categories. That is, summing across the results of the various analyses would "double count" certain benefits. For example, measures of total WTP for conservation of agricultural land and the effects of

[11] 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.

agricultural land conservation on property values both value the same change, albeit to potentially different populations (general public versus homeowners). It is therefore likely that summing these values would result in double counting benefits of conserving agricultural land. Because of the overlapping nature of some of the categories of benefits, summing across value metrics in order to get a "total ecosystem service" benefit in a given area would not be appropriate. In light of these limitations, we present results for each category of benefits separately, clearly articulating what the monetary values reflect.

To convey where the suite of benefits may be concentrated for a given project category, we sum monetized ecosystem service benefits to illustrate the "benefits potential" across counties in California. The benefits potential indicator communicates the expected distribution and relative magnitudes of benefits of these projects. We express benefits potential by grouping counties into five categories that reflect the range in the monetized ecosystem service benefits. Where a given benefit is expressed as a range, we take the high-end of the range when aggregating. Because this approach is unable to capture all possible ecosystem service benefits of a given project type – for instance because several benefits are described qualitatively – the categorization should not be interpreted as precise but instead an indicator of relative magnitude and distribution.

Distribution of Ecosystem Service Benefits Across Demographic Groups

The ecosystem service benefits of CCI projects may accrue to different demographic groups. This analysis does not address these distributional implications.

For instance, for several project categories, available literature suggests that project activities may increase nearby property values because of the values people place on the services provided by the environmental resources. In aggregate, economists generally view property value increases as a net societal benefit (i.e., increasing wealth). However, those benefits are likely experienced by property owners, not renters. In fact, renters may experience this change as an increase in housing costs.

Temporal Dimensions

Ecological changes may occur over variable timeframes following the implementation of CCI projects. In some cases, ecological improvements are observed immediately (e.g., food waste diverted from landfills, decreases in water used for irrigation) whereas in other cases the benefits may take decades to materialize (e.g., trees planted in urban areas may take decades to reach maturity and offer cooling benefits). This analysis focuses on providing information on the types and magnitudes of ecosystem service benefits resulting from these projects once the benefits are realized. However, when comparing the benefits and costs of a particular project, the timing of the flow of costs and benefits is an important consideration.

We present benefits that are expected to recur each year in annual terms. For those cases where we find the potential for property value improvements stemming from the ecosystem service benefits of CCI projects, those benefits are not recurring. However, for comparison purposes, we convert the total increase in property values into their annualized equivalent using a discount rate of 3 percent. This discount rate is commonly used in economic analysis and reflects the "consumptive rate," or household after-tax earnings on their investments.[12]

[12] Resources for the Future (RFF). 2021. "Discounting for Public Benefit-Cost Analysis." Accessed at https://www.rff.org/publications/issue-briefs/discounting-for-public-benefit-cost-analysis/.

Summary Findings

Beyond reducing atmospheric GHG concentrations, CCI projects contribute to a host of ecosystem service benefits by improving environmental quality and the well-being of Californians. Abundant research demonstrates that people value these changes in environmental amenities and benefit through new opportunities (e.g., recreational trips), cost-savings (e.g., home cooling costs), and revenue-generation (e.g., through increased productivity of agricultural lands). This report identifies over 7,800 CCI projects across 12 broad categories that improve ecological conditions and benefit the residents of California. In total, this report quantifies and values over 30 ecosystem service endpoints across these projects and describes several other benefit streams qualitatively.

In addition to reducing GHGs, CCI projects contribute to more sustainable agricultural production, restore beneficial wetland functions, reduce the threat of future forest fires, increase green space in urban areas, reduce consumption of scare water and energy resources, and prevent waste of reusable products. These projects help protect and preserve the valuable ecosystem services that sustain California's residents, communities, and economy.

Table 2 summarizes these findings for each of the 12 project categories included in this report, including a general description of project activities, information about the scope of the projects drawn from reported data, and our evaluation of ecosystem service benefits. These results should be interpreted as best estimates that reflect the types and general magnitudes of the ecosystem service benefits potential of these projects, which are anticipated to range widely between project categories and types of ecosystem services. Across the project categories, we find the following:

- ***Agriculture:*** People value the continued existence of agricultural land in the state and have a preference for agricultural operations that contribute to healthier soils, cleaner water, and improved local air quality. Project participants – typically farmers – may also benefit when changes in agricultural management practices enabled by the CCI grants improve agricultural yields and/or reduce management costs. Properties, including other agricultural land, near the CCI projects on farms experience benefits in terms of increased pollinator activity as well as cleaner waterways and airsheds that benefit species habitat and human health.
- ***Wetlands:*** Well-functioning wetlands benefit people by improving water quality, providing additional water storage, protecting wildlife, and generating recreational and educational opportunities, among other benefits. Coastal wetlands projects can protect adjacent properties from the effects of coastal storms. We monetize these benefits separately for inland and coastal wetlands projects throughout the state.
- ***Forestry:*** Forests improve air quality, provide flood and storm hazard reduction, generate recreation and tourism opportunities, and filter, capture, and store groundwater. CCI projects help to conserve, restore, and protect forests in California, generating numerous benefits to people. Additionally, fuel risk reduction projects also reduce the probability of catastrophic wildfire and reduce the associated risks to infrastructure and human health and safety.
- ***Neighborhood greening:*** Trees planted in urban areas help to reduce ambient temperatures and cooling energy needs. Literature also demonstrates that urban trees are associated with reduced crime and increased property values, given the environmental amenities associated with trees as well as the aesthetic benefits. Beyond trees, restoring and increasing green space and parks in urban neighborhoods generates recreational opportunities and improves human health and well-being. Urban gardens can provide food security benefits to nearby residents.
- ***Water and energy efficiency:*** People value the water-savings associated with improved efficiency of domestic appliances promoted by CCI. Reduced demand for domestic water decreases the need for groundwater pumping and the likelihood of subsidence that damages properties. Replacing woodburning appliances with safer and more efficient alternatives cleans the air and improves the health and safety of beneficiaries as well as residents in their airsheds. More efficient stoves also reduce the amount of wood burned for heating purposes, thereby leaving more trees in the ground.
- ***Waste diversion:*** Rescuing food destined for the waste stream generates meals for people and can increase food security and promote human health. By diverting food and other valuable products from the waste, the environmental costs associated with landfilling are avoided, including odors for nearby residents. Increased production of compost, recycled products, and biogas increases commercial revenues associated with those products.

The sections that follow provide the complete analytic details underlying each assessment, including the relevant data sources, methods, and assumptions underpinning each analysis.

Table 2: Summary of Report Findings by Project Category

PROJECT CATEGORY	PROJECT ACTIVITIES	PROJECT SCOPE	ECOSYSTEM SERVICE BENEFITS POTENTIAL (2021 DOLLARS)
 Agricultural Land Conservation (34 projects)	Conserve productive farmland and ranchland under threat of development	43,000 acres of cropland and ranchland conserved	- Estimated public willingness to pay between $140,000 and $35 million per year for the acres conserved. - CCI projects may increase market prices for up to 17,000 parcels between $5,900 to $1.6 million on an annualized basis. - Market value of the agricultural yield sustained through these projects of $110 million per year. - Continued local agricultural production may contribute to regional food security.
 On-farm Conservation Management (482 projects)	Implement farming practices that improve soil health and the environmental conditions of agriculture	37,000 acres of farmland with improved soil management practices 5,700 acres of pollinator habitat created	- The annual benefits that may accrue from improved soil health range from $2,500 to $10 million. - Increasing yields of pollinator-dependent crops near project sites may be valued at $2 million per year. - Improvements in regional food security and habitat for non-aquatic species are also possible through these practices.
 Increasing Efficiency of Agricultural Irrigation (598 projects)	Implement more efficient strategies to reduce on-farm water and energy use	36 billion gallons of water saved annually	- The potential magnitude of benefits resulting from reduced water supply maintenance needs is on the order of $15 million per year. - Reduced groundwater pumping may avoid property damage through reduced subsidence. - Replacing pumps with more energy efficient options also increases local air quality and improves human health.
 Alternative Manure Management (210 projects)	Implement projects using anaerobic digestion and other methods for more sustainable manure management	430,000 dairy cows are supported by the projects 36,000 cubic yards of compost are produced in projects area	- Consumers are willing to pay on the order of $467 million per year for milk produced in more environmentally sustainable conditions from these projects. - Property values could increase by $880,000 on an annualized basis near project sites due to reduced odor. - The market value of compost produced from these projects in 2020 was $430,000. - The application of composted manure to fields may provide safer drinking water valued up to $19 million per year and $3,000 in plant-available water storage.
 Wetland Restoration and Maintenance (25 projects)	Construct, enhance, restore, and monitor wetland, salt marsh, riparian, meadow, and/or dune habitat	2,000 acres of coastal wetlands treated 6,000 acres of inland wetlands treated	- Estimated willingness to pay on the order of $32 million per year for the 6,000 acres of inland wetlands treated, restored, or conserved. - Inland wetlands increased water storage, with a potential value of approximately $190,000 per year. - Property values near coastal wetlands may increase on the order of $12 million when annualized. - The wetland restoration and maintenance projects may also offer flood and storm protection benefits to nearby households. - Eight of the wetland restoration and maintenance projects may also benefit endangered species.

PROJECT CATEGORY	PROJECT ACTIVITIES	PROJECT SCOPE	ECOSYSTEM SERVICE BENEFITS POTENTIAL (2021 DOLLARS)
 Fuels Management (275 projects)	Implement fuels management activities at various scales	270,000 acres of forested land treated with fuel management activities	- By reducing the likelihood of catastrophic burn, the projects may generate $3.1 million in ecosystem service benefits and avoid $2.8 million in property damage. - The projects have the added benefits of improving human health and safety and protecting habitat, among others.
 Reforestation (83 projects)	Reforest, manage pests, and other forest restoration activities	320,000 acres of land restored or reforested	- Estimated ecosystem service value of these acres once restored to full functionality at approximately $750 million annually.
 Forest Conservation (21 projects)	Conserve forested land under threat of development	57,000 acres of forested land conserved	- Estimated willingness to pay for conserved forests up to $8.8 million per year. - CCI projects may increase market prices for 27,000 nearby parcels between $110,000 to $3.8 million on an annualized basis.
 Urban Forests and Green Space (257 projects)	Plant trees and upgrade green space in urban areas	84,000 trees planted 61 projects involving urban green space maintenance 25 projects with gardening activities	- Expanded tree canopy may reduce energy needs by $3.3 million per year. - The trees planted may naturally manage 310 million gallons of stormwater, potentially reducing management costs by $3.2 million per year. - Increasing tree canopy may avoid approximately 1,300 crimes per year, reducing related costs by $5.2 million. - CCI projects may increase market prices for adjacent properties by $4.1 million on an annualized basis, although the distribution of these benefits is uncertain. - These projects may also yield benefits to human health and well-being, revenue from urban wood rescue, recreation, and food security.
 Domestic Water Systems (4,910 projects)	Replace appliances in underserved communities with cleaner and more energy efficient alternatives	1.5 billion gallons of water saved annually	- The potential magnitude of benefits resulting from reduced water supply maintenance needs is on the order of $12 million per year. - Reduced groundwater pumping may avoid property damage through reduced subsidence.
 Woodsmoke Reduction (826 projects)	Replace residential woodburning stoves in underserved communities with cleaner and more energy efficient alternatives	940 tons of $PM_{2.5}$ emissions reductions per year	- Improvements in air quality may reduce 840 to 864 human health incidences, avoiding between $170 million to $370 million in annual healthcare costs - Increased efficiency of stoves also reduces the amount of wood burned for heating purposes, thereby leaving more trees in the ground. - Replacing outdated stoves also decreases home fire risks, improving human safety and avoiding property damage.
 Waste Prevention and Food Rescue (112 projects)	Divert waste from landfills through food rescue, waste prevention, recycling, composting, and anaerobic digestion	570,000 million tons of waste diverted from landfills per year 28,000 tons of food rescued per year	- Rescuing food waste, equivalent to 47 million meals, saved the $150 million in food costs per year. - Avoided $27 million in annual landfill tipping fees. - Reductions in food waste also increases food security and promotes human health. - Less green waste in landfills benefits human health by reducing landfill odors. - Production of compost, recycled products, and biogas increases commercial revenues.

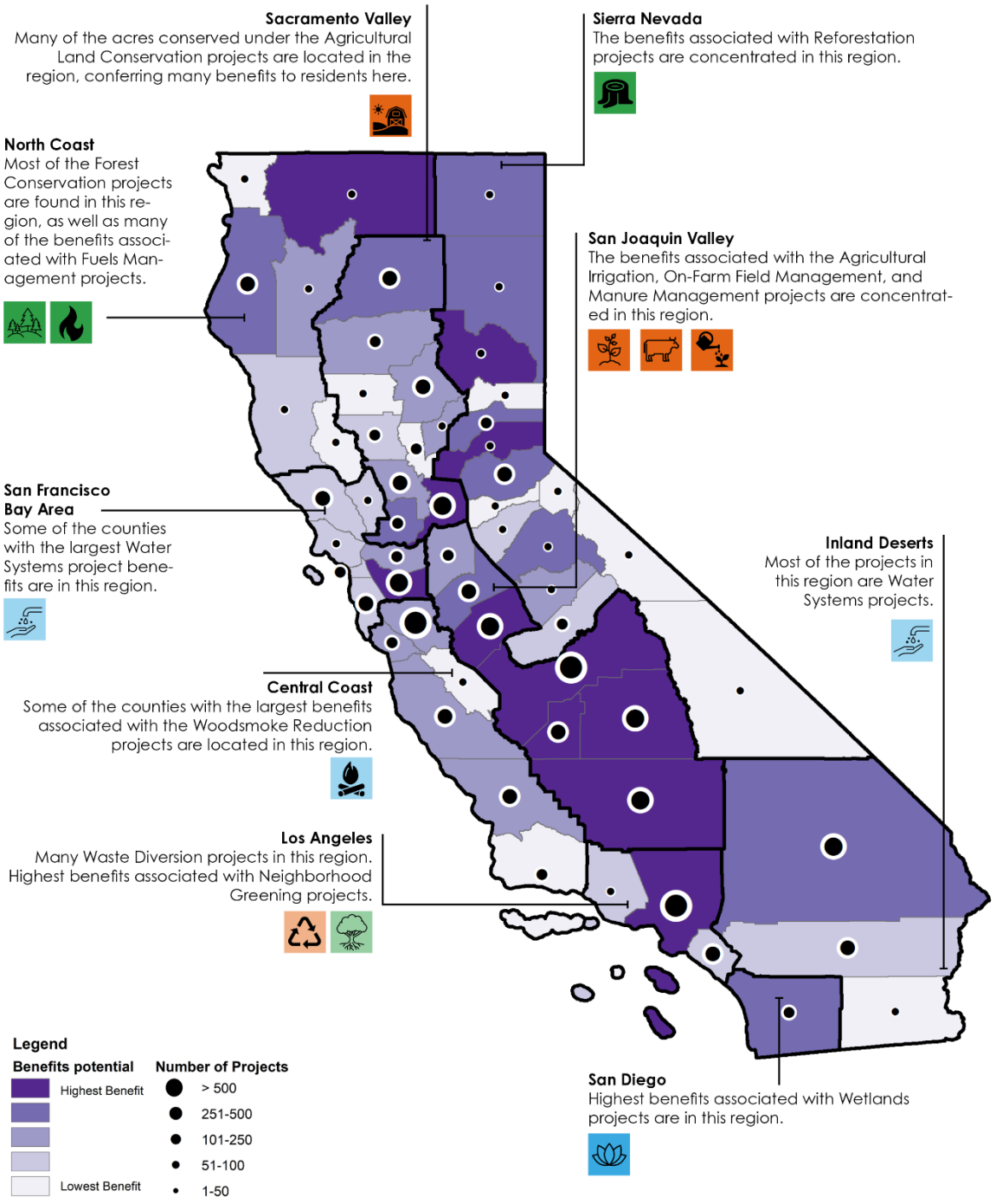
Finally, **Figure 2** presents the geographic distribution of the 7,833 projects considered in this report as well as the relative magnitude of their ecosystem service benefits potential at the county level. The purple shading conveys the gradient of benefits potential, where darker shading communicates a larger magnitude of benefits. The size of the circle over each county expresses the number of CCI projects considered in this analysis that fall into each county.

Every county in California contains CCI projects considered in this analysis. There are several "hot spots" where CCI projects are concentrated, including Los Angeles County (1,030 projects), Fresno County (667 projects), Santa Clara County (581 projects), and Sacramento County (493 projects). These counties generally align with the areas of the state in which natural and working lands are concentrated and population densities are relatively high. In general, the counties with the greatest number of projects also have the greatest ecosystems service benefits potential, although exceptions occur.

Figure 2 also highlights nine regions within the state, adapted from regional definitions used in the California Climate Assessment.[13] The map uses text to describe the concentration of projects and ecosystem service benefits across these regions. For instance, the benefits of forestry projects generally are concentrated in the North Coast and Sierra Nevada regions, whereas the benefits of the agricultural projects are experienced in Sacramento Valley and San Joaquin Valley. While wetlands projects around found throughout the state, the region with the greatest related benefits is San Diego. The benefits potential of the water and energy efficiency projects are found in their highest density across the San Francisco Bay and the Central Coast. The urban Los Angeles region is home to the greatest benefits associated with the neighborhood greening and waste diversion projects. The Inland Desert region also contains a high number of water efficiency projects. The sections that follow include similar maps that present the distribution of projects and ecosystem services benefit potential for each of the 12 project categories.

[13] The regions used in the California Climate Assessment are described here: https://climateassessment.ca.gov/regions/. In this classification scheme, five counties are split between two regions each (Riverside, San Bernadino, Placer, Solano, and Madera counties). For the purposes of this report, we assign these counties to one region each.

Figure 2: Spatial Distribution of Ecosystem Service Benefits Potential of CCI Projects (2015-2020)



AGRICULTURE

Agricultural Land Conservation

Ecosystem Service Benefits

- The public demonstrates a preference for preventing farms and ranches from development and may be willing to pay between $140,000 and $35 million per year for the acres conserved.
- Another way to measure how the public values the conservation of farmland is through increases in property values of nearby parcels. CCI projects may increase market prices for up to 17,000 parcels between $5,900 to $1.6 million on an annualized basis.
- The agricultural production sustained through these projects also generates revenue for farmers. Crops produced on this land may have a market value of $110 million per year. This revenue contributes to maintaining agriculture as a viable livelihood for farmers.
- Continued local agricultural production may also contribute to regional food security.

OVERVIEW OF PROJECTS

Project activities

Conserve productive farmland and ranchland under threat of development

Implementing agency

California Department of Conservation

34 projects

funded across 19 counties (2015-2019)

43,000 acres

of cropland and ranchland conserved

Between 2015 and 2019, CCI invested in 34 projects through the Sustainable Agricultural Lands Conservation (SALC) Program at the California Department of Conservation. The primary activity for these projects is conserving productive farmland and ranchland under threat of development in perpetuity. During this five-year period, CCI conserved 43,000 acres across 19 counties, about 8 percent of which is cropland and 92 percent ranchland (CARB 2021).[14] The two counties with the most conserved acres are Butte and Napa, although the most projects are found in Monterey. Relative to the agricultural land conserved pre-CCI (GreenInfo Network 2022), these projects are increasing land devoted to agricultural easements by 0.03 percent in Lassen County to 10 percent in Napa County.

This analysis documents the societal benefits related to keeping agricultural land in productive use. Appendix page A-2 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Relative to developed land, agricultural land provides pollinator and wildlife habitat, acts as a catchment for stormwater, provides green and open space that can reduce the likelihood of heat island effects, provides food sources for people, and sustains income and a livelihood for farmers. To demonstrate how people value these services, the analysis includes information on two different measures: 1) an overall WTP reflecting people's preference for maintaining agricultural land and 2) an assessment of the property value benefits to nearby parcels. In addition to these measures of broad societal values, the analysis also considers the commercial revenues to farmers associated with keeping agricultural land in productive use. Finally, the benefits to regional food supplies and habitat for species are qualitatively summarized.

Willingness to pay (WTP) to conserve farmland.[15]

There are several possible ecosystem service benefits of conserving farmland in rural areas, including aesthetic values and the values people place on the habitat sustained by agricultural land (McConnell and Walls 2005). Beyond benefits associated with the environmental attributes of farmland, people may also value the continued existence of the agricultural way of life, source of local food, among other broader socioeconomic benefits. While no studies are specific to residents of California, evidence from across the United States consistently demonstrates that people are willing to pay to prevent the conversion of agricultural land to developed land. A literature search identified six studies that offer information on WTP per acre of farmland conserved per household per year (Bergstrom et al. 1985; Beasley et al. 1998; Rosenberger and Walsh 1997; Johnston et al. 2001; Swartzentrauber 2019; Johnston and Duke 2007).[16] After dropping two high-end outliers, these studies provide a range of $0.046 to $12 per 1,000 acres conserved per household per year.[17] Applying these values to the nearly 43,000 acres conserved across CCI projects and the 1.8 million households in the counties in which the farms and ranches are found (according to U.S. Census data), the analysis suggests

[14] There were about 450 acres that were not valued, primarily due to being open water, developed land (together about 1.313 percent of total acreage), or, to a significantly lesser extent, a crop with no value in the data (0.048 percent of total acreage).

[15] 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.

[16] Four of these studies were summarized in McConnell and Walls (2005). This analysis added two studies published since 2005 to establish the range.

[17] The two outliers included WTP for coastal farmland in New York (Johnston et al. 2001) and farmland in Alaska (Beasley et al. (1998), which are both sufficiently different from the cropland and ranchland conserved by CCI.

that Californians may value the agricultural acres conserved by CCI between **$140,000 and $35 million per year**.[18] This broad range reflects the uncertainty associated with this outcome at a given project site.

Increased property values for nearby residents.
Another way to measure the value of conserving farmland is through increases in property values of adjacent parcels. To demonstrate the potential effects of CCI projects on property values, this analysis considers findings from Geoghegan et al. (2003), which studies increases in property values associated with increases in agricultural land conserved across two counties experiencing development pressure in Maryland. The study authors find that homes within 100 meters (m) of an agricultural easement experience a 0.04 percent increase in market value in one county while homes within 1,600 m experience a 0.71 percent increase in a different county. We use the property value benefit experienced by households within 100 m of the projects as a low-end estimate for the overall property value effect of the projects and the benefit experienced by households within 1600 m as the high-end. Spatial analysis identifies over 550 parcels within 100 m and over 17,000 within 1,600 m of the CCI projects (County of Los Angeles 2022). Assuming all identified parcels are valued at the median home price for the county (U.S. Census Bureau 2020), this analysis suggests the property value benefits of the conserved acres may be between $190,000 and $51 million in present value terms, equivalent to **$5,900 to $1.6 million on an annualized basis** (assuming a 3 percent discount rate).

Commercial revenues from sustained agricultural production.
In addition to the benefits experienced by the public and nearby property owners, sustaining agricultural production ensures continued commercial revenue to farmers. This analysis first used spatial data from the U.D. Department of Agriculture (USDA 2021a) to identify the primary crop or fodder agricultural product on each conserved parcel outlined in geospatial data provided by SALC (2022). Across all conserved acres, 69.0 percent (approximately 29,000 acres) are classified as shrubland or grassland/pasture, while forests and wetlands make up about 23.4 percent (approximately 9,900 acres). Among parcels with crop production (7.6 percent of acres, equivalent to 3,200 acres), the primary crops include alfalfa, olives, and rice. Then, to determine the magnitude of potential revenue from selling the crops and fodder from these fields, data from the California Agricultural Statistics Review and the USDA Land Values Summary were incorporated to assign an average market value, in dollars per acre, for each crop or land use type. Overall, these acres can produce crops and fodder valued at **$110 million annually**, equivalent to about $2,700 per acre. For reference, the total farm receipts in California for 2020-2021 was $49 billion across 24 million acres (CDFA 2021).[19]

[18] Both of the underlying studies represented in the range also extrapolated their findings to households within the county.

[19] Not included in this assessment is the value of livestock and other animals sustained by the agricultural land conserved, which may be significant given the high proportion of ranchland.

Beyond revenue, agriculture also represents a livelihood and way of life for many Californians. According to the California Department of Food and Agriculture's Agricultural Statistics Review, California's agriculture industry "supports 1.2 million jobs, including the vital farmworkers who labor to harvest, process, and transport California's agricultural bounty" (CDFA 2021). Though California is responsible for nearly 14 percent of agricultural production in the United States, most farming operations in California are small (CDFA 2021). In 2020, 71 percent of farms brought in less than $100,000 in sales, whereas only 14 percent brought in more than $500,000 (CDFA 2021). Many of the farmers running these small-scale operations work the land they live on. For these individuals, the conservation of farmland is necessary to protect both their homes and incomes.

Improved regional food security.
Agricultural land easements also have the potential to support California's regional food security. By conserving local, arable land, agricultural easements protect California from out-of-state and international agricultural supply shocks. Protecting a parcel by restricting nonagricultural development "gives a relative priority to economic and food security objectives. It may be the most effective, pragmatic, and tailored approach for a given project, land trust, geographic area, or even type of working landscape" (Phelps 2017). In addition to the other benefits characterized above, we anticipate that the conservation of nearly 43,000 acres of cropland and ranchland will further bolster California's regional food security.

Positive preference for protection of species habitat.
Many of the agricultural easements provide habitat for species or a buffer between developed sites and important ecosystems, like rivers, grassland, and woodland. Depending on location, some of the conserved properties may function as habitat during annual migrations or for breeding specifically. The economics literature generally finds that people have a positive preference for increasing the conservation of species of concern, including endangered and threatened species. However, data are not available to quantify or monetize these benefits.

Table 3: Summary of Monetized Ecosystem Service Benefits for the Agricultural Land Conservation Projects by County (2021 dollars)

County	Total Acres Conserved[a]	WTP for Conserved Agricultural Land (Annual)[b,c]	Increased Property Values (Annualized)[b,c]	Commercial Value of Agricultural Production (Annual)[b]
Butte	9,100	$35,000 - $8,900,000	$1,000 - $56,000	$28,000,000
Calaveras	3,300	$2,500 - $640,000	$1,600 - $310,000	$9,100,000
Contra Costa	520	$9,600 - $2,400,000	<$100 - $100,000	$640,000
Humboldt	2,900	$7,300 - $1,900,000	<$100 - $8,300	$4,100,000
Lassen	580	$250 - $62,000	<$100 - $1,300	$510,000
Marin	330	$1,600 - $400,000	<$100 - $4,700	$790,000
Mariposa	280	$100 - $26,000	--	$830,000
Merced	60	$230 - $57,000	<$100 - $520	$280,000
Mono	2,400	$570 - $140,000	<$100 - $820	$4,700,000
Monterey	1,900	$11,000 - $2,800,000	$190 - $220,000	$6,400,000
Napa	13,000	$29,000 - $7,200,000	$1,600 - $110,000	$36,000,000
Placer	860	$5,800 - $1,500,000	<$100 - $18,000	$2,200,000
San Joaquin	120	$1,300 - $330,000	<$100 - $4,500	$220,000
San Luis Obispo	1,800	$8,700 - $2,200,000	<$100 - $2,200	$4,100,000
Santa Cruz	49	$220 - $55,000	<$100 - $31,000	$310,000
Shasta	670	$2,200 - $550,000	<$100 - $390	$1,500,000
Sierra	690	<$100 - $10,000	<$100 - $4,500	$1,600,000
Solano	2,200	$15,000 - $3,900,000	$780 - $340,000	$6,100,000
Yolo	2,400	$8,400 - $2,100,000	$380 - $390,000	$7,700,000
Statewide Total	**43,000**	**$140,000 - $35,000,000**	**$5,900 - $1,600,000**	**$110,000,000**

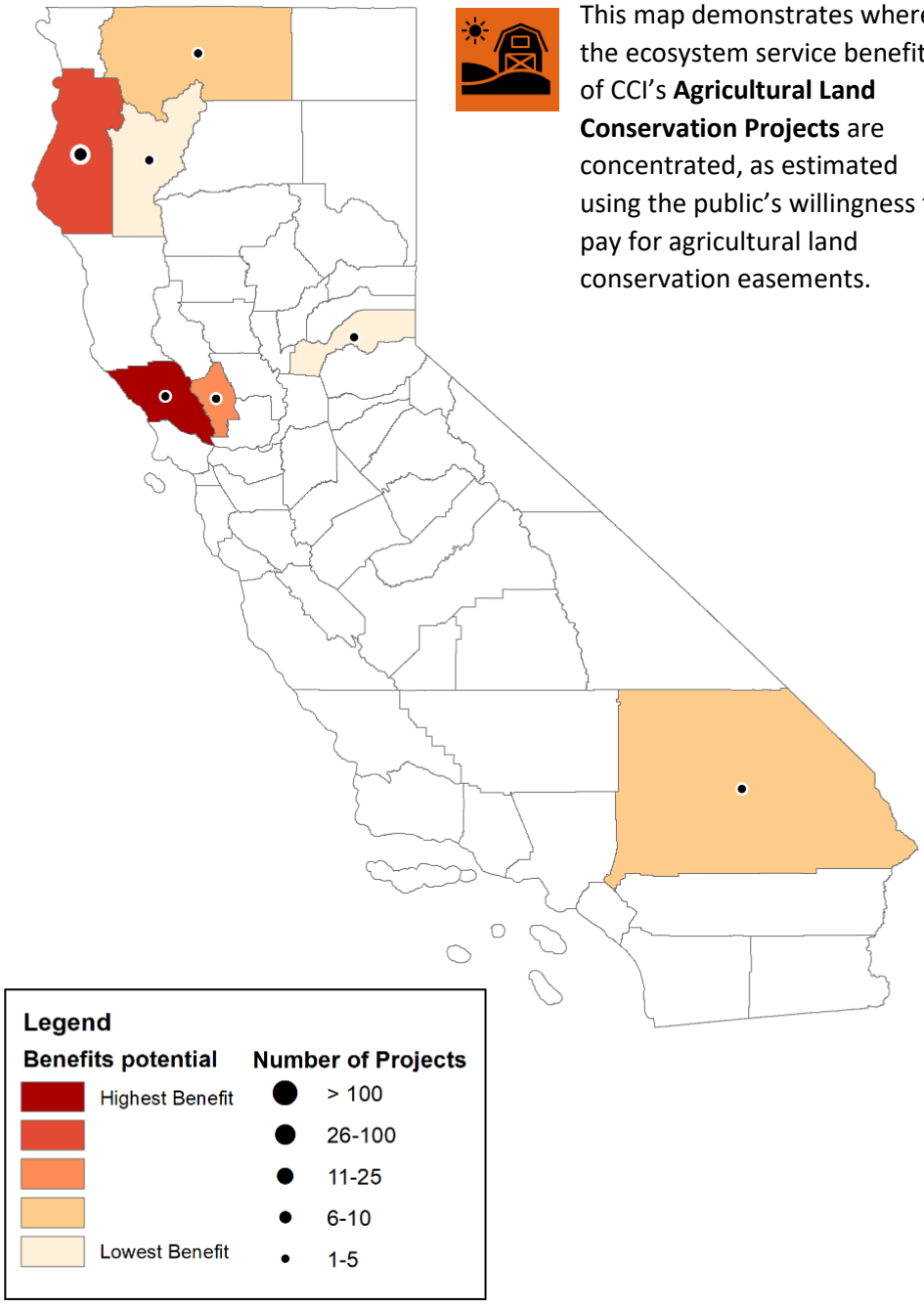
Sources and notes:

a. Data observed in CARB (2021) considering projects implemented from 2015 to 2019.

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.

c. When "<$100" is used to express the low-end of a range, the expected value of the metric is between a value less than $100 and the high-end value.

Figure 3: Spatial Distribution of Ecosystem Service Benefits Potential for the Agricultural Land Conservation Projects



Note: The benefit potential conveyed in this map reflects the WTP for conserved agricultural land (as opposed to solely the acreage of land conserved), as presented in Table 3. The high-end value of the range is included.

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AGRICULTURE

On-farm Conservation Management

Ecosystem Service Benefits

- On-farm conservation management practices lead to increases in soil organic matter (SOM), resulting in more nutrient-rich and biologically active soils. This makes soils more resistant to erosion and more effective in water filtration, which reduces drinking water maintenance needs, increases retention of plant-available water, and improves fish habitat. The annual benefits that may accrue from improved soil health range from $2,500 to $10 million.
- These practices can also create pollinator habitat, potentially increasing yields of pollinator-dependent crops at an average value of $2 million per year.
- Improvements in regional food security and habitat for non-aquatic species are also possible through these practices.

OVERVIEW OF PROJECTS

Project activities

Implement farming practices that improve soil health and the environmental conditions of agriculture

Implementing agencies

California Department of Food and Agriculture; State Coastal Conservancy

482 projects

funded across 46 counties (2018-2020)

37,000 acres

with improved soil practices

5,700 acres

of new pollinator habitat

The California Department of Food and Agriculture (CDFA) and State Coastal Conservancy (SCC) implemented 482 projects aiming to improve soil health from 2018 to 2020. Project activities include on-farm conservation management practices such as cover cropping, no or reduced till farming, mulching, compost application, and conservation plantings. Through the implementation of these practices, 37,000 acres of soil were improved, and 5,700 acres of new pollinator habitat established (CARB 2021). Projects spanned 46 counties, with the greatest soil benefits achieved in Sutter and Yuba counties and the largest amount of new pollinator habitat established in Yolo and Tulare counties.

Appendix page A-3 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Increased soil organic matter (SOM) is a primary benefit of implementing on-farm conservation management practices. SOM is the portion of the soil comprised of plant or animal matter and is a useful proxy for the health and productivity of soils (Cornell University Cooperative Extension 2008). This analysis measures benefits flowing from increased SOM including increased availability of nutrients, greater water retention, and reduced soil erosion, which in turns leads to ecosystem service benefits such as increased agricultural production, reduced need for water supply maintenance, and avoided water treatment costs. For the purposes of this analysis, information about changes in SOM from demonstration plots funded by CDFA are used as a proxy for changes in SOM across all projects in this category. We assume these short-term increases in SOM will persist over time as conservation management practices become more routine. This analysis also values benefits from increased pollinator habitat from practices like adding hedge rows and planting cover crops. These benefits include increased agricultural yields and improved habitat.

CCI projects increase soil organic matter.

Of the 482 projects, 11 projects function as demonstration plots used for research and as teaching tools for farmers and ranchers. These projects contribute to a better understanding of how the practices encouraged and funded by CCI contribute to improvements in soil health over time. Data on measured SOM on demonstration plots were available for these 11 demonstration projects, many of which studied multiple practices across multiple plots (CDFA 2021). Comparing changes in SOM from pre-project levels and relative to "control" plots that maintained pre-project practices on the same farms, the data show average increases in SOM of **0.15 percent after one year, 0.20 percent after two years, and 0.60 percent after three years**.[20,21] While variations across practices and project sites can be substantial, data are insufficient to calculate changes in SOM by project. Instead, we apply the average observed increases in SOM described above for these 11 projects to all 37,000 acres identified to assess the potential ecosystem service benefits associated with these improvements. Importantly, these demonstration plots only tracked changes for up to three years, and these plots are expected to continue to accrue SOM benefits over time.

[20] The types of management practices covered by these data include but are not limited to composting, applying wood chips, planting cover crops (both legumes and non-legumes), mulching, and combinations that considered multiple of these practices simultaneously (e.g., compost and cover crops). While the practices supported by CCI fall into specific classifications defined by USDA's Natural Resources Conservation Service (NRCS), we refer to them using more general terms in this report.

[21] To derive these numbers, we calculated the difference between SOM measured on the treatment plots (T) and control plots (C) at each time period (t) then divided that difference by the difference between the treatment and control plots before project implementation (t=0). For example, after one year of project implementation (t=1), the change in SOM is: $(T_1-C_1)/(T_0-C_0)$. The change in SOM was calculated for each demonstration plot then averaged across all plots with data points in each of the three years. These measures represent percent by weight per year and are a standard way of conveying the amount of organic matter in soils.

Commercial value of additional nutrients in improved soils. As SOM decomposes, nutrients are released and made available to plants. In some cases, these nutrients displace the need for additional fertilizer. In other cases, they supplement the nutrients farmers apply to their fields. A standard rule of thumb for temperate regions is that, at an average mineralization rate of 1.5 percent, each percent of organic matter contains up to 17 pounds of nitrogen and 1.75 pounds of phosphorus (NRCS 2023). These two nutrients are essential for sustained agricultural production; nitrogen is responsible for crop yields while phosphorous is required for plant maintenance. Given the SOM trajectories observed on the CCI demonstration plots described above, this translates to 10.2 pounds of nitrogen per acre and 1.05 pounds of phosphorus per acre after implementing the healthy soils practices for three years. In total, this translates to **over 370,000 pounds of additional plant-available nitrogen and nearly 39,000 pounds of phosphorus** across the 37,000 project acres implementing healthy soils practices.

To value these added soil nutrients, we use the commercial cost of nitrogen and phosphorus-based fertilizers paid by farmers from studies providing sample costs to produce various crops (UC Davis 2018-2021). On average, the analysis finds these nutrients costs California farmers about $5.30 per pound of nitrogen and $6.80 per pound of phosphorus.[22] Combined with the total area under these improved soil conditions, this analysis calculates the potential value of additional nutrients in soil to be about **$2.2 million** per year. Eighty-eight percent of the total average value is attributed to increases in soil nitrogen, and 12 percent is attributed to increased phosphorus in the soil. Increasing SOM levels also may increase the presence of other soil nutrients besides nitrogen and phosphorous, therefore this value likely represents an under-estimate of the total potential magnitude of additional soil nutrients benefits of these practices.[23]

Avoided water treatment and water use costs from reduced soil erosion. Increases in SOM are linked to decreased soil erosion, which leads to a reduction in the amount of sediment that could enter into waterways serving as drinking water sources. To the extent that these projects are located in areas that also serve as drinking water sources, people benefit from soil stabilization through reduced drinking water treatment costs. The universal soil loss equation (RUSLE) is used to predict soil losses given site-specific soil properties, management practices, and other influential environmental conditions like rainfall (Tisdale et al. 1985). The equation considers cropping and management conditions, although soil organic matter improvements do not enter directly into the model. Data used in the universal soil loss equation indicate that increasing SOM from 1 to 3 percent can reduce erosion 20 to 33 percent due to increased water infiltration and stable soil formation (Funderburg 2001). Using the increases in SOM found in the project demonstration plots, we scale the percent decrease in soil erosion by the mean increases in SOM observed in the plots, resulting in a 6 to 9.9 percent reduction in erosion. The soil loss in the Pacific region is estimated to be 1.8 tons per acre

[22] To calculate these costs per nutrient, we decomposed the total cost of the fertilizer into the component nutrients. For example, NPK 15-5-5 contains 15 percent nitrogen and 5 percent phosphorus. We then apply these percentages to the total cost of the fertilizer per pound to create an equivalent cost per pound of nitrogen and phosphorous. The reports reviewed for this report included 15 fertilizer types used on several crops (alfalfa, almond, avocado, blackberries, pistachios, etc.).

[23] These other essential nutrients include but are not limited to calcium, magnesium, and potassium (Cornell University Cooperative Extension 2008).

each year (NRCS 2007). Adjusting this baseline soil loss by a low end and high-end estimate of SOM increases from the demonstration plot data, we estimate a **total reduction in soil loss between 4,000 and 6,500 tons per year** across the 37,000 acres where on-farm conservation management practices were implemented.

Decreased soil erosion can benefit people in various ways. The USDA's Economic Research Service (ERS) developed a methodology to monetize the economic benefit of soil conservation benefits specifically associated with decreased soil erosion (Hansen and Ribaudo 2008a). Among other things, the methodology considers water quality improvements and subsequent impacts on industries, municipalities, and households.[24] Across California, the data reveals that the avoided municipal and industrial water treatment and water use to be $0.64 per ton of soil retained. Applying this valuation to the above estimated reduction in soil loss, this analysis suggests welfare gains associated with avoided water treatment and water use costs of these projects may be between **$2,500 and $4,200 annually** across the project acres. The ERS methodology considers other economic benefits associated with a reduction in soil erosion, including soil productivity. Therefore, the valuation included here likely represents an underestimate of the total ecosystem service benefits associated with reduced soil erosion.

Value of additional water storage in improved soils.
Higher levels of SOM allow soils to hold additional water. For each percent increase in SOM, Arkansas soil scientists report that soil can hold an additional 16,500 gallons of plant-available water per acre-foot of soil (Sullivan 2002; USDA n.d.; Scott et al. 1986). While not specific to conditions in California, we can apply this conversion factor to approximate the water storage benefits of added SOM. Applying the increased SOM from CCI demonstrate plots after three years, we find a potential annual increase in plant-available water from improved soil health of **360 million gallons, equivalent to 1,100-acre feet,** across the projects.[25]

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.[26] Shadow prices are willingness-to-pay (WTP) measures that generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market.[27] Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent water shortage for agricultural purposes ranges across regions in the state, varying from $79 per acre foot in the San Francisco Bay Area to $272 per acre foot in the South Coast (De Souza et al. 2011). By

[24] Avoided municipal water treatment costs are associated with consumer and producer surplus gains due to lower sediment removal cost for water treatment plans. Avoided municipal and industrial water use is associated with reduced damages from salts and minerals dissolved from sediment. See Hansen and Ribaudo (2008b) for details.

[25] Additionally, CCI projects located over aquifers have the potential to recharge groundwater aquifers. These potential benefit streams are not considered in this analysis and would represent an additional ecosystem service benefit stream.

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

[27] 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.

applying these regional estimates to the areas where projects in this category are located, we estimate a total WTP of approximately **$140,000** associated with additional water storage in soils from the implementation of on-farm conservation management practices.

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 the pressure on these non-renewable groundwater resources.[28]

Value of fish habitat improvements.
Aquatic species are sensitive to changes in soil conditions near waterways. Factors such as stream discharge, nutrient content, and sediments can affect the ecological conditions in fish habitat. Studies by Keitzer et al. (2016a, 2016b) model how greater erosion control and nutrient management on agricultural fields improve the Fish Index of Biotic Integrity (fish IBI), a measure of ecological conditions based on fish populations, in waterways near agricultural sites in the Lake Erie Basin. Under specific erosion control and nutrient management assumptions, they estimate that fish IBI can improve 6 percent relative to baseline conditions. While studies from California demonstrate that fish habitat and communities are sensitive to environmental conditions, including the influence of agriculture (e.g., Brown 2000), they do not offer specific information about how fish IBI improves under specific agricultural management regimes, including those promoted by CCI. For demonstration purposes, this analysis considers a range of possible increases in fish IBI based on one percent and 6 percent increase in fish IBI scenarios relative to pre-project levels.

Johnston et al. (2011) find that households in Rhode Island were willing to pay $1.50 per year for each percentage point increase in fish IBI. We assume that watersheds categorized as Hydrologic Unit Code (HUC) 12 abutting the project areas experience these improvements in fish IBI and that households within these affected watersheds value ecological improvements within nearby fish habitat (USGS n.d.; County of Los Angeles 2022).[29] Our GIS analysis overlaying Census metrics atop a spatial layer of HUC-12 watersheds identifies 1.2 million households within 207 watersheds containing projects, equivalent to about 9 percent of all households in the state. Applying the valuation from Johnston et al. (2011) to each of the households in the watersheds abutting project areas for both fish IBI increase scenarios, we estimate a total potential benefit ranging from **$1.7 million to $10 million** per year.

Value of increased agricultural production from pollinator services.
Some of the CCI projects in this category increase pollinator habitat near or on cropland, which has the potential to improve yields of crops dependent on pollinator services.[30]

[28] 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.

[29] HUC-12 represents a local sub-watershed level that captures tributary systems. There are approximately 90,000 HUC-12 watersheds nationwide (EPA n.d.), and 4,500 in California specifically (California Nature 2021).

[30] Specific program activities that increase pollinator habitat include but are not limited to planting hedgerows, riparian buffers, trees, cover crops, and field borders.

Following the methodology in a study by Walston et al. (2018), we assume that highly pollinator-dependent crops within 1.5 kilometers (km) of added pollinator habitat may experience a one percent increase in crop yields.[31] Pollinator-dependent crops found near the 5,700 acres of pollinator habitat added by CCI projects include almonds; fruits such as apples, nectarines, berries, and melons; and vegetables including cucumbers, squash, and pumpkins (USDA NASS CropScape; California DWR Statewide Crop Mapping).[32] GIS analysis reveals that over 45,000 acres of highly dependent pollinator crops are within 1.5km of pollinator habitat added through these projects across 27 counties, and that the majority of these acres are cultivated with almonds (87 percent), plums (5 percent), and cherries (3 percent). Counties with the greatest acreage of pollinator-dependent almond crops within the buffer include Merced, Fresno, and Yolo counties.

We determine baseline productivity using average crop yields per acre for each crop across California (USDA 2023). The one percent increase in productivity is applied to these baseline acres by county to estimate the increase in crop output of approximately 827,000 kilograms of pollinator dependent crops. To value this increase in production, we apply California-specific commercial sales price per kg for each type of crop (USDA 2023; CDFA 2021). Combined the total commercial value of the increased production of pollinator-dependent crops from increased pollinator habitat may be approximately **$2 million**.

Improved regional food security.
Implementing conservation management practices that improve agricultural productivity also supports California's regional food security. By increasing agricultural production, these projects may reduce California's vulnerability to agricultural supply shocks and the need to source food from elsewhere. Research also indicates that a reduction in pollinator habitat and populations may create challenges for global food security (e.g., Bauer and Wing 2010). These projects generate pollinator habitat that may help to counteract observed global declines in pollinators and food security linked with their services.

Services associated with habitat for other species.
Employing nature-friendly field conservation management practices by installing vegetative buffers around fields can result in the added benefit of increasing the presence of birds and other species. Since vegetative buffers can serve as bird habitat, planting them can increase local bird populations. For example, one project documented that bird sightings increased by 27 percent between 2019 and 2020 after planting one mile of riparian restoration (CDFA 2021). Birds offer several ecosystem service benefits, including pest control, pollination, and waste disposal, among others (Şekercioğlu 2017).

[31] We use a conservative estimate of crop yield increases from pollinator services from the literature in order to account for uncertainty. Other studies, such as Blaauw and Isaacs (2014), estimate increases in crop yield from pollinator services of up to 30 percent after ten years.

[32] To determine which crops are pollinator-dependent, we rely on the characterization in Walston et al. (2018). In the supplemental materials, the authors provide pollinator dependence categories by crops produced across the United States. Consistent with their methods, we include all crops ranked 3 and 4, the highest two categories, in this analysis. The ranking in Walston et al. relied on information from Aizen et al. (2009) and Calderone (2012).

Table 4: Summary of Monetized Ecosystem Service Benefits for the On-Farm Conservation Management Projects by County (2021 dollars)

County	Total Acres with Improved Soil Practices[a]	Total Acres of New Pollinator Habitat[a]	Value of Nutrient Supply (Annual)[b]	WTP for Avoided Water Treatment Costs (Annual)[b,c]	Value of Water Supply (Annual)[b]	WTP for Improved Fish Habitat (Annual)[b,c]	Value of Increased Agricultural Production (Annual)[b]
Alameda	1,100	--	$70,000	<$100 - $130	$2,700	$150 - $880	--
Amador	240	61	$15,000	<$100	$1,100	$450 - $2,700	$4,100
Butte	3,000	140	$180,000	$200 - $340	$9,000	$130,000 - $770,000	$190,000
Colusa	1,800	180	$110,000	$120 - $200	$5,300	$11,000 - $64,000	$77,000
Contra Costa	170	--	$10,000	<$100	$400	$9,000 - $54,000	--
Del Norte	130	--	$7,900	<$100	$640	$3,700 - $22,000	--
El Dorado	51	45	$3,100	<$100	$160	$16,000 - $96,000	$880
Fresno	1,400	530	$86,000	<$100 - $160	$6,300	$210,000 - $1,200,000	$430,000
Glenn	610	260	$37,000	<$100	$1,900	$3,100 - $19,000	$22,000
Humboldt	280	71	$17,000	<$100	$1,400	$8,700 - $52,000	--
Imperial	1,100	--	$66,000	<$100 - $120	$5,200	$52,000 - $310,000	--
Kern	1,300	480	$77,000	<$100 - $140	$5,700	$170,000 - $1,000,000	$34,000
Kings	810	410	$49,000	<$100	$3,600	$13,000 - $81,000	$46,000
Lake	8	--	$490	<$100	<$100	$360 - $2,200	--
Madera	410	210	$25,000	<$100	$1,900	$21,000 - $130,000	$160,000
Marin	530	210	$32,000	<$100	$1,300	$4,100 - $25,000	$330
Mariposa	--	--	--	--	--	$810 - $4,900	--
Mendocino	180	110	$11,000	<$100	$870	$4,500 - $27,000	<$100
Merced	1,400	470	$84,000	<$100 - $160	$6,200	$69,000 - $420,000	$450,000
Modoc	440	30	$27,000	<$100	$1,300	$160 - $940	--
Monterey	20	11	$1,200	<$100	$130	$33,000 - $200,000	$540
Napa	40	26	$2,400	<$100	<$100	$33,000 - $200,000	$570
Nevada	17	14	$1,000	<$100	<$100	$990 - $5,900	--
Orange	1	1	<$100	--	<$100	$71,000 - $420,000	--
Placer	--	--	--	--	--	$28,000 - $170,000	--
Riverside	25	9	$1,500	<$100	$120	$14,000 - $81,000	--

County	Total Acres with Improved Soil Practices[a]	Total Acres of New Pollinator Habitat[a]	Value of Nutrient Supply (Annual)[b]	WTP for Avoided Water Treatment Costs (Annual)[b,c]	Value of Water Supply (Annual)[b]	WTP for Improved Fish Habitat (Annual)[b,c]	Value of Increased Agricultural Production (Annual)[b]
Sacramento	110	40	$6,800	<$100	$340	$42,000 - $250,000	$18,000
San Benito	230	--	$14,000	<$100	$1,500	$11,000 - $65,000	--
San Diego	910	3	$56,000	<$100	$7,500	$35,000 - $210,000	--
San Joaquin	160	97	$10,000	<$100	$500	$63,000 - $380,000	$98,000
San Luis Obispo	1,100	60	$66,000	<$100 - $120	$6,900	$62,000 - $370,000	$760
Santa Barbara	150	53	$9,100	<$100	$950	$76,000 - $450,000	$1,900
Santa Clara	200	--	$12,000	<$100	$480	$72,000 - $430,000	--
Santa Cruz	32	2	$2,000	<$100	$200	$11,000 - $67,000	$18,000
Shasta	600	--	$37,000	<$100	$1,800	$140 - $830	--
Solano	1,300	280	$81,000	<$100 - $150	$4,100	$53,000 - $320,000	$43,000
Sonoma	520	230	$31,000	<$100	$1,200	$140,000 - $810,000	$1,200
Stanislaus	380	130	$23,000	<$100	$1,700	$58,000 - $350,000	$130,000
Sutter	6,900	63	$420,000	$470 - $780	$21,000	$17,000 - $100,000	$44,000
Tehama	750	74	$46,000	<$100	$2,300	$6,400 - $38,000	$13,000
Tulare	2,400	600	$150,000	$170 - $270	$11,000	$52,000 - $310,000	$160,000
Ventura	85	7	$5,200	<$100	$700	$35,000 - $210,000	<$100
Yolo	2,600	830	$160,000	$180 - $300	$7,900	$80,000 - $480,000	$220,000
Yuba	3,400	--	$200,000	$230 - $380	$10,000	$10,000 - $63,000	--
Statewide Total	**37,000**	**5,700**	**$140,000,000**	**$2,500 - $4,200**	**$140,000**	**$1,700,000 - $10,000,000**	**$2,200,000**

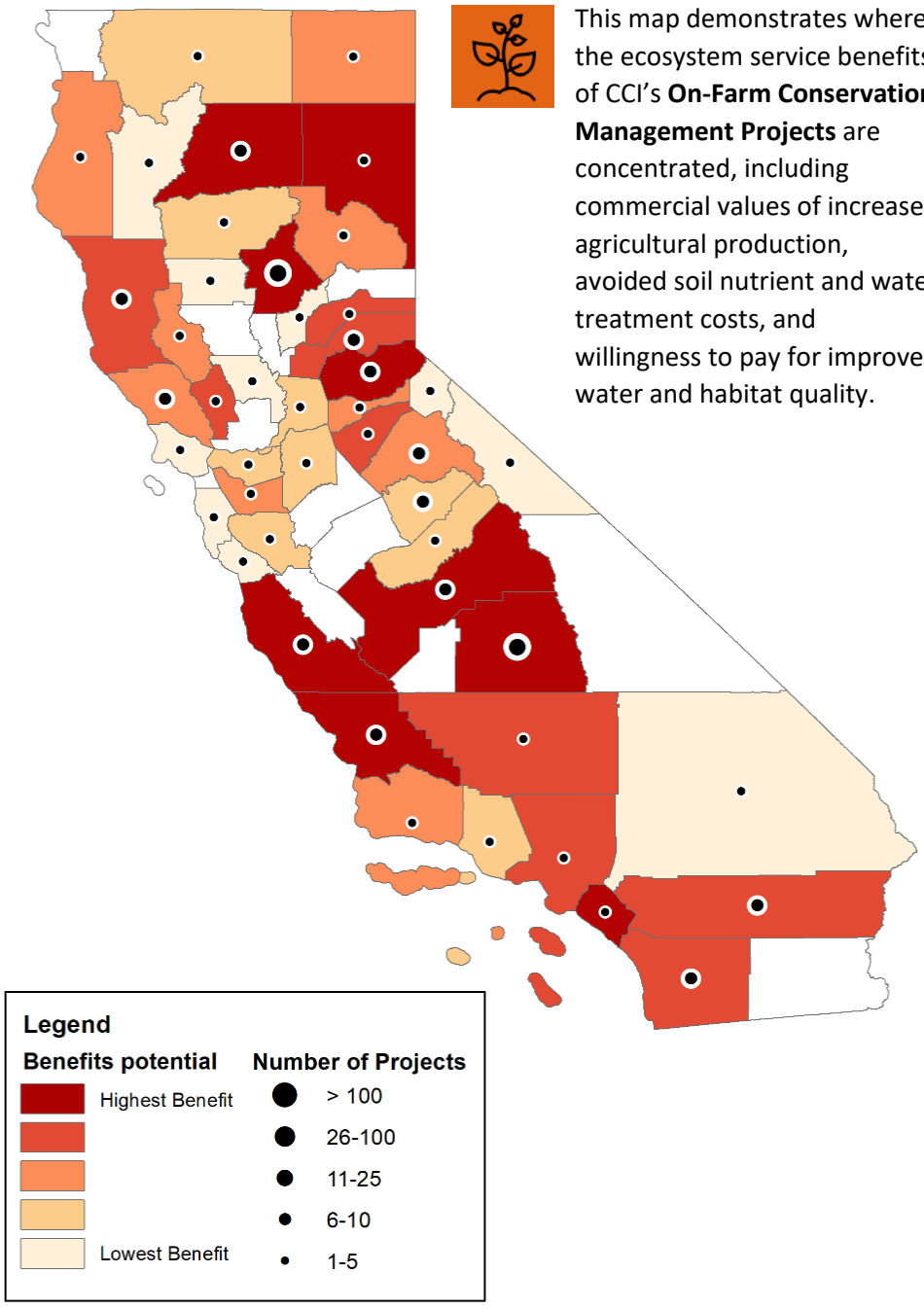
Sources and notes:

a. Data observed in CARB (2021) considering projects implemented from 2018 to 2020.

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.

c. When "<$100" is used to express the low-end of a range, the expected value of the metric is between a value less than $100 and the high-end value. When "<$100" is used to express the entirety of a range, both the low-end and high-end values of the metric are less than $100.

Figure 4: Spatial Distribution of Ecosystem Service Benefits Potential for the On-Farm Conservation Management Projects



Note: The benefit potential conveyed in this map considers all five monetized values presented in Table 4. For the two categories expressed as a range, the high-end value is included.

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AGRICULTURE

Increasing Efficiency of Agricultural Irrigation

Ecosystem Service Benefits

- Improved efficiency in water use results in reduced need for water supply maintenance and avoided property damage through reduced subsidence.
- The potential magnitude of benefits resulting from reduced water supply maintenance needs is on the order of $15 million per year.
- Replacing pumps with more energy efficient options also increases local air quality and improves human health.

OVERVIEW OF PROJECTS

Project activities

Implement more efficient strategies to reduce on-farm water and energy use

Implementing agency

California Department of Food and Agriculture

598 projects

across 33 counties (2015-2018)

36 billion

gallons of water saved annually

The California Department of Food and Agriculture (CDFA)'s State Water Efficiency and Enhancement Program (SWEEP) aims to boost energy and water efficiency practices on farms, mostly in the form of upgrading agricultural irrigation systems. Examples of irrigation system upgrades supported by CCI include soil moisture monitoring, drip systems, low pressure irrigation systems, pump retrofits, variable frequency drives and installation of renewable energy to reduce on-farm water use and energy. Between 2015 and 2018, CDFA implemented a total of 598 SWEEP projects across 33 counties (CARB 2021). The four counties with more than 50 projects each are Butte, Fresno, San Luis Obispo, and Tulare.

While the energy and greenhouse gas emissions benefits of these projects are considerable, they are outside the scope of this analysis. This analysis focuses on the ecosystem services specifically associated with improved water efficiency. Appendix page A-4 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Improved efficiency in water use is valued both by the agricultural industry and the general public. Improved irrigation efficiency is also linked to avoided property damage, as excessive groundwater pumping can lead to costly land subsidence. Human health benefits can also be expected for the subset of projects that involve retrofitting electric pumps that result in local air quality improvements.

Avoided water supply maintenance.
Increased efficiency of irrigation systems leads to a reduction in water needs. These projects report nearly 36 billion gallons of water saved each year, equivalent to about 110,000 acre-feet.[33,34,35]

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.[36] Shadow prices are willingness-to-pay (WTP) measures that generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market.[37] Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent water shortage for agricultural purposes ranges across regions in the state, varying from $79 per acre foot in the San Francisco Bay Area to $272 per acre foot in the South Coast (De Souza et al. 2011). This analysis finds that the potential water savings associated with improved irrigation practices are valued at approximately **$15 million per year.**

[33] '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)

[34] The project implementers report total water gallons saved throughout the life of the project. Most projects are associated with 10-year life spans, although a subset last 15as long as 100 years. To calculate an annual water savings quantity, we divide the total water savings reported by the project lifetime.

[35] While large in magnitude, 110,000 million acre-feet is equivalent to about 0.3 percent of all water used for agricultural purposes in California annually (CARB 2022).

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

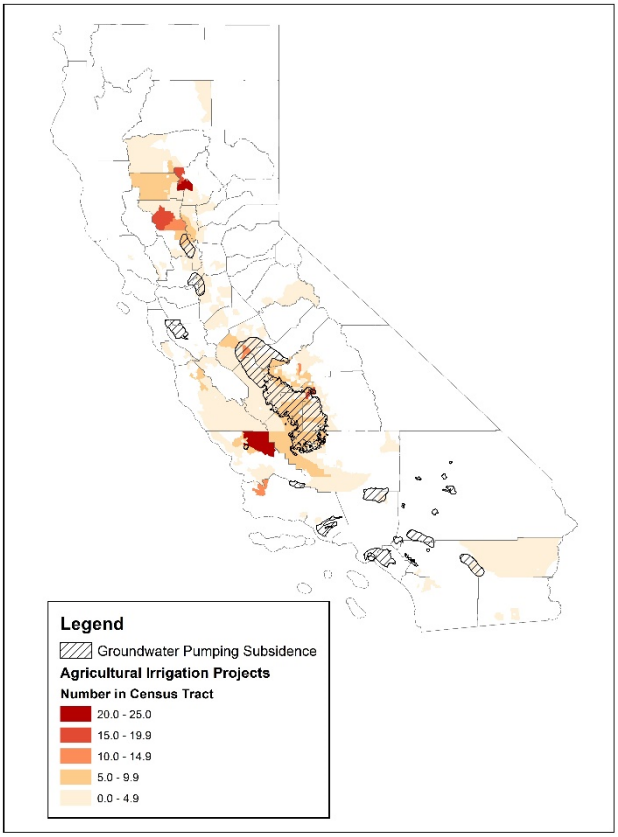
[37] From an economic perspective, WTP is a conceptually appropriate measure of value of a resource or service. WTP is the maximum amount of money an individual would voluntarily exchange to obtain a resource or environmental improvement, given budget constraints. In other words, WTP indicates the point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

Water 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 the pressure on these non-renewable groundwater resources.[38]

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 in California 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). Of the 598 SWEEP projects, 128 overlap an area of land subsidence caused by groundwater pumping (USGS n.d.). This analysis cannot quantify this benefit because there is limited information on the role these projects play in mitigating subsidence.

Figure 5: CCI Project and Subsidence Locations



Improved human health from localized air quality improvements.

The pumps used for irrigation can degrade air quality through the release of pollutants such as oxides of nitrogen and volatile organic compounds resulting in the formation ground level ozone (Lu et al. 2016) as well as particulate matter and an array of other pollutants. Retrofitting the pumps used for irrigation purposes has the potential to improve localized air quality by reducing these emissions. This is especially true for projects that reduce diesel fuel combustion. Improved air quality can also benefit human health. SWEEP projects do not monitor local air quality conditions associated

[38] 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.

with pump upgrades and therefore we are unable to monetize the reduction in health impacts associated with improvements in local air quality at these project sites.

Table 5: Summary of Monetized Ecosystem Service Benefits for the Increasing Efficiency of Agricultural Irrigation Projects by County (2021 dollars)

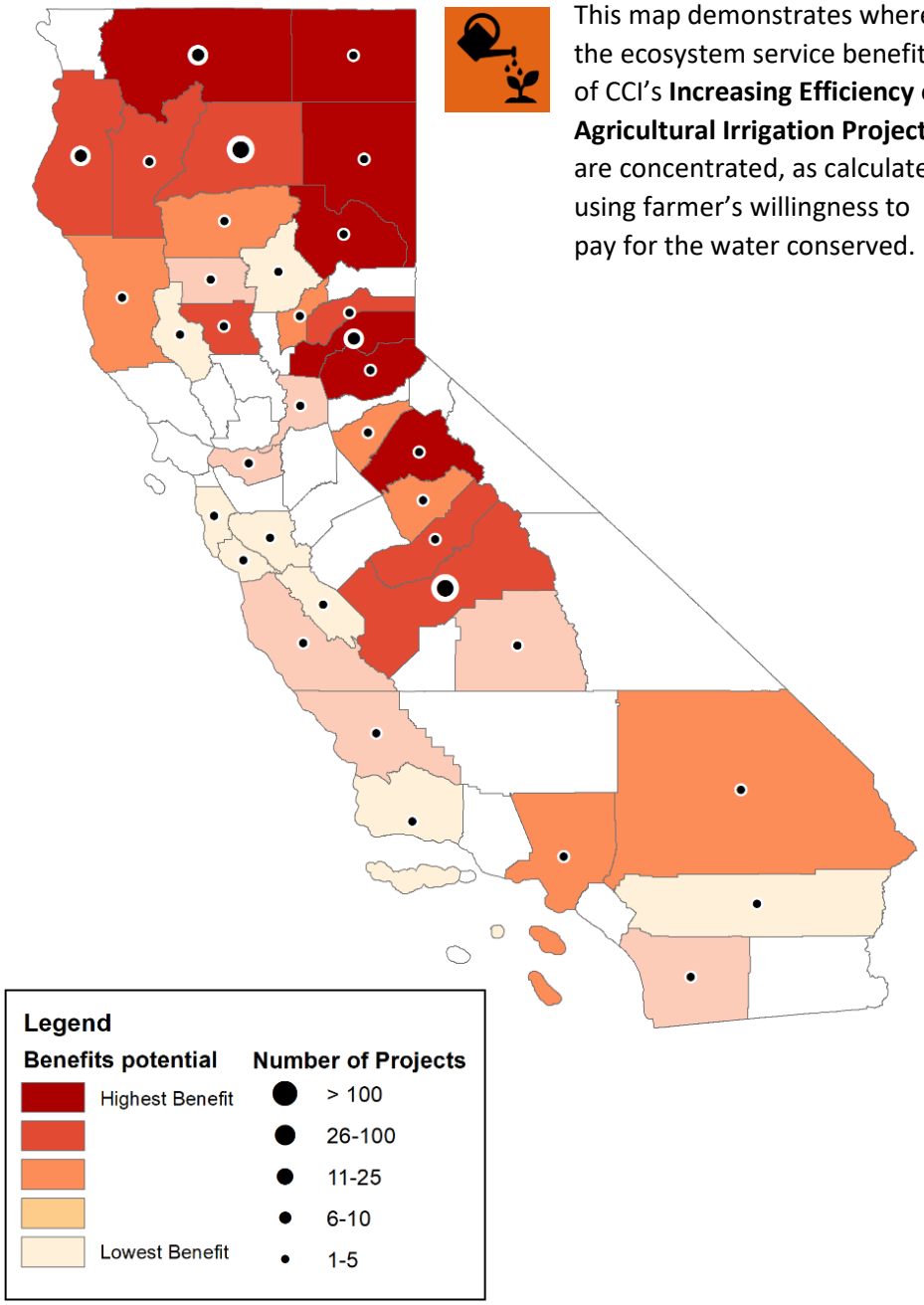
County	Acre-Feet of Water Saved (Annual)[a]	WTP for Water Saved (Annual)[b]
Butte	1,800	$180,000
Colusa	6,200	$620,000
Contra Costa	<1	<$100
Fresno	28,000	$4,100,000
Glenn	1,400	$140,000
Imperial	110	$18,000
Kern	12,000	$1,700,000
Kings	13,000	$1,900,000
Los Angeles	<1	<$100
Madera	1,200	$180,000
Merced	6,800	$1,000,000
Monterey	1,200	$250,000
Napa	41	$3,200
Riverside	430	$67,000
Sacramento	490	$49,000
San Benito	61	$13,000
San Diego	220	$59,000
San Joaquin	7,400	$740,000
San Luis Obispo	970	$200,000
Santa Barbara	660	$140,000
Santa Clara	530	$42,000
Santa Cruz	69	$14,000
Shasta	45	$4,600
Solano	280	$28,000
Sonoma	1	<$100
Stanislaus	350	$51,000
Sutter	3,500	$350,000
Tehama	250	$25,000
Tulare	21,000	$3,100,000
Tuolumne	4	$600
Ventura	19	$5,100
Yolo	1,600	$160,000
Yuba	470	$47,000
Statewide Total	**110,000**	**$15,000,000**

Sources and notes:

a. Data observed in CARB (2021). The annual average considers projects implemented from 2015 to 2018.

b. Author calculations described in this report.

Figure 6: Spatial Distribution of Ecosystem Service Benefits Potential for the Increasing Efficiency of Agricultural Irrigation Projects



Note: The benefit potential conveyed in this map considers farmers' WTP for the water saved presented in Table 5.

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AGRICULTURE

Alternative Manure Management

Ecosystem Service Benefits

- Sustainable manure management and compost production is associated with benefits related to soil health, odor reduction, and improved human health.
- Consumers are willing to pay a premium for milk produced in more environmentally sustainable conditions. The public may value the environmental attributes of the milk produced by dairy cows as a result of these projects on the order of $467 million per year.
- Property values could increase by $880,000 on an annualized basis near project sites due to reduced odor.
- The market value of compost produced in 2020 was $430,000. The application of composted manure to fields is estimated to result in benefits of up to $19 million in safer drinking water per year and $3,000 in plant-available water storage.

OVERVIEW OF PROJECTS

Project activities
Implement projects using anaerobic digestion and other methods for more sustainable manure management

Implementing agency
California Department of Food and Agriculture

210 projects
funded across 14 counties (2015-2020)

430,000 dairy cows
with manure managed more sustainably

36,000 yards^3 compost
produced annually

Between 2015 and 2020, the California Department of Food and Agriculture (CDFA) funded 104 projects as part of its Alternative Manure Management Program (AMMP) and 106 projects as part of its Dairy Digester Research and Development Program (DDRDP), which both implement activities related to the handling and storing manure with and without the use of an anaerobic digester.[39] The projects in this category are found across 14 counties (CARB 2021), with the highest concentration in Tulare County. Methods of manure management include pasture-based management, compost bedded pack barns, solid separation, conversion of flush to scrape manure collection systems, and the use of anaerobic digesters. All projects in this category require methods other than manure storage in open and uncovered lagoons. As part of their monitoring efforts, the projects additionally measure the amount of compost produced (if applicable), which can either be used on the farm or sold for use elsewhere.

Improved manure handling leads to ecological changes such as improvements in water quality from reduced nutrient loss. Other environmental benefits of improved manure management include reduced odor and improved local air quality. Appendix page A-5 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Improved manure management strategies are linked to ecosystem service benefits in this analysis using valuations of compost production, improved human health from higher quality drinking water, and increased property values from odor reductions. These values are calculated using data from the CDFA's AMMP and DDRDP Benefits Calculator Tools and are based on methods and assumptions found in the relevant literature.[40] We also qualitatively characterize the pathways to improved human health from local air quality improvements and reduced pathogens as well as the positive preference people have for improved water quality.

Willingness to pay (WTP) to for milk produced with higher environmental standards.[41] Research demonstrates that people are willing to pay a higher price for agricultural products produced with greater consideration of environmental sustainability. For instance, one study finds that consumers in California are willing to pay a $0.40 per pound premium for food produced at a higher environmental standard of sustainability, defined as products which result in lower greenhouse gas emissions (Campbell 2021). For demonstration purposes, we apply this WTP for milk produced at CCI project sites.[42]

[39] For simplicity, we refer to this broader project category as "Alternative Manure Management," which includes both the AMMP and DDRDP projects. In this category, we explore the combined benefits of AMMP and DDRDP projects, both of which focus on sustainable agricultural manure management practices. DDRDP has additional co-benefits related to renewable energy generation via anaerobic digestion, but these benefits are captured as part of the GHG methodology. Instead, we evaluate the ecosystem service benefits related to improved manure handling specifically across the AMMP and DDRDP projects.

[40] The CCI Benefits Calculators were constructed primarily to estimate the GHG emission reduction and select co-benefits for reporting to CARB. All benefits calculators can be found online at: https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials. This analysis incorporates data from completed calculator tools provided by CDFA (CDFA 2021).

[41] 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.

[42] For context, related research demonstrates that consumers are willing to pay for milk produced under higher animal welfare standards (Wolf and Tonsor 2017). Wolf and Tonsor find that households are willing to pay greater than $0.40 per gallon of milk for *each* welfare attribute described in their survey, suggesting that applying the WTP value from Campbell (2021) to milk produced at CCI project sites is unlikely to be an over-estimate.

The CCI projects in this category are home to approximately 430,000 dairy cows as of 2020 (CDFA 2021), and research demonstrates that dairy cows produce a national average of 2,700 gallons of milk per year (NASS 2020).[43] Combined the dairy cows at these project sites produce about **1.2 billion gallons** of milk per year.[44] If we assume consumers are willing to pay an additional $0.40 per pound for this milk, then this analysis finds that California consumers may value the various environmental benefits of improved manure management practices on the order of **$470 million per year**.

Increased property values from odor reduction.
Odor from livestock facilities has been shown to negatively affect property values (Ready and Abdalla 2003). Anaerobic digestion, one of the practices promoted by these projects, reduces the odor from waste by processing its biodegradable parts. For example, Wilkie et al. (2005) show that flushed dairy manure after anaerobic digestion decreases odor by 97 percent relative to flushed dairy manure that does not undergo anaerobic treatment. Although the available literature does not describe the WTP for odor reduction specifically, we draw upon studies linking changes in property value to proximity to livestock facilities with high odor in order to estimate the potential magnitude of property value increases from odor reduction in project areas. Ready and Abdalla (2003) find that being located near animal production facilities in Berks County, Pennsylvania leads to a 6.4 percent decrease in housing price for houses within 500 meters of facilities; a 4.1 percent decrease in property value for houses within 800 meters of facilities; and a 1.6 percent decrease in value for houses within 1,200 meters of facilities.

To apply these findings to this analysis, we first count the number of unique land parcels within each buffer from AMMP and DDRDP project sites (County of Los Angeles 2022). Across the 14 counties with projects, 684 parcels were counted within 500 meters; 470 within 800 meters; and 2,404 within 1,200 meters. We determine baseline property values by county using data from the U.S. Census Bureau (2021), then apply the change in property values from Ready and Abdalla (2003), but in the opposite direction: we assume property value increases when odor is reduced. Combined, the potential property value increase from odor reduction across buffer sizes may be $29 million in present value terms, equivalent to **$880,000 on an annualized basis** (with a 3 percent discount rate). Forty-three percent of the estimated property value increase is attributed to the properties within closest range of the project areas, followed by properties within a 1,200-meter buffer. Because this analysis considers a broader geographic coverage than just the project sites, select properties in Del Norte and Sacramento counties also experience this benefit.

Commercial market value of compost.
For some projects, changes in manure management practices result in production of composted manure for use as a soil amendment on agricultural fields.[45] Compost production data was documented for both AMMP and DDRDP in 2020 only. We assume 2020 is representative of typical compost production at these sites, although it is possible that compost application will increase

[43] NASS (2020) also demonstrates that dairy cows in California typically have higher efficiency than the national average.

[44] There are 1.72 million milk cows in California, therefore the dairy cows at CCI project sites represent about 25 percent of the state total (USDA NASS 2011). Similarly, California produced about 4.9 billion gallons of milk in 2021, meaning milk produced at CCI project sites could represent about 24 percent of all milk produced in the state (Statista 2022).

[45] CDFA reports that some project sites may use composted and dried manure as animal bedding as well. We do not separately value the use of composted manure as animal bedding.

among these project locations in the future. In 2020, 36,000 cubic yards of compost were produced from manure at project sites in five counties (CDFA 2021).[46] Composted manure can be used on nearby agricultural fields and potentially displace the need for other nutrients. Farmers with excess nutrients may choose to sell the compost to other farmers, representing an additional income stream. Applying a statewide estimated market price of $12 per cubic yard of compost produced (CalRecycle 2019), we value the total amount of compost produced at approximately **$430,000 per year**. Most the compost produced (70 percent) —worth $300,000—was in project areas in Stanislaus and Merced counties.

WTP for avoided nitrates in water.
Animal manure from agricultural operations is a primary source of nitrates in ground and surface water (EPA 2023).[47] Applying composted manure to fields instead of raw manure results in lower levels of nitrogen runoff that could enter nearby waterways and drinking water systems (Sustainable Conservation 2017). For instance, one study found that 9 percent of nitrogen is lost from applying uncomposted manure, while only 4 percent is lost from composted manure (Rodale Institute 2004). Similarly, upgrading the lagoons that capture and store animal manure (e.g., with liners or improved lagoon covers) has the potential to reduce nitrates in drinking water by keeping it on site. Available research is insufficient to value the human health benefits associated with this specific reduction in nitrogen runoff. Instead, we consider evidence showing that households in areas of Indiana, Nebraska, and Washington are willing to pay between $840 and $1,100 per year to avoid nitrates in their drinking water above EPA safe minimum levels (Crutchfield et al. 1997).[48]

[46] CDFA notes this is likely an under-estimate of the total composted manure produced by the projects.

[47] EPA (2023) estimates that California agriculture contributes nearly 3,200 kgs of nitrogen from animal manure per square kilometer.

[48] EPA's maximum contaminant level (MCL) for nitrate set to protect against blue-baby syndrome is 10 mg/L.

Most agricultural areas in California are surrounded by groundwater wells that support drinking water.[49] Wells sampled in only two of the 14 counties with AMMP and DDRDP projects—Kern and Tulare—recently have been observed to contain nitrogen levels above EPA safe standards (State Water Resources Control Board 2017).[50] Therefore, households in these two counties are the most likely to benefit from any potential reduction in nitrates in drinking water due to project activities. These two counties also contain many projects in this category: 53 projects in Tulare and 17 projects in Kern. The CCI projects in these two counties may reduce nitrate levels, contributing to the ability of the water sources to meet EPA safe standards. Crutchfield et al. (1997) find that the value meeting these standards to the 17,000 households in Census tracts containing AMMP and DDRDP project sites in Kern and Tulare counties may be on the order of $14 million to $19 million per year.[51] This value represents the benefits to the residents of achieving safe standards as opposed to the specific benefits of the CCI projects; however, the CCI project improve the likelihood of the water quality improvements.

Positive preference for improved ambient and surface water quality. Improvements in manure management are also associated with improvements in surface and ambient water conditions (Aillery et al. 2005). Reducing nitrate runoff through these practices has the potential to improve water and habitat quality for aquatic species. Several studies demonstrate people have a WTP to improve ambient and surface water quality (e.g., Von Houtven et al. 2007) given the many ecosystem services clean surface water provides: improved water-based recreation opportunities (like boating, swimming, and fishing), increased populations of fish targeted for recreational and commercial fishing, and better aesthetics. Larson et al. (2001) provides estimates specific to households in California and found that the average household in their survey sample was willing to pay about $15 per month (1997 dollars) for a program that would raise water quality in water bodies throughout the state to levels that would be in compliance with clean water laws. Improvements in water quality resulting from these CCI projects are likely to be more modest, however data are not available to quantify or model these changes.

Value of additional water storage in soils treated with composted manure. Some of the project sites use the composted manure on their fields, either fields that support fodder for livestock or crop agriculture. Compost application improves soil health through increased soil organic matter (SOM). As described elsewhere for CCI projects that implement on-farm field conservation management practices, higher levels of SOM enable soils to retain more water. The literature describes that for each percent increase in SOM, soils hold an additional 16,500 gallons of plant-available water per acre-foot of soil (Sullivan 2002; USDA n.d.; Scott et al. 1986). Assuming the SOM levels of these fields respond similarly to the fields as part of the On-Farm Conservation Management Practices projects, which includes fields treated with compost, data from those projects shows average increases in SOM of 0.15 percent after one year, 0.20 percent after two years, and 0.60 percent after three years. In 2020, the only year with compost application data available for both AMMP and DDRDP, compost was applied to a total of 571 acres in five counties across 15 projects (7 percent of total) (CDFA 2021). Applying the increase in water retention among fields with higher SOM, this analysis

[49] See for example: https://www.waterboards.ca.gov/gama/well_location_information.html.

[50] It is possible that more recent data would reveal other counties with high nitrate levels. The 2017 report was the most recently available for use in this assessment.

[51] These household represent one percent of total households in Kern County and 9 percent of all households in Tulare County (U.S. Census data).

finds that compost application at these project sites retains approximately 5.6 million gallons of water in the soil after three years of application.

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.[52] Shadow prices are WTP measures that generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market. Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent water shortage for agricultural purposes ranges across regions in the state, varying from $79 per acre foot in the San Francisco Bay Area to $272 per acre foot in the South Coast (De Souza et al. 2011). Applying this valuation to the water savings from improved soil management, this analysis finds a potential total benefit of **$2,600** associated with increased water storage in soils with compost application. As additional project sites apply composted manure to their fields, the magnitude of this benefit is likely to increase.

Improved human health.
Livestock waste may contain pathogens harmful to human health, including *Salmonella spp.*, *E.coli*, *Campylobacter spp.*, and *Cryptosporidium spp.* (Bicudo and Goyal 2003). Studies demonstrate that anaerobic digester systems substantially reduce E. coli levels (Wang and Pandey 2017) and other pathogens (Wilkie et al. 2005) on farm. These reductions may also reduce the likelihood of illness resulting from these pathogens, through exposures of farm staff, downstream consumers of food products that may come into contact with the manure, or via waterways connected to project sites. USDA's Economic Research Service modeled the cost of foodborne illness associated with these and other pathogens, finding that the average economic burden per case is on the order of thousands of dollars.[53]

Human health is also affected by manure's role in degrading localized air quality. When manure is stored, microorganisms decompose organic matter and release pollutants into the air, including volatile organic compounds, ammonia, hydrogen sulfide, and particulate matter (Zhang 2011). These pollutants can cause a range of health effects, including skin and eye irritations, headaches, and nausea. Alternative manure management approaches incentivized by CCI have the potential to reduce these impacts. Workers that interact directly with the pollutants are likely to benefit most, although nearby communities may also experience health improvements. Data are not available to quantify the reduction in health impacts associated with changes at these project sites.

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

[53] The full set of USDA ERS's cost estimates for these and other foodborne illnesses is available at: https://www.ers.usda.gov/data-products/cost-estimates-of-foodborne-illnesses.aspx

Table 6: Summary of Monetized Ecosystem Service Benefits for the Alternative Manure Management Projects by County (2021 dollars)

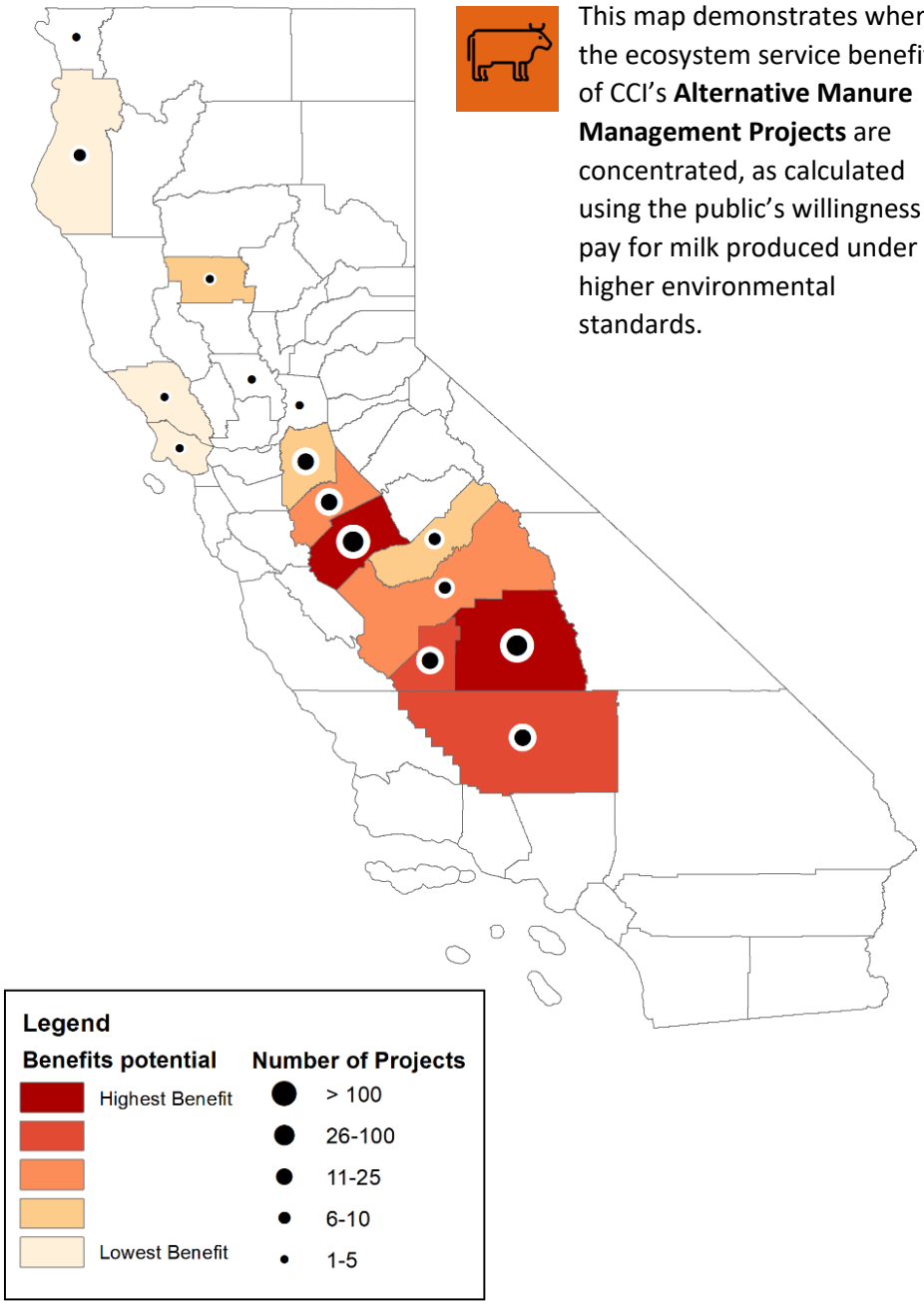
County	Total Dairy Cows[a]	Cubic Yards of Compost Produced (Annual)[a]	Acres with Compost Application (Annual)[a]	WTP for Milk Produced with Environmental Standards (Annual)[b]	Increased Property Values from Odor Reduction (Annualized)[b]	Commercial Market Value of Compost (Annual)[b]	Value of Additional Water Storage (Annual)[b]
Del Norte	--	--	--	--	$1,200	--	--
Fresno	32,000	--	--	$35,000,000	$65,000	--	--
Glenn	600	--	--	$650,000	$4,900	--	--
Humboldt	550	--	--	$600,000	$25,000	--	--
Kern	67,000	4,600	56	$73,000,000	$8,200	$55,000	$250
Kings	49,000	--	--	$53,000,000	$33,000	--	--
Madera	4,300	2,200	54	$4,600,000	$13,000	$27,000	$240
Marin	450	--	--	$490,000	$6,600	--	--
Merced	80,000	5,100	95	$87,000,000	$260,000	$62,000	$430
Sacramento	--	--	--	--	$5,400	--	--
San Joaquin	7,100	--	--	$7,700,000	$120,000	--	--
Sonoma	440	--	--	$480,000	$42,000	--	--
Stanislaus	14,000	3,700	89	$30,000,000	$170,000	$44,000	$1,300
Tulare	160,000	4,100	78	$170,000,000	$130,000	$49,000	$350
Statewide Total	**430,000**	**36,000**	**571**	**$470,000,000**	**$880,000**	**$430,000**	**$2,600**

Sources and notes:

a. Data observed in CDFA (2021). The total dairy cows column considers all projects implemented from 2015 to 2020. The annual compost production and application figures are derived from 2020 data only.

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 7: Spatial Distribution of Ecosystem Service Benefits Potential for the Alternative Manure Management Projects



Note: The benefit potential conveyed in this map considers the WTP for milk produced under higher environmental standards presented in Table 6.

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WETLANDS
Wetland Restoration and Maintenance

Ecosystem Service Benefits

- Freshwater (inland) wetlands provide numerous ecosystem services. The public may be willing to pay on the order of $32 million per year for the 6,000 acres of inland wetlands treated, restored, or conserved by CCI projects.
- One specific service associated with restored inland wetlands is increased water storage, with a potential value of approximately $190,000 per year.
- Coastal wetlands also provide numerous ecosystem services that people value. The economics literature suggests that proximity to restored coastal wetlands may increase property values on the order of $12 million when annualized.
- The wetland restoration and maintenance projects may also offer flood and storm protection benefits to nearby households. Finally, eight of the wetland restoration and maintenance projects may also benefit endangered species.

OVERVIEW OF PROJECTS

Project activities
Construct, enhance, restore, and monitor wetland, salt marsh, riparian, meadow, and/or dune habitat

Implementing agencies
Department of Fish and Wildlife, Wildlife Conservation Board, and State Coastal Conservancy

25 projects
funded across 21 counties (2015-2020)

2,000 acres
of coastal wetlands treated

6,000 acres
of inland wetlands and mountain meadows treated

Between 2015 and 2020, CCI invested in 25 wetland restoration and conservation projects: 22 through the Department of Fish and Wildlife, two through the Wildlife Conservation Board, and one through the State Coastal Conservancy (CARB 2021). The primary activities of these projects are constructing, enhancing, restoring, and monitoring of wetland, salt marsh, riparian, meadow, and/or dune habitat. Some projects replaced non-native species with native vegetation, made river channel and road drainage improvements, or employed "pond and plug" techniques (i.e., excavating the floodplain and plugging channels with excavated material to form ponds). During this six-year period, CCI treated, conserved, or restored 2,000 acres of coastal and delta wetlands as well as 6,000 acres of inland wetlands and mountain meadows across 21 counties throughout California (CARB 2021). The county with the most restored inland wetland acres is Plumas while Contra Costa, Solano, and Humboldt counties each have more than 600 acres of restored coastal wetland acres.

This analysis provides information on the types and the magnitude of societal benefits potentially associated with restoring and maintaining wetlands. Appendix page A-5 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. These activities can improve water quality, increase water storage availability, provide flood attenuation and storm protection benefits, offer recreational opportunities, and improve habitat for vulnerable species (EPA 2022). To demonstrate how people value these services, the analysis includes information on three different quantitative measures: 1) public willingness to pay (WTP) for freshwater inland wetland restoration, 2) the property value effects of costal wetland restoration, and 3) public WTP for increased water storage.[54] We also qualitatively describe some of the other benefits associated with wetland restoration, including avoided water treatment costs (from improved water quality), avoided property damage (through flood attenuation and flow reliability), values associated with species habitat, and improved or increased recreation opportunities.

WTP for freshwater (inland) wetland restoration.
Numerous studies across the United States have demonstrated that the public is willing to pay for the restoration of freshwater wetlands. The public values freshwater wetlands because they improve water quality, provide additional water storage, protect wildlife, and generate recreational and educational opportunities among other benefits. To estimate how much households in California are willing to pay for the complete set of CCI-funded freshwater wetland restoration projects, this analysis relies on a meta-analysis of 11 freshwater wetland valuation studies conducted in the US. To inform regulatory analyses of federal programs that restore wetlands, Moeltner et al. (2019) developed a multiple linear meta-regression model that estimates public WTP for wetland preservation. We utilize this model at the county-level for areas of the state with inland wetland restoration projects.[55] Employing the model requires data on baseline wetland acres (pre-project conditions from United States Fish and Wildlife Service 2022), new or restored wetland acres (on account of project

[54] 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.

[55] This analysis assumes all projects were completed the year they started at the local (sub-state) level. It also assumes all wetlands are forested, and that all projects have effects on the provisioning, regulating, and cultural functions of the baseline wetlands. Since we do not have any information to support these assumptions, we acknowledge that this methodology introduces error into our analysis.

activities, using data from CARB 2021), average household income, geographic region, and several other categorical variables as inputs to predict household WTP (U.S. Census Bureau 2021).

Across the 14 counties with inland wetland restoration projects, 6,000 new acres were added to the 760,000 baseline acres in those counties. The increase in functioning wetland area ranged from approximately 0.1 percent to 7.9 percent across counties. Our analysis finds that household WTP estimates ranged from $13.66 per household per year (Mariposa County) to $14.88 per household per year (Lassen County). Combined with the number of households in these counties, San Diego County had the highest potential WTP, with over 1.1 million households that may be willing to pay an estimated $16 million for wetland restoration projects in their county (U.S. Census Bureau 2021). In total, this analysis estimates that the public may be willing to pay **$32 million per year** for the 6,000 inland wetland acres restored.

Property value improvements associated with coastal wetland restoration. The link between proximity to wetlands and higher property values is well-documented, as wetlands can improve water quality and provide recreational opportunities (Boyer and Polasky 2004). These benefits are expected particularly for properties near coastal wetlands, which can support diverse fish and wildlife and provide shoreline anchoring, flood control, groundwater recharge, and aesthetic appeal. Mahan et al. (2000) find an approximately 0.02 percent increase in property values in Portland, Oregon per each acre increase in urban wetlands—including open-water coastal wetlands—an average of 2/3 of a mile away from each property. We apply this potential property value increase to properties in the same census tract as the CCI coastal wetlands projects.

To evaluate the impacts of added coastal wetlands from the projects, we first count the number of land parcels in each census tract containing a coastal wetlands project (nearly 11,000) and identify the median property value in the corresponding counties (County of Los Angeles 2022; U.S. Census Bureau 2021).[56] Combined with the results of Mahan et al., we estimate that the total present value increase in property values could be over $390 million, equivalent to **$12 million on an annualized basis** (assuming a 3 percent discount rate). The greatest share of this potential increase in property values occurs in Solano, Contra Costa, and Humboldt counties, accounting for 95 percent of the total potential increase, because of the large number of coastal wetland acres added to census tracts within these counties. The total potential benefit is spread across 2,000 acres of added coastal wetlands, amounting to a benefit of approximately **$5,700 per acre of coastal wetland**.

[56] Three counties containing coastal wetlands projects—Monterey, Contra Costa, and Humboldt—had two projects in the same Census tracts. To provide conservative estimates of property value increases, we do not double-count these land parcels.

WTP for increased water storage in inland wetlands.
To illustrate the potential magnitude of benefits, this analysis identifies the added acreage of inland wetlands from the CCI projects and values the potential avoided loss in water storage capacity. One acre of wetland one foot deep can store 330,000 gallons of water (Miller n.d.), and degraded meadows (freshwater wetlands) are able to store 30 percent less water than a fully functioning wetland (NFWF 2010). CCI projects restored nearly 6,000 acres of inland wetland across 14 counties, with the largest expansion of wetland acreage in Plumas and Sacramento counties. To apply the water storage capacity value to these wetlands, we assume that the project wetlands are one foot deep and find that the restored wetlands may be responsible for an additional **1,800 acre-feet** of water in their restored state, equivalent to approximately 590 million gallons.

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.[57] Shadow prices are WTP measures that generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market. Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent water shortage for agricultural purposes ranges across regions in the state, varying from $79 per acre foot in the San Francisco Bay Area to $272 per acre foot in the South Coast (De Souza et al. 2011). The potential benefit from increased water storage in inland wetlands is valued at **$190,000 annually**, with an average benefit of **$30 per acre** of wetland.

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 the pressure on these non-renewable groundwater resources.[58]

Avoided water treatment costs through reduced sedimentation.
Inland wetlands can improve water quality by sequestering nutrients and removing toxins from groundwater. This is because native and well-functioning inland wetlands have long and sense root and rhizome networks that limit erosion (NFWF 2010). For instance, one project in the Plumas National Forest in California demonstrated a 17.5 percent reduction in annual sediment production following a meadow restoration project (as cited in Conway 2012). While likely that CCI inland wetland restoration projects improve downstream drinking water quality, data are not available to quantify those ecological changes. One benefit of improved water quality is a reduction in the costs associated with water treatment before consumption. For context, recently the California Water Board

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

[58] 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.

indicated that annual sediment removal costs were $0.452 per cubic yard (about $730 per acre-foot) (California Water Board 2020-21).

Positive preference for increase in species abundance.
Wetlands can support diverse fish, plants, and other wildlife through enhanced wildlife habitat. Some of the CCI wetland projects document benefits to species living at or near the project sites, including aquatic and non-aquatic species. Through project monitoring activities, implementers describe at least 39 species benefiting from the projects. Wetlands can also help preserve habitat for endangered and threatened species; 3 threatened species and 6 endangered species may benefit from coastal wetland projects, while 2 endangered species may benefit from inland wetland projects. Examples of endangered species found in project sites include the Tidewater goby, Northern California steelhead, salt marsh harvest mouse, and mountain yellow-legged frog (CARB 2021). The economics literature demonstrates that the public exhibits a positive preference for increases in species abundance, especially for endangered and threatened species, although data from these projects are insufficient to quantify and monetize benefits.

Avoided property damage through flood attenuation and flow reliability.
Restoration of wetlands can reduce and delay peak flows on streams, resulting in a reduction in downstream flooding (NFWF 2010). Modeling efforts of similar inland systems in California demonstrate that flood peak may be reduced by 10 to 20 percent in a wet year and the baseflow may be increased by 10 to 20 percent during the following dry season (Ohara et al. 2013). On the other hand, restoration of coastal wetlands has the potential to reduce flooding and create storm protection (Ballard et al. 2017). Therefore, CCI wetland restoration projects have the potential to reduce flood- and/or storm-related property damage. The costs associated with flooding are highly context and location specific and cannot be evaluated for these project sites at a programmatic level.

Improved or increased recreation.
Wetlands provide and support opportunities for outdoor recreation (particularly downstream water-based recreation), hunting, nature observation, and ecotourism (Ballard et al. 2017). Some of the coastal wetlands projects funded by CCI may further enable these opportunities by

improving access to recreation sites, for example by adding interpretive signs and clear trail paths and offering educational opportunities (CARB 2021). The inland projects also provide opportunities for wildlife viewing and may support increased recreational opportunities. Additional or improved recreation and tourism provides value to people.

Table 7: Summary of Monetized Ecosystem Service Benefits for the Wetlands Projects by County (2021 dollars)

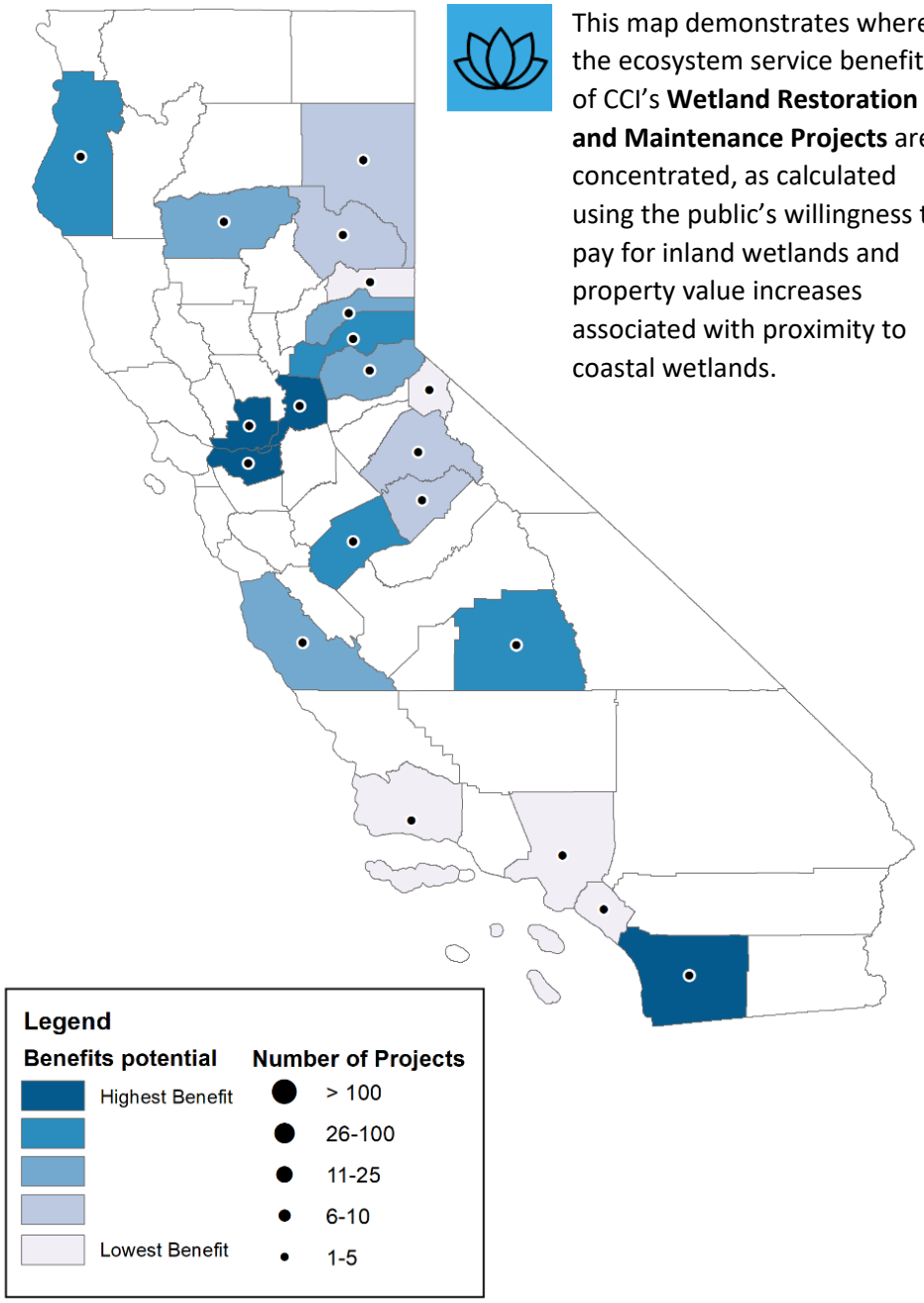
County	Total Inland Wetland Acres Treated[a]	Total Coastal Wetland Acres Treated[a]	WTP for Inland Wetland Acres (Annual)[b]	Increased Property Values Near Coastal Wetlands (Annualized)[b]	WTP for Water Storage at Inland Wetlands (Annual)[b]
Alpine	120	--	$5,700	--	$5,500
Contra Costa	--	600	--	$3,500,000	--
El Dorado	250	--	$1,000,000	--	$7,600
Humboldt	--	630	--	$3,200,000	--
Lassen	250	--	$140,000	--	$7,700
Los Angeles	--	3		$28,000	--
Mariposa	39	--	$110,000	--	$1,800
Merced	10	--	$1,200,000	--	$450
Monterey	--	100	--	$520,000	--
Nevada	490	--	$570,000	--	$15,000
Orange	--	10	--	$3,400	--
Placer	39	--	$2,100,000	--	$1,200
Plumas	2,700	--	$120,000	--	$81,000
Sacramento	1,700	--	$7,700,000	--	$52,000
San Diego	38	--	$16,000,000	--	$3,100
Santa Barbara	--	54	--	$95,000	--
Sierra	170	--	$17,000	--	$5,000
Solano	--	650	--	$4,500,000	--
Tehama	80	--	$350,000	--	$2,400
Tulare	90	--	$1,900,000	--	$4,000
Tuolumne	9	--	$320,000	--	$400
Statewide Total	**6,000**	**2,000**	**$32,000,000**	**$12,000,000**	**$190,000**

Sources and notes:

a. Data observed in CARB (2021) for projects implemented from 2015 to 2020.

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 8: Spatial Distribution of Ecosystem Service Benefits Potential for the Wetlands Projects



Note: The benefit potential conveyed in this map considers the public's WTP for the services provided by inland wetlands and property value premiums associated with residing near coastal wetlands presented in Table 7.

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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

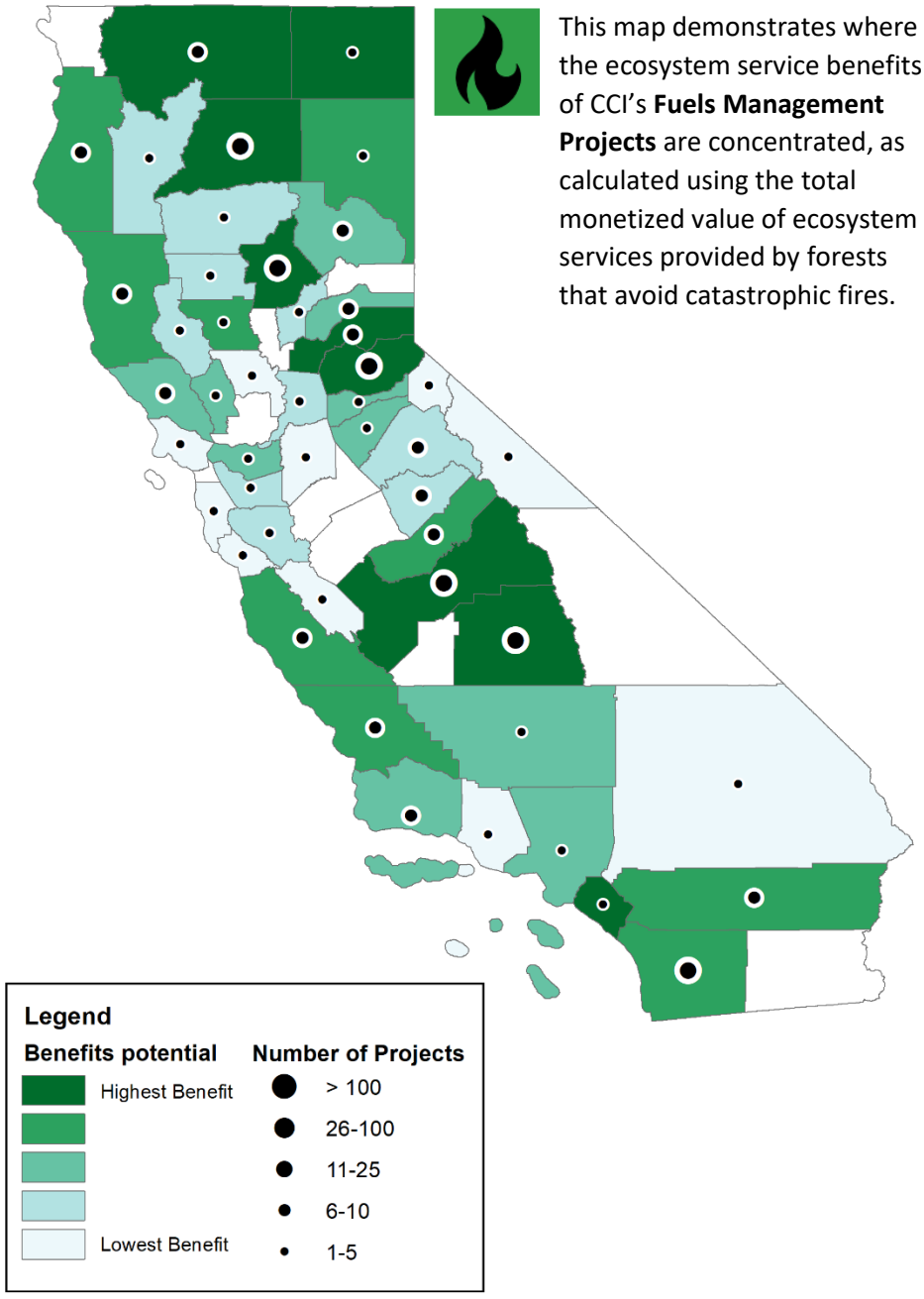
County	Total Acres Treated with Fuel Reduction Activities[a]	Overall Ecosystem Service Benefit (Annual)[b]	Avoided Property Damages (Annual)[b]
Plumas	2,500	$39,000	$35,000
Riverside	3,400	$52,000	$47,000
Sacramento	4,400	$23,000	$21,000
San Benito	240	$3,700	$3,400
San Bernardino	1,300	$13,000	$12,000
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.

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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.

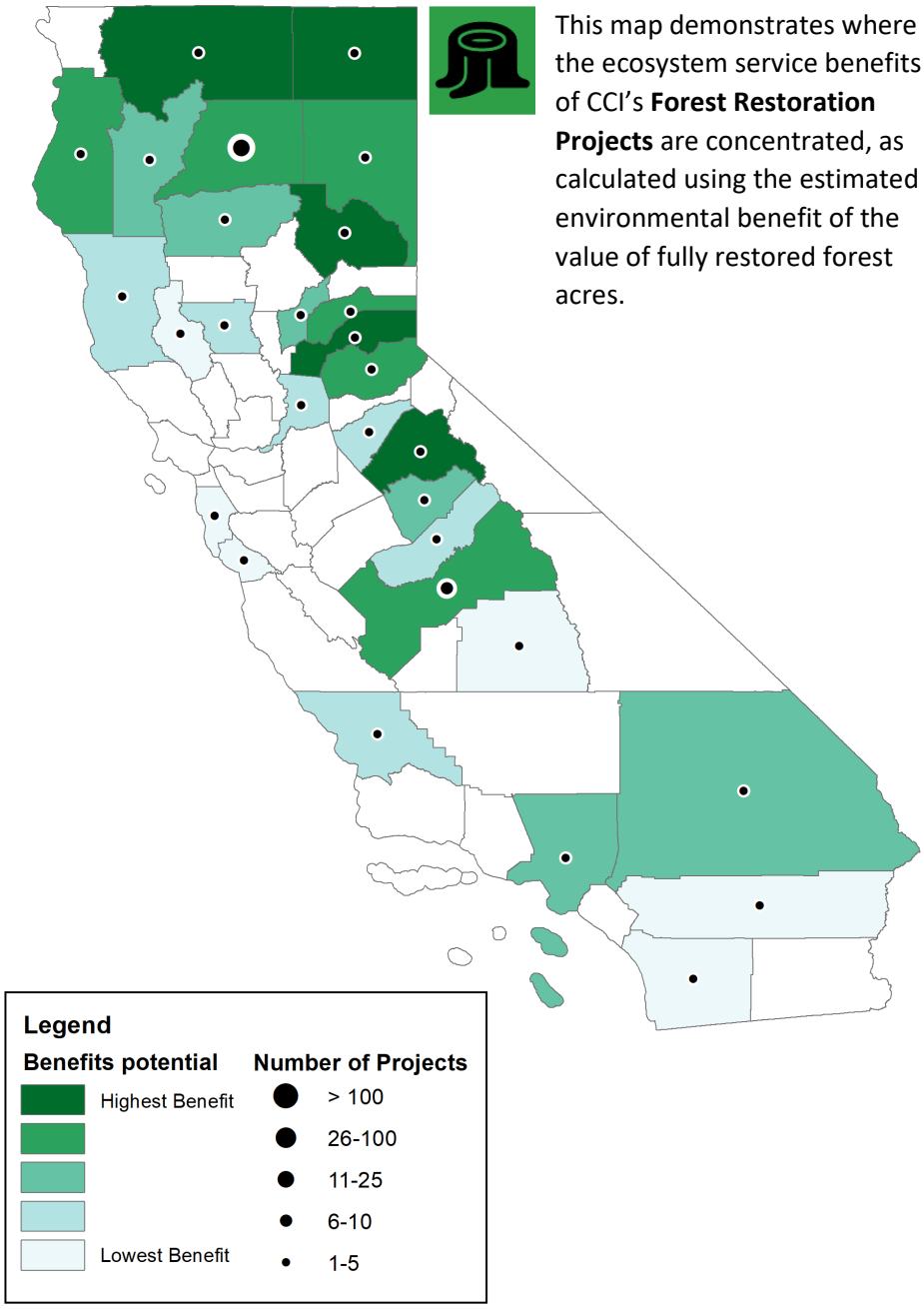
County	Total Acres Restored[a]	Environmental Service Benefit of Fully Restored Acres (Annual)[b]
Plumas	110,000	$250,000,000
Riverside	13	$30,000
Sacramento	1,200	$2,800,000
San Bernardino	4,700	$11,000,000
San Diego	460	$1,100,000
San Luis Obispo	980	$2,300,000
San Mateo	460	$1,100,000
Santa Cruz	160	$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.

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FORESTS

Forest Conservation

Ecosystem Service Benefits

- The public demonstrates a preference for preventing forests from development and may be willing to pay up to $8.8 million per year for the acres conserved by CCI projects.
- Because forests are a valuable amenity, forest conservation projects may also increase the property values of nearby parcels. CCI projects may increase the market prices of nearly 27,000 parcels by between $110,000 and $3.8 million on an annualized basis.
- Forest conservation provides a host of other ecosystem service benefits such as air quality, climate regulation, flood and storm hazard reduction, recreation/tourism, water filtration, and water supply benefits.

OVERVIEW OF PROJECTS

Project activities
Conserving forested lands under threat of development

Implementing agency
California Department of Forestry and Fire Protection

21 projects
funded across 7 counties (2015-2020)

57,000 acres
of forested land conserved

Between 2015 and 2020, CCI invested in 21 forest conservation projects through the Department of Forestry and Fire Protection (CARB 2021). In total, these projects span more the 57,000 acres of land, nearly half of which is in the Whiskey Working Forest Conservation Easement in Siskiyou County (CARB 2021). This analysis documents the societal benefits that may result from these forest conservation projects. Appendix page A-8 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. We leverage prior analysis conducted by Moore (2013) to quantify the public's willingness to pay (WTP) for forest conservation.[73] We also estimate the property value benefits associated with the CCI-funded easements.

Public WTP for forest conservation.
It is well documented that the public has a preference for forest conservation (Cho et al. 2008; Hjerpe and Hussain 2016; Racevskis and Lupi 2006; Thompson et al. 2002). A literature search identified a WTP estimate resulting from a 2013 study conducted in the Red Hills region along the border between Georgia and the Florida as the best available proxy for how Californians may value CCI's conservation easements on forested lands. The model demonstrates that for every one percent increase in conserved private forested land within a region, each household in the region is willing to pay an average of $32 per year (Moore 2013).[74] Because the Red Hills region is roughly the size of a county, we employ this WTP estimate at the county level to approximate how Californians value CCI's conservation easements on forested lands. We calculate baseline acres by county using spatial vegetation data downloaded from the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program's website (U.S. Forest Service 2022). Since CCI-funded forest conservation projects are required to present a documented threat of development to qualify for funding, we assume the land conserved by CCI's conservation easements would have been developed absent the projects. From that assumption, we conclude that the projects increased the forested land of each of the seven counties with projects by an average of 0.51 percent. We estimate that the 1.1 million households that benefit may be willing to pay on the order of **$8.8 million annually** for these conservation projects.

Increased property values from proximity to forests.
Forest conservation projects can also be valued by considering how they affect the property values of adjacent parcels. To demonstrate the potential effects of CCI's conservation easements on property values, this analysis considers findings from Geoghegan et al. (2003), which studies increases in property values associated with increases in land conserved across two counties experiencing development pressure in Maryland. The study authors find that homes within 100 meters (m) of an easement experience a 0.04 percent increase in market value in one county while homes within 1,600m experience a 0.71 percent increase in a different county. We use the property value benefit experienced by households within 100m of the projects as a low-end estimate for the overall property value effect of the projects and the benefit experienced by households within 1600m as the high-end. Spatial analysis identifies over 8,300 parcels within 100m and nearly 27,000 within 1,600m of

[73] 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.

[74] Though CCI's conservation easements are on public land, we assume that public forested land is more valuable to the public than private forested land on account of recreational accessibility among other reasons. Thus, relying on this study will likely understate public WTP for CCI's conservation easements.

the CCI forest conservation easements (County of Los Angeles 2022, Microsoft Open Source 2023; CARB 2021).[75,76] Assuming all identified parcels are valued at the median home price for the county (U.S. Census Bureau 2020), this analysis suggests the property value benefits of the conserved acres may be on the order of between $3.5 and $130 million in present value terms, equivalent to $110,000 to $3.8 million on an annualized basis (assuming a 3 percent discount rate).

Table 10: Summary of Monetized Ecosystem Service Benefits for the Forest Conservation Projects by County (2021 dollars)

County	Total Acres Conserved[a]	Increased Property Values (Annualized)[b,c]	WTP for Forest Conservation (Annual)[b]
Humboldt	17,000	$100,000 - $3,600,000	$1,500,000
Napa	1,200	$530 - $84,000	$870,000
Placer	190	<$100 - $4,300	$160,000
San Bernardino	78	<$100 - $440	$360,000
Siskiyou	34,000	$1,900 - $86,000	$730,000
Sonoma	4,300	$680 - $32,000	$5,100,000
Trinity	750	<$100	$7,600
Statewide Total	**57,000**	**$110,000 - $3,800,000**	**$8,800,000**

Sources and notes:

a. Data observed in CARB (2021) for projects implemented from 2015 to 2020.

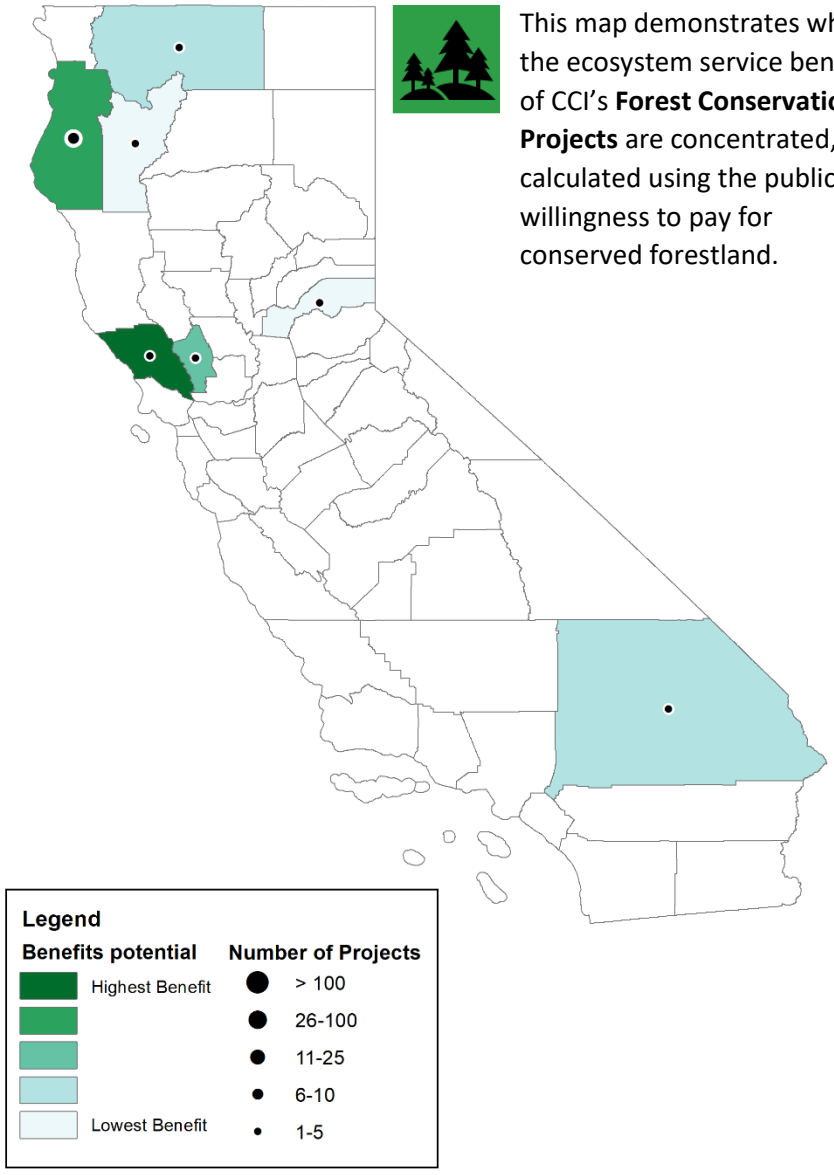
b. Author calculations described in this report. The monetary values presented in this table are not necessarily additive to a single, total benefits value as they reflect alternative valuation methods and measures (e.g., market values, social welfare values) and may double-count the same benefit stream.

c. When "<$100" is used to express the low-end of a range, the expected value of the metric is between a value less than $100 and the high-end value. When "<$100" is used to express the entirety of a range, both the low-end and high-end values of the metric are less than $100.

[75] Since these projects do not have spatial data, IEc created polygons for each project by using the latitude and longitude coordinates provided in the CCIRTS database as each project's centroid and drawing circles around each centroid such that the area of the circle was equivalent to the total estimated acres conserved by the project.

[76] Since the statewide parcel boundaries data set does not have parcel data for Siskiyou County, IEc employed an alternative method to estimate the number of parcels within the buffers of projects in Siskiyou County. After identifying the number of structures and the number of households in each county, IEc calculated the ratio of households to structures for each county (U.S. Census Bureau 2021, Microsoft Open Source 2023). IEc then applied this ratio to the number of structures within each buffer in Siskiyou County to estimate the number of households within the buffer.

Figure 11: Spatial Distribution of Ecosystem Service Benefits Potential for the Forest Conservation Projects



Note: The benefit potential conveyed in this map considers the public's WTP for conserved forestland category presented in Table 10.

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NEIGHBORHOOD GREENING

Urban Forests and Green Space

Ecosystem Service Benefits

- Expanded tree canopy may reduce energy needs associated with cooling for nearby residents, potentially resulting in cost savings on the order of $3.3 million per year.
- The trees planted also have the potential to naturally manage 310 million gallons of stormwater, potentially reducing management costs by $3.2 million per year.
- Increasing tree canopy is also linked with a reduction in crime. CCI projects may reduce approximately 1,300 crimes per year, reducing related costs by $5.2 million.
- The various ecosystem service benefits of urban trees could lead to an increase in values of adjacent properties of approximately $4.1 million on an annualized basis, although the distribution of these benefits is uncertain.
- These projects may also yield benefits to human health and well-being, revenue from urban wood rescue, recreation, and food security.

OVERVIEW OF PROJECTS

Project activities

Plant trees and upgrade green space in urban areas

Implementing agencies

California Department of Forestry and Fire Prevention, California Natural Resources Agency, Strategic Growth Council, and State Coastal Conservancy

257 projects

funded across 35 counties (2016-2020)

84,000 trees

planted

47 projects

involving urban green space maintenance

8 projects

with gardening activities

Between 2016 and 2020, CCI invested in 257 projects across 35 counties that contributed to the greening of urban spaces throughout California, with the highest concentration of projects in Los Angeles, San Diego, and Fresno counties (CARB 2021). The projects are primarily in the Urban Forestry Program (CAL FIRE) and Urban Greening Program (Natural Resource Agency) as well as select projects in the Transformative Climate Communities Program (Strategic Growth Council), Affordable Housing and Sustainable Communities Program (Strategic Growth Council), and Climate Ready Program (State Coastal Conservancy). Projects activities included planting trees, upgrading existing and developing new green space, and creating urban gardens.

This analysis monetizes the ecosystem service benefits associated with the over 84,000 trees planted across these projects.[77] Urban trees provide abundant ecosystem services: the production of oxygen used for people to breathe, mitigation of urban heat island effects, overall mediation of temperatures, stormwater run-off support, habitat for species that people value, etc. (Riley and Gardiner 2020). Appendix page A-9 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. In this analysis, we quantify the benefits associated with energy savings, human safety, water supply maintenance, and increases in property values from a suite of benefits. Given data limitations, the benefits associated with additional or improved green space (like parks) and new community gardens—including improved human health and well-being, recreation opportunities, and food security—are discussed qualitatively.

Energy utility savings from cooling services provided by increased tree canopy. One ecosystem service provided by trees is the localized cooling effect due to expanded tree canopy, which allows nearby residents to save on electricity costs. Simpson (2002) find that each tree planted in urban Sacramento has an average cooling capacity of approximately 177 kilowatt-hours (kWh) per year.[78] Data from a sample of 2,681 trees planted through these projects identifies that each tree planted is estimated to save an average of 1,224 kWh of over the project lifetime, assumed to be the first 40 years of the tree's life (iTree Eco reports provided via email).[79] Applying the cooling savings from Simpson (2002), likely to be better representative of more mature urban trees, all 84,000 planted trees are estimated to save **14.8 million kWh** of cooling energy per year. Using an average cost of electricity of $0.22 per kWh in the Los Angeles-Long Beach-Anaheim region (U.S. Bureau of Labor Statistics 2022), the trees planted are estimated to save reduce cooling costs by **$3.3 million per year**.[80] The greatest benefits are projected in the counties with the largest number of tree plantings, Los Angeles and Sacramento counties.

[77] The total number of trees is derived from tree roster databases maintained by the Urban Forestry Program and Urban Greening Program. Other programs in this category planted trees as well, therefore this represents an under-estimate of all trees planted in this category.

[78] We calculate this number using information from Table 11 of Simpson (2002) by averaging across the cooling provided by trees placed in different directions around buildings: north, south, east, and west. A study by Donovan and Butry (2009), which also looked at urban trees in Sacramento, only found decreases in electricity use for trees planted on the west and south side of the single-family homes they studied.

[79] iTree Eco is a model produced by the U.S. Forest Service to help predict the environmental benefits associated with individual trees. More information is available at: https://www.itreetools.org/. The methods estimating electricity effects are derived from Nowak et al. (2017).

[80] The cost of electricity varies across time and space. Applying the unit cost from the Lost Angeles-Long Beach-Anaheim region to all electricity saved by the trees planted across these projects provides context on the magnitude for these cost savings although may over- or under-estimate the total value of these services for any particular project site.

Avoided stormwater runoff.
Trees and shrubbery naturally maintain water supplies through increased groundwater infiltration and avoided stormwater runoff relative to impervious cover, reducing the need for active stormwater management (Berland et al. 2017). Data from a sample of 2,681 trees planted through CCI-funded projects identifies that each tree planted manages an average of 3,700 gallons of stormwater per year (iTree Eco reports).[81] Across all trees planted by the projects, this suggests approximately **310 million gallons** of stormwater may be intercepted by the trees per year. iTree Eco finds that the average value per gallon of managed stormwater is $0.0089. Applying that value to all stormwater intercepted by the trees results in a potential benefit on the order of **$3.2 million per year**. The greatest benefits are again expected to accrue in the counties with the largest number of tree plantings, Los Angeles and Sacramento counties.

Improved human safety from increased tree canopy.
Existing literature suggest a link between high temperatures and increased levels of violent and nonviolent crime in cities like Los Angeles (Heilmann and Kahn 2021). Increased tree cover and the associated localized cooling effects may result in reductions in crime, which in turn benefits human safety. Beyond the cooling services, trees also can discourage crime in other ways, for instance by bringing more people to urban spaces (which increases surveillance and makes crimes less easy to carry out), by creating a feeling that people are "taking care" of space, and by mitigating mental fatigue (Kuo and Sullivan 2001). A number of studies have demonstrated a positive association between the extent of tree canopy and crime after controlling for other factors that are also correlated with crime. For instance, one study estimates a 10 percent increase in tree canopy is associated with 15 percent decrease in violent crime and 14 percent decrease in property crime in New Haven, Connecticut (Gilstad-Hayden et al. 2015).[82] We apply this relationship to estimate the potential reduction in crime associated with the cooling benefits of increased tree canopy across California from the CCI projects.

To estimate the expansion in canopy from the project tree plantings relative to the tree canopy provided by existing trees, we identify the locations of all trees planted through the Urban Forestry Program and Urban Greening Program then estimate the canopy provided by the trees at maturity.[83] The tree canopy

[81] See footnote 79 for additional details on iTree Eco is a model produced by the U.S. Forest Service to help predict the environmental benefits associated with individual trees. More information is available at: https://www.itreetools.org/. The. The specific methods estimating precipitation interception are described in Hirabayashi (2013).

[82] Similarly, Troy et al. (2012) find that a 10 percent increase in tree canopy is associated with a 12 percent reduction in crime in Baltimore, Maryland. Heilmann and Kahn (2021) also identify a strong relationship between the level of urban greenness and crime in Los Angeles, California although do not interpret these findings as causally related.

[83] The Urban Tree Database maintained by the USDA's Forest Service provides select characteristics across a sample of trees in various urban areas in the U.S. (McPherson et al. 2016). When restricting the data to trees in urban California aged 30 years or older, the average crown diameter is 12m. Assuming the trees are roughly circles from above, then the total area of the tree canopy for a single mature tree is 113m. While each tree species is likely to vary in size at maturity, this approach allows us to approximate the total change in tree canopy across all 84,000 trees planted through these programs.

provided by the project trees is then compared with existing tree cover provided through the National Land Cover Database (U.S. Forest Service 2019). At the census tract level, we calculate the percent change in canopy provided in urban areas by project trees. Relative to the total baseline tree canopy across all affected census tracts, the new canopy added by CCI trees at maturity may increase the tree canopy by up to 0.7 percent.[84]

Following an approach by Wolf et al. (2015), we estimate the number of baseline crimes at the county level by scaling statewide violent and property crime levels by the population of each county (CA Department of Justice 2014; U.S. Census Bureau 2021).[85] Integrating these pieces of information together, this analysis finds that the increase in tree cover from projects may yield a statewide reduction of 70 violent and 1,200 property crimes per year.[86] We then use the available literature to draw out the average costs of violent and property crime, which are $71,000 and $1,800 respectively (Miller et al. 1996; Heaton 2010),[87] resulting in a potential total cost savings of roughly **$5.2 million annually**.

Increased property values resulting from increased tree canopy.
One way to measure how people value this suite of services is to evaluate the effects of increased tree canopy on nearby property values. In a meta-analysis that considered various published studies, Siriwardena et al. (2016) find that property values increase by approximately $110 for each percent increase in tree canopy.[88]

Siriwardena et al. (2016), however, do not convey the geographic area of benefiting properties. If we count the number of parcels in the 2,200 census tracts with newly planted trees using data from the County of Los Angeles (2022) and the U.S. Census Bureau (2021), then we identify over 2.7 million parcels that may experience property value benefits associated with the positive preference people have for urban trees. Because this catchment area is likely too broad for CCI's projects, we instead assume each of the 84,000 trees planted in urban areas affects one residential property and increases the value of that property by approximately $110. Given that trees can provide benefits to more than just one adjacent property, the number of properties considered in this analysis may be an under-estimate. Similarly, one mature tree may increase available canopy for a single property by more than

[84] When considering the percent increase in tree canopy at the county level, the variation is considerable. For instance, the trees planted in urban areas of seven counties increase the tree canopy in the affected census tracts by over 10 percent each. These counties include Alameda, Imperial, Los Angeles, Orange, Sacramento, San Francisco, and Yolo.

[85] For instance, CA Department of Justice (2014) identified 393 violent crimes and 2,459 property crimes per 100,000 residents. These "rates" are multiplied by county level populations from the U.S. Census to approximate the number of crimes at the county level. To the extent that some counties with tree projects have a higher volume of baseline crime than the state level average, this analysis under-estimates the benefits of tree plantings.

[86] For context, there were over 150,000 violent crimes and over 946,000 property crimes across California in 2014 (CA Department of Justice 2014). The projected reductions in crime associated with CCI tree plantings is significantly less than 1 percent of crimes per year.

[87] These costs consider medical care, property damage and loss, mental health care, policy and fire services, victim services, victim productivity loss, pain, suffering, and reduced quality of life.

[88] We calculate a weighted average increase in property value using information in Table 2 of Siriwardena et al. (2016) that shows an average increase in property values of $280 across the studies that demonstrate a benefit (64 percent) and an average decrease in property values of $180 across the remainder of the sample (36 percent). The fact that some of the studies in the meta-analysis demonstrate a negative effect on property values highlights that trees can also provide disamenities for people, including increases in pollen that can exacerbate allergies as well as damage to infrastructure (Riley and Gardiner 2020). Siriwardena et al. (2016) does not provide details on the spatial extent of properties that experience this benefit, therefore we follow an approach that may undercount the total property value benefits of CCI trees planted in urban areas.

one percent. Our approach, therefore, may represent a lower-bound estimate of the total property value benefits. Using this framework, we estimate an increase in the net present value of properties may be on the order of $140 million, equivalent to **$4.1 million on an annualized basis** (3 percent discount rate).

The greatest share of benefits is found in the counties with the highest number of trees planted, Los Angeles and Sacramento counties, which account for 43 percent of the total benefit. The distribution across demographic groups of any potential increase in property values associated with urban tree canopy is uncertain. It is possible that landowners reap this benefit as an increase in wealth while renters experience overall increases in rental costs and pressure to leave the neighborhood. In other words, increases in property values also has the potential to increase housing inequity and gentrification in urban areas (Sachs et al. 2023).

Increased revenue from products made of recycled urban trees. Approximately 10 projects in this category facilitate the use of reclaimed wood from urban areas to create products for sale by local businesses. Each year, a large volume of mature trees is removed due to health issues and infrastructure needs. Before these projects, the removed wood would end up in the landfill. These projects keep the removed wood out of the waste stream, which may reduce landfilling costs and add a revenue stream for urban wood businesses. Data are not available to quantify the revenue benefits associated with these project activities.

Improved human health from additional urban green space. Increased urban green space is linked to human physical and mental health benefits through various pathways. Analyses on the topic have found a relationship between green space exposure and reduced effects of cardiovascular disease, diabetes, stress, and mortality (Castillo et al. 2021). A study in California also found that greater urban tree cover reduces rates of asthma (Ulmer et al. 2016). A meta-analysis conducted by Rojas-Rueda et al. (2019) finds that most studies find a significant inverse relationship between an increase in the Normalized Difference Vegetation Index (NDVI) and all-cause mortality outcomes for residents within a 500-meter buffer of the study sites. Some of these benefits may be attributed to reduced exposure to air pollution and noise associated with increased greenness (Markevych et al. 2017).

As discussed above, expanded tree canopy also leads to localized cooling, which can have significant impacts in urban environments with non-reflective and impervious surfaces that are likely to amplify heat and high temperatures. Since heat can serve as a stressor for cardiac and other health conditions, increased tree canopy can potentially reduce these outcomes. A range of studies has showed even more significant benefits to human health from exposure to green space for disadvantaged communities, the elderly, pregnant women, and children (Castillo et al. 2021). Wolch et al. (2011) conduct a longitudinal study based in 12 Southern California communities and find a significant inverse relationship between

park access within 500 meters of children's homes and their body mass index at age 18, signaling an association between proximity to parks and occurrence of childhood obesity. Green space is also linked to health benefits like stress recovery, increased activity, and social cohesion. These pathways are likely to build upon one another to benefit people's physical and mental health in response to increased green space from the Neighborhood Greening projects (Markevych et al. 2017).

Preference for increases in bird and other species habitat and increased well-being from encounters with birds.

Urban forests in California provide habitat to a diverse set of bird and other species (Wood and Esaian 2020). The trees and other habitat provided by the introduction and revival of urban green space creates additional habitat for these species and the potential for increases in bird population. Evidence is limited on the value people place on bird populations in urban areas, although evidence increasingly links birds with increased well-being among urban residents (Hedblom et al. 2017). One study from the Pacific Northwest finds that bird watchers are willing to pay $3 per species per trip (Kolstoe and Cameron 2017).[89] It is uncertain if and how those values would apply to the potential increase in bird sightings in urban areas that may not be thought of as traditional birding destinations. In addition, some of these projects entail planting native Californian wetland and riparian tree species, which will benefit fish and other wildlife in addition to birds. However, it is not possible to quantify or monetize these benefits either.

Improved and increased urban recreation opportunities.

Newly tree-lined streets may become more desirable destinations for walking. For instance, research from urban California identifies that the presence of street trees is associated with more walking trips (Alfonzo et al. 2008). The green spaces added by the projects may also become recreation destinations and provide value to residents and visitors. For example, many of these CCI-funded projects enhance and enlarge public parks, which support several recreational activities in addition to walking.

Improved food security from urban gardens and urban fruit trees.

Eight projects reported establishing a garden as one project activity. Urban community gardens expand access to fresh and diverse foods for local communities, improving overall food security and community health. Clarke and Jenerette (2015) compare the demographics of communities living near urban gardens in Los Angeles County and find that crops are likely to fulfill nutritional and food security needs at gardens near immigrant populations, while gardens near high-income populations are often comprised of ornamental plants. Urban community gardens in food-insecure regions, therefore, are likely to lead to greater food security and fulfill the needs of nearby communities. It is also possible that trees planted through specific programs may be fruit-bearing, providing an additional food security benefit where the fruit can be harvested by local residents. Because most of the CCI-funded projects are located in disadvantaged communities, these projects are likely to result in benefits related to food security for communities who are able to access the gardens and fruit-bearing trees.

[89] From an economic perspective, willingness to pay (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.

Table 11: Summary of Monetized Ecosystem Service Benefits for the Neighborhood Greening Projects by County (2021 dollars)

County	Total Trees Planted[a]	Avoided Cooling Energy Costs (Annual)[b]	Value of Stormwater Managed (Annual)[b]	Value of Decreased Violent Crime (Annual)[b]	Value of Decreased Property Crime (Annual)[b]	Increased Property Values (Annualized)[b]
Alameda	3,600	$140,000	$140,000	$270,000	$140,000	$170,000
Butte	850	$33,000	$33,000	$590	$190	$440
Contra Costa	1,400	$55,000	$54,000	$3,900	$3,600	$2,500
Fresno	3,700	$140,000	$140,000	$9,300	$2,000	$4,000
Imperial	1,800	$71,000	$69,000	$1,600,000	$270,000	$1,500,000
Kern	1,800	$71,000	$70,000	$820	$500	$550
Kings	300	$12,000	$11,000	$630	$2,300	$2,500
Los Angeles	34,000	$1,300,000	$1,300,000	$2,300,000	$800,000	$1,500,000
Madera	770	$30,000	$30,000	$650	$130	$340
Marin	86	$3,400	$3,300	$300	$2,200	$410
Mendocino	3	$120	$120	$180	$340	<$100
Merced	1,200	$48,000	$47,000	$3,700	$980	$2,300
Monterey	290	$11,000	$11,000	$110	<$100	<$100
Napa	4	$160	$150	<$100	<$100	<$100
Orange	680	$27,000	$26,000	$99,000	$210,000	$25,000
Riverside	850	$33,000	$33,000	$24,000	$120,000	$23,000
Sacramento	5,800	$230,000	$220,000	$230,000	$120,000	$250,000
San Bernardino	1,900	$73,000	$71,000	$140,000	$87,000	$42,000
San Diego	5,600	$220,000	$220,000	$170,000	$170,000	$160,000
San Francisco	1,800	$71,000	$70,000	$200,000	$100,000	$130,000
San Joaquin	3,400	$130,000	$130,000	$65,000	$25,000	$62,000
San Luis Obispo	160	$6,100	$6,000	<$100	<$100	<$100
San Mateo	930	$36,000	$36,000	$1,200	$2,100	$1,500
Santa Barbara	760	$30,000	$29,000	$300	$210	$200
Santa Clara	2,500	$96,000	$94,000	$3,200	$1,900	$1,400
Santa Cruz	800	$31,000	$31,000	$3,900	$2,200	$3,700
Shasta	260	$10,000	$9,800	$1,300	$930	$730
Solano	400	$16,000	$15,000	$2,700	$5,300	$2,600
Sonoma	110	$4,400	$4,300	$110	$1,600	$200
Stanislaus	4,300	$170,000	$160,000	$50,000	$15,000	$66,000

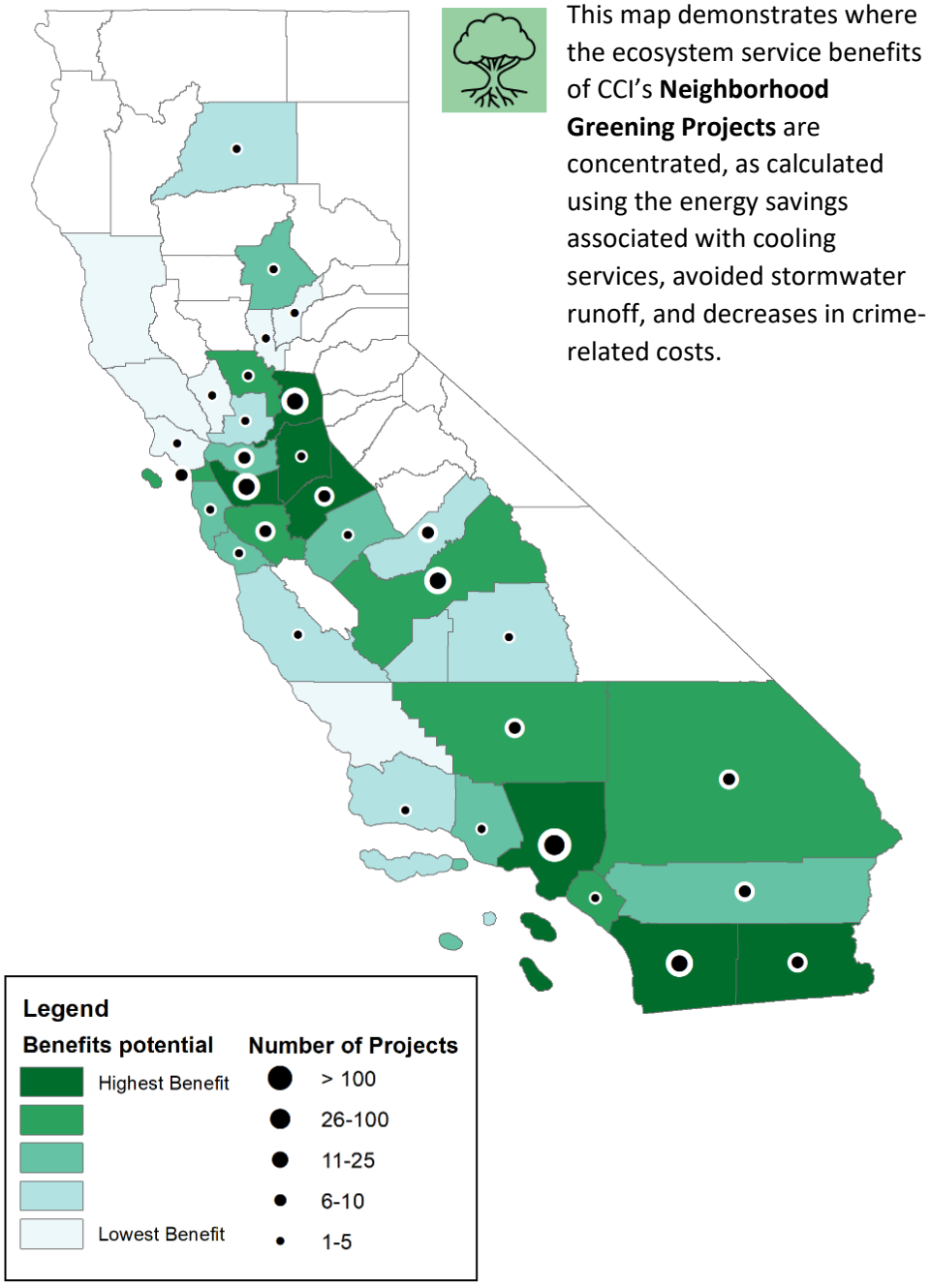
County	Total Trees Planted[a]	Avoided Cooling Energy Costs (Annual)[b]	Value of Stormwater Managed (Annual)[b]	Value of Decreased Violent Crime (Annual)[b]	Value of Decreased Property Crime (Annual)[b]	Increased Property Values (Annualized)[b]
Sutter	33	$1,300	$1,300	$2,100	$2,600	$490
Tulare	240	$9,500	$9,300	<$100	<$100	<$100
Ventura	1,100	$43,000	$43,000	$14,000	$12,000	$9,000
Yolo	2,200	$87,000	$85,000	$56,000	$18,000	$100,000
Yuba	130	$5,000	$4,900	$3,500	$2,000	$1,700
Statewide Total	**84,000**	**$3,300,000**	**$3,200,000**	**$5,200,000**	**$2,100,000**	**$4,100,000**

Sources and notes:

a. Data observed in tree roster databases maintained by the Urban Forestry Program and Urban Greening Program for projects implemented from 2016 to 2020. Therefore, these totals understate the total trees planted across all programs considered in this project category and for which similar databases were not provided for this analysis.

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 12: Spatial Distribution of Ecosystem Service Benefits Potential for the Neighborhood Greening Projects



Note: The benefit potential conveyed in this map considers avoided energy costs, avoided stormwater runoff costs, and avoided crime costs presented in Table 11.

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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.

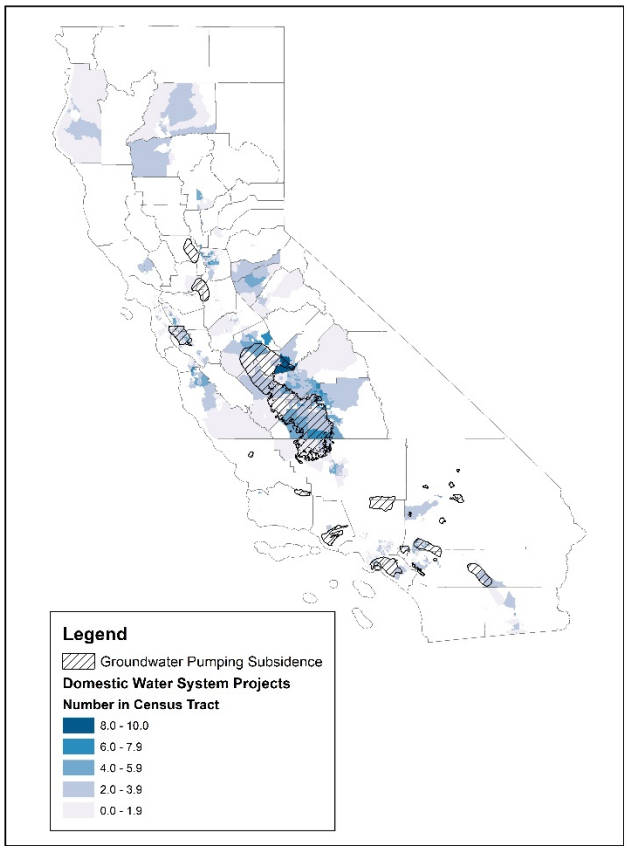
water shortage for urban use purposes ranges across regions in the state, varying from $908 per acre foot in Colorado River to $7,744 per acre foot in Central Valley North of Delta (De Souza et al. 2011). This analysis finds that the potential water savings associated with these water efficiency upgrades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

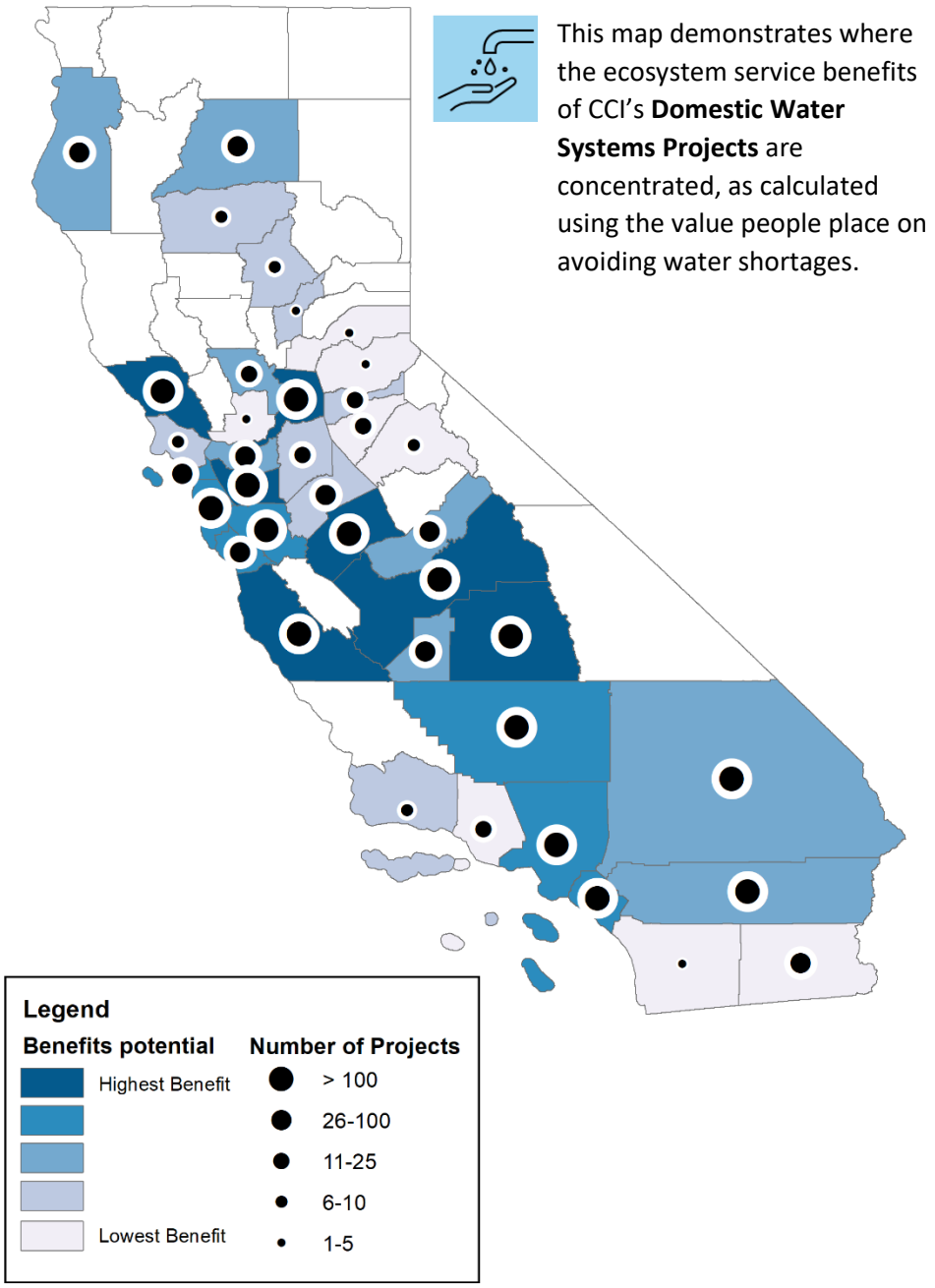
County	Acre-Feet of Water Saved (Annual)[a]	Value of Water Savings (Annual)[b]
Tulare	180	$410,000
Tuolumne	0.018	<$100
Ventura	0.068	$330
Yolo	4.9	$40,000
Yuba	0.1	$1,000
Statewide Total	**4,500**	**$12,000,000**

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.

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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 PM2.5 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 PM2.5 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**

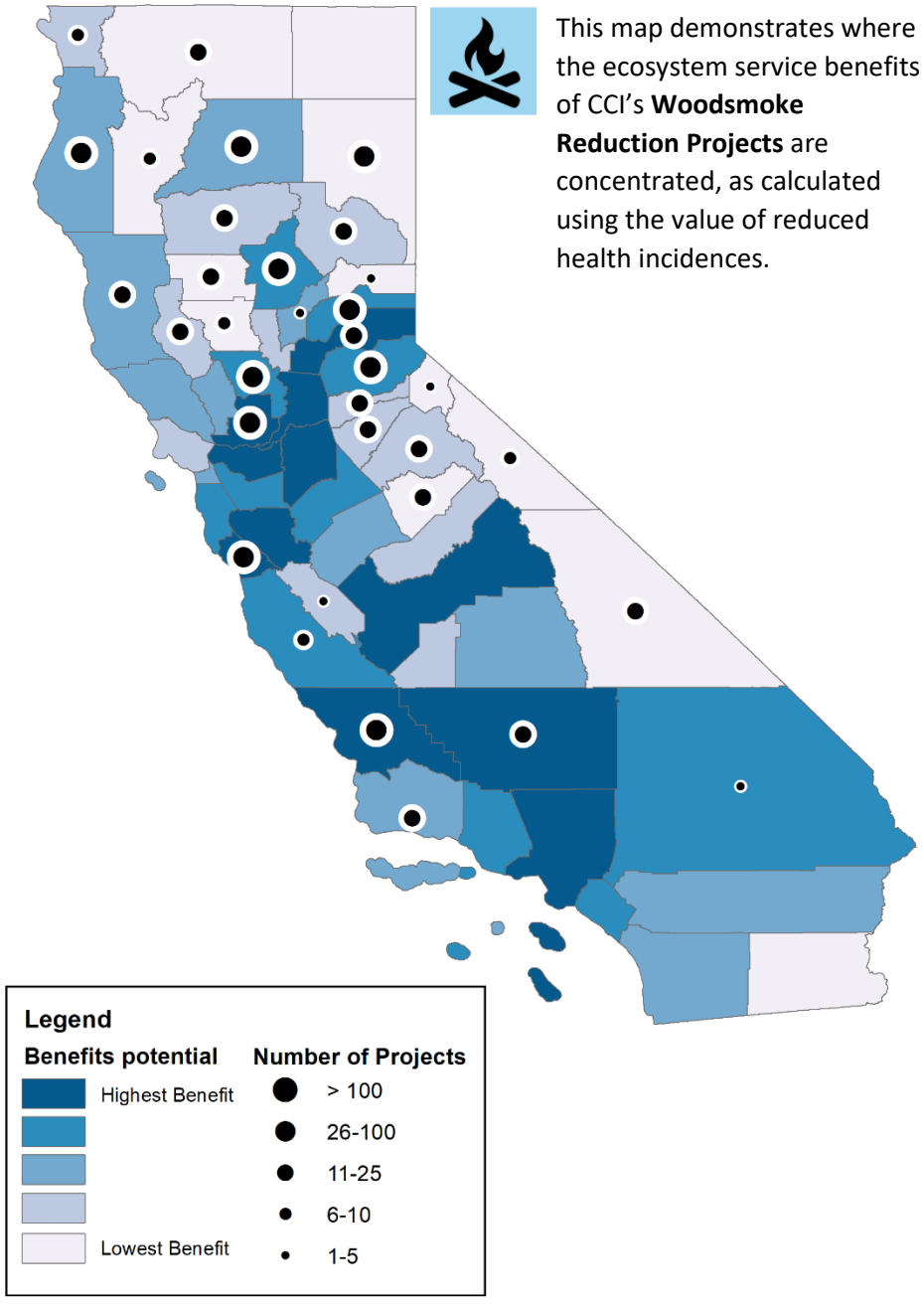
Sources and notes:

a. Data observed in CARB (2021). Average annual avoided $PM_{2.5}$ emissions consider projects implemented from 2018 to 2020.

b. Author calculations described in this report.

c. 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.

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WASTE DIVERSION

Waste Prevention and Food Rescue

Ecosystem Service Benefits

- Rescuing food waste, equivalent to 47 million meals, saved the public $150 million in meal costs annually.
- Diverting waste from landfills saved the public $27 million per year in landfill tipping fees.
- Reductions in food waste also increases food security and promotes human health by improving diets, increasing food availability, and avoiding the adverse impacts of agricultural production.
- Less green waste in landfills benefits human health by reducing landfill odors.
- New production of compost, recycled products, and biogas increases commercial revenues associated with those products.

OVERVIEW OF PROJECTS

Project activities

Divert waste from landfills through food rescue, waste prevention, recycling, composting, and anaerobic digestion

Implementing agencies

Department of Resources, Recycling, and Recovery and the Strategic Growth Council

112 projects

funded across 34 counties (2015-2020)

570,000 tons

of waste diverted from landfills per year

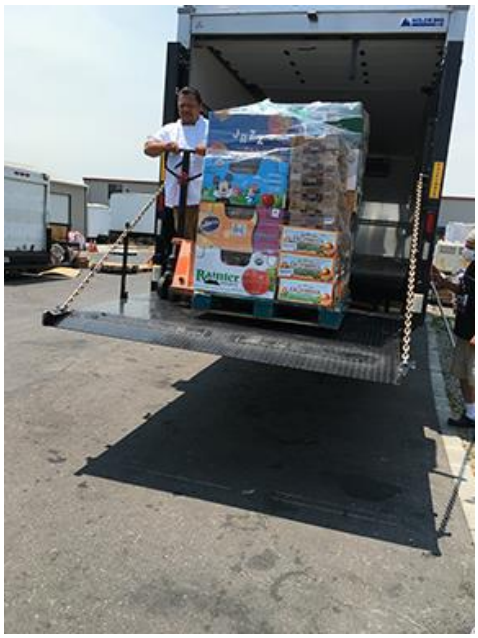
28,000 tons

of food rescued per year

Between 2015 and 2020, CCI invested in 112 projects through the Waste Diversion Program managed by the Department of Resources, Recycling, and Recovery and the Transformative Climate Communities Program managed by the Strategic Growth Council (CARB 2021). The primary activities of these projects are rescuing food and diverting waste from landfills through waste prevention, recycling, composting, and anaerobic digestion. Projects funded by CCI during this six-year period rescued 28,000 tons of food and diverted 570,000 tons of waste, annually (CARB 2021). These projects existed in 34 counties throughout California. The two counties with the greatest amount of rescued food are Alameda and Los Angeles, and the two counties that diverted the most waste are Tulare and San Bernardino.

This analysis documents the societal benefits related to rescuing food and diverting waste from landfills. Appendix page A-12 and page A-13 describe the pathways through which these projects generate environmental changes as well as ecosystem service benefits. Waste diversion avoids landfill costs, reduces landfill odors, and generates commercial revenue for composting, recycling, and anaerobic digestion facilities. Food rescue increases food availability, while saving on meal costs. To demonstrate how people value these services, the analysis includes information on two different quantitative measures: 1) avoided costs of landfilling and 2) avoided meal costs. In addition to these benefits, the analysis also considers the effect of food rescue on food security and human health. Finally, the effect of waste diversion on commercial revenues and landfill odors are summarized.

Avoided meal costs.



CCI invested in 72 food rescue projects, which reclaim high-quality food and deliver it to food banks, food pantries, and other organizations that distribute meals to low-income and underserved populations. The primary benefit of food rescue projects is associated with improvements in the physical and mental health of recipients, which lead to reductions in health care costs and increases in worker productivity. However, while the literature on adverse impacts of food security is extensive, there are few studies that have focused on quantifying the impacts of food banks and food pantries on health outcomes and potential changes in health care costs.

In lieu of this information, this analysis values the benefits of these food rescue projects by estimating the cost savings associated with the total number of meals saved. The 72 food rescue projects reclaimed a total of nearly 28,000 tons of food per year, which is equivalent to approximately 47 million meals.[100] The U.S. Department of Agriculture (USDA's Thrifty Food Plan provides estimates for food costs across all age groups. Using Census data to weight each of these estimates according to the age distribution of California's population—and adjusting all values to account for California's high cost of living—this analysis finds that meals on the Thrifty Food Plan cost $3.10 each. By multiplying this cost estimate with the total number of meals reclaimed each, this analysis finds that the 72 food rescue projects avoided approximately **$150 million** in costs, annually.

[100] Based on an average of 1.2 pounds per meal (Feeding America n.d.).

Improved diet and food availability.
Each of the 72 CCI-funded food rescue projects delivers reclaimed, high-quality food to food banks, food pantries, and other organizations that distribute meals to low-income and underserved populations. These organizations are essential to improving the nutrient intake of California's most vulnerable people. A Texas study found that a local food pantry accounted for more than half of its recipients' daily intake of energy, carbohydrates, vitamin B6, phosphorus, copper, and selenium (Mousa and Freeland-Graves 2017). Though the study found that the food pantry failed to fully meet some of the dietary needs of its recipients, it concludes that food pantries are an important resource for improving the nutrient intake of low-income populations.

By delivering some 28,000 tons of food to these organizations each year, CCI-funded food rescue projects could significantly improve the physical and mental health of recipients, leading to reductions in health care costs and increases in productivity. For example, it is well documented that malnourishment in children under the age of five can severely and irreversibly undermine cognitive development (Prado and Dewey 2014; Krebs et al. 2017; Black et al. 2017). Addressing malnourishment by increasing food availability could both lower children's healthcare needs and substantially improve their life-long earnings potential. Though the literature has not been developed enough to quantify these benefits, the amount of food rescued by CCI's projects indicates these benefits could be substantial. In addition, seven of the food rescue projects operate in school settings and are expected to provide educational opportunities for school-aged children.

Avoided costs of landfilling.
All 112 projects diverted waste from landfills for other beneficial uses, such as composting, recycling, and/or the redistribution of food to feed people. In addition to reducing greenhouse gas emissions, the primary ecosystem benefits of waste diversion include extending the lifespan of existing local landfills, reducing odors to properties located adjacent to landfills, and attenuating existing inefficiencies in consumption behaviors (e.g., food rescue) and/or product supply chains (e.g., recycling).

To estimate the economic value associated with these and other benefits, this analysis relies on tipping fees as a proxy for the overall benefit of avoided landfilling. Though tipping fees are not a precise measure of the value of reducing a ton of waste to people's well-being, they capture enough of the costs associated with waste to serve as a lower bound estimate of the value of waste diversion. Indeed, tipping fees account for the up-front costs of purchasing land to site and construct a landfill, annual operations and maintenance costs to receive and process waste, and additional facility measures designed to minimize and monitor for potential adverse impacts of landfills on public health and the environment. Combined, the 112 CCI projects diverted 570,000 tons of green waste from landfills on an annual basis. According to Department of Resources, Recycling, and Recovery analysis, the average tipping fee for green waste is $47.35 (CalRecycle 2015). By multiplying the average tipping fee for green

waste with the total number of tons of waste diverted, this analysis finds that the 112 waste diversion projects avoided approximately **$27 million** in annual landfilling costs.

Commercial revenues associated with eco-friendly waste processing.
Commercial entities, such as composting, recycling, and anaerobic digestion facilities, received increased commercial revenues because of the 112 waste diversion projects. Since data on the facilities affected by the waste diversion projects are not available, this analysis cannot quantify the revenue gains of these facilities. However, it is safe to assume that redirecting some portion of the 570,000 tons of waste from landfills to these facilities on an annual basis significantly benefited these revenue streams. In addition, the increased business likely allowed these facilities to create local green jobs, thereby stimulating regional economic activity.

Human health and well-being benefits of reduction in odors.
Projects that divert green waste have the added benefit of reducing odors generated by landfills. As waste undergoes the complex physiochemical processes of decomposition, landfills emit odor pollution that adversely affects the quality of life of nearby households (Palmiotto et al. 2014). The public has demonstrated a strong preference to avoid these externalities. For example, it is well documented that the presence of landfills negatively affects property values (Reichert et al. 2020; Nelson et al. 1992). By diverting 570,000 tons of waste from landfills on an annual basis, the 112 CCI-funded waste diversion projects may reduce the volume of pungent gas emitted by Californian landfills. To the extent that this reduction substantively reduces landfill-related odors, households within close proximity to these landfills may gain health and welfare benefits from the cleaner air.

Avoided adverse impacts of agricultural production.
Finally, food rescue projects have the potential to reduce demand for new food, which in turn may reduce the environmental consequences of agricultural production. As the USDA states, “when food is wasted, so too is the land, water, labor, energy, and other inputs that are used in producing, processing, transporting, preparing, storing, and disposing of the discarded food” (USDA n.d.). The more food gets discarded, the more agricultural producers need to compensate to keep everybody fed. Large-scale agricultural production causes environmental harm, such as undermining water-quality due to manure and chemical run off. By reducing food waste and redistributing excess food to those in need, food rescue projects have the potential to increase the efficiency of existing agricultural production processes and in turn avoid the adverse environmental impacts associated with agricultural production of delivered meals.

Table 14: Summary of Monetized Ecosystem Service Benefits for the Waste Prevention and Food Rescue Projects by County (2021 dollars)

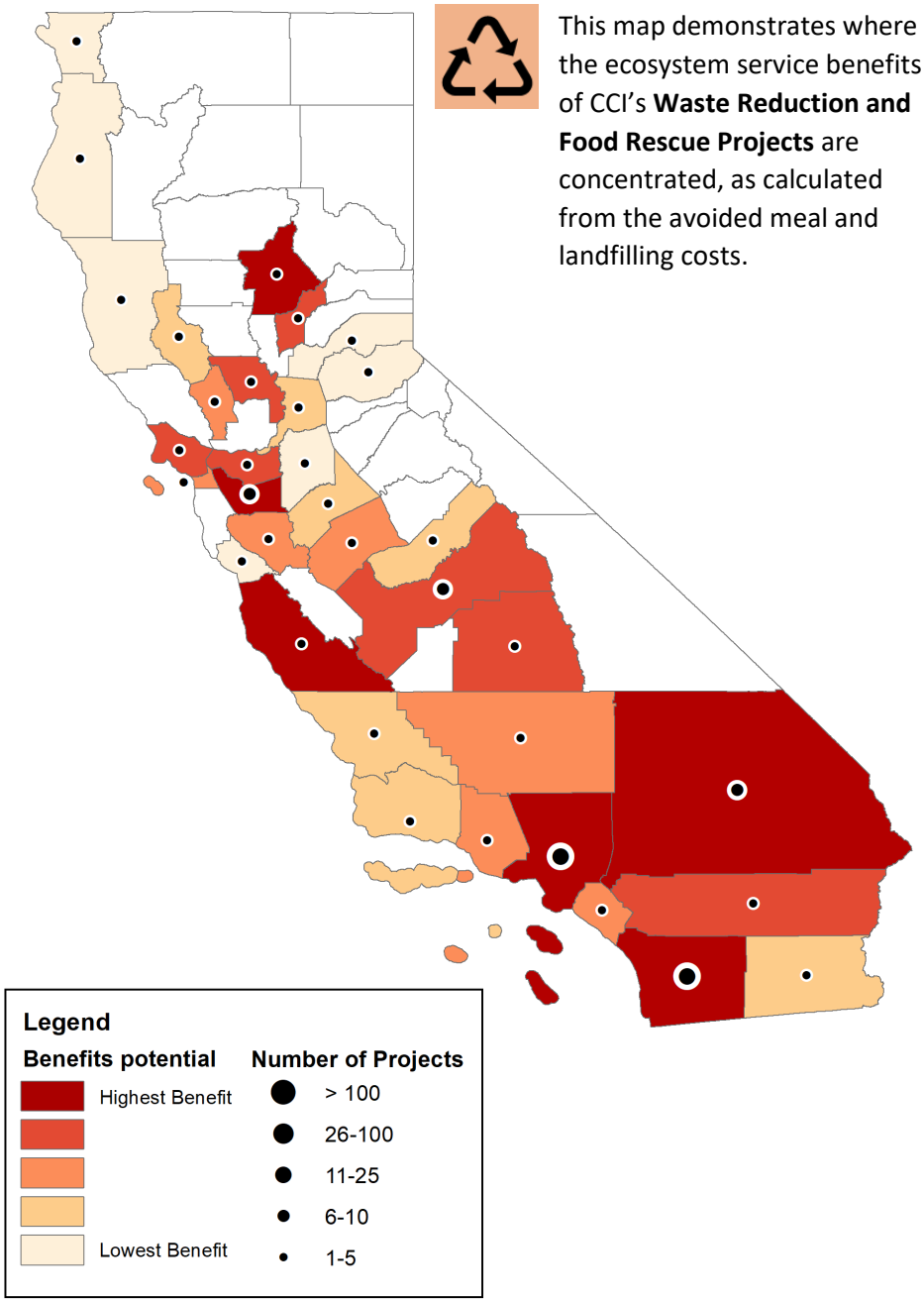
County	Tons of Food Rescued (Annual)[a]	Tons of Waste Diverted from Landfills (Annual)[a]	Avoided Meal Costs (Annual)[b]	Avoided Costs of Landfilling (Annual)[b]
Alameda	12,000	49,000	$61,000,000 - $64,000,000	$2,300,000
Butte	1,200	17,000	$6,100,000 - $6,400,000	$820,000
Contra Costa	930	930	$4,800,000 - $5,100,000	$44,000
Del Norte	27	72	$140,000 - $140,000	$3,400
El Dorado	77	77	$400,000 - $420,000	$3,600
Fresno	470	45,000	$2,400,000 - $2,500,000	$2,100,000
Humboldt	28	28	$150,000 - $150,000	$1,300
Imperial	250	250	$1,300,000 - $1,400,000	$12,000
Kern	250	250	$1,300,000 - $1,400,000	$12,000
Lake	150	4,800	$780,000 - $820,000	$230,000
Los Angeles	5,800	57,000	$30,000,000 - $31,000,000	$2,700,000
Madera	--	26,000	--	$1,200,000
Marin	530	530	$2,800,000 - $2,900,000	$25,000
Mendocino	--	5,400	--	$260,000
Merced	370	370	$1,900,000 - $2,000,000	$17,000
Monterey	1,400	9,500	$7,000,000 - $7,400,000	$450,000
Napa	240	7,900	$1,200,000 - $1,300,000	$370,000
Orange	370	390	$1,900,000 - $2,000,000	$18,000
Placer	42	110	$220,000 - $230,000	$5,300
Riverside	370	36,000	$1,900,000 - $2,000,000	$1,700,000
Sacramento	180	180	$950,000 - $1,000,000	$8,700
San Bernardino	730	100,000	$3,800,000 - $4,000,000	$4,700,000
San Diego	1,400	13,000	$7,400,000 - $7,800,000	$630,000
San Francisco	350	470	$1,800,000 - $1,900,000	$22,000
San Joaquin	--	10,000	--	$500,000
San Luis Obispo	160	5,000	$820,000 - $860,000	$240,000
Santa Barbara	14	18,000	$72,000 - $76,000	$870,000
Santa Clara	270	270	$1,400,000 - $1,400,000	$13,000

County	Tons of Food Rescued (Annual)[a]	Tons of Waste Diverted from Landfills (Annual)[a]	Avoided Meal Costs (Annual)[b]	Avoided Costs of Landfilling (Annual)[b]
Santa Cruz	42	42	$220,000 - $230,000	$2,000
Stanislaus	--	22,000	--	$1,000,000
Tulare	--	88,000	--	$4,200,000
Ventura	260	260	$1,400,000 - $1,400,000	$12,000
Yolo	770	3,800	$4,000,000 - $4,200,000	$180,000
Yuba	--	52,000	--	$2,500,000
Statewide Total	**28,000**	**570,000**	**$150,000,000**	**$27,000,000**

Sources and notes:

1. Data observed in CARB (2021). The average annual calculations consider projects implemented from 2015 to 2020.
2. 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 16: Spatial Distribution of Ecosystem Service Benefits Potential for the Waste Diversion and Food Rescue Projects



Note: The benefit potential conveyed in the avoided meal costs and avoided landfilling costs presented in Table 14.

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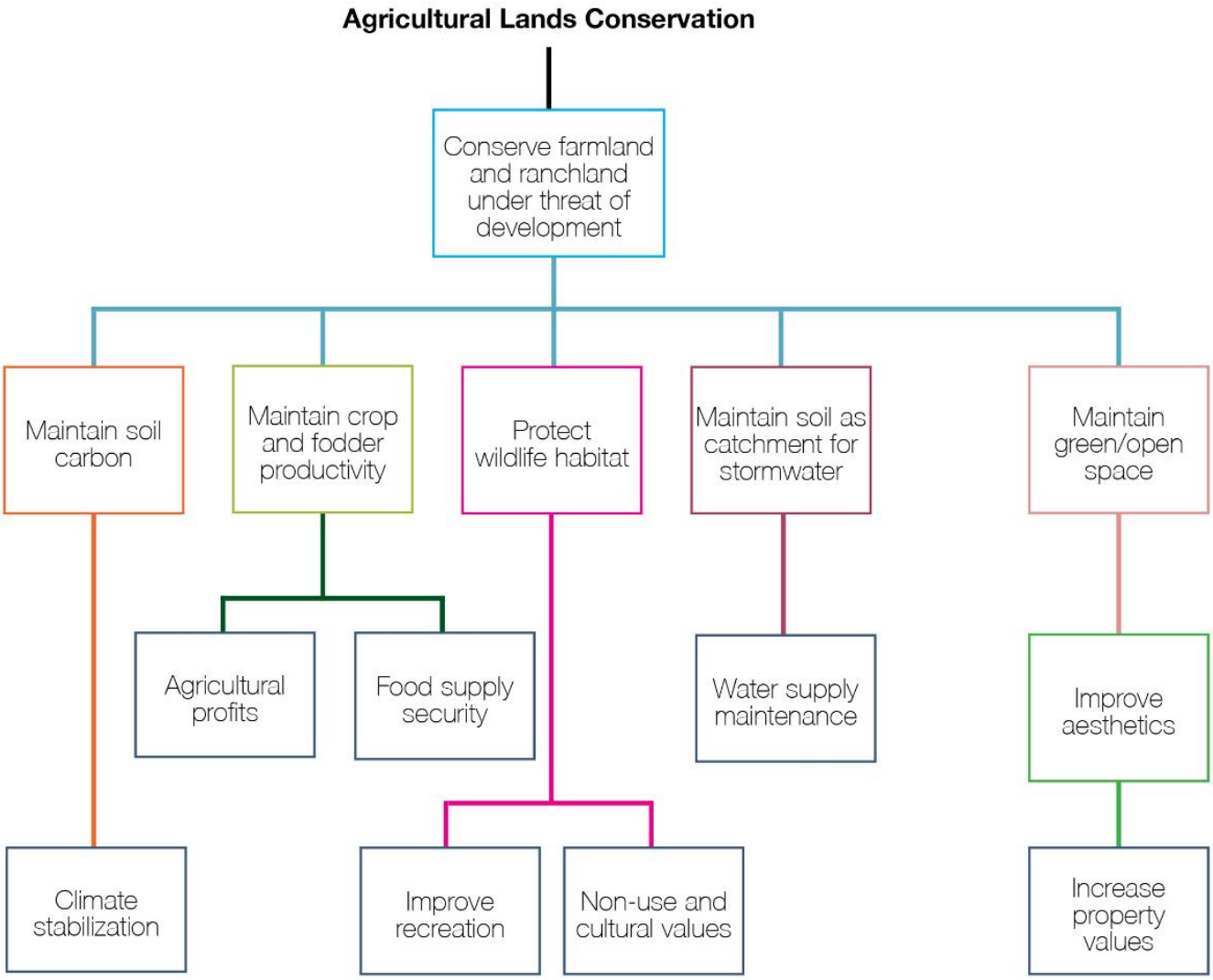
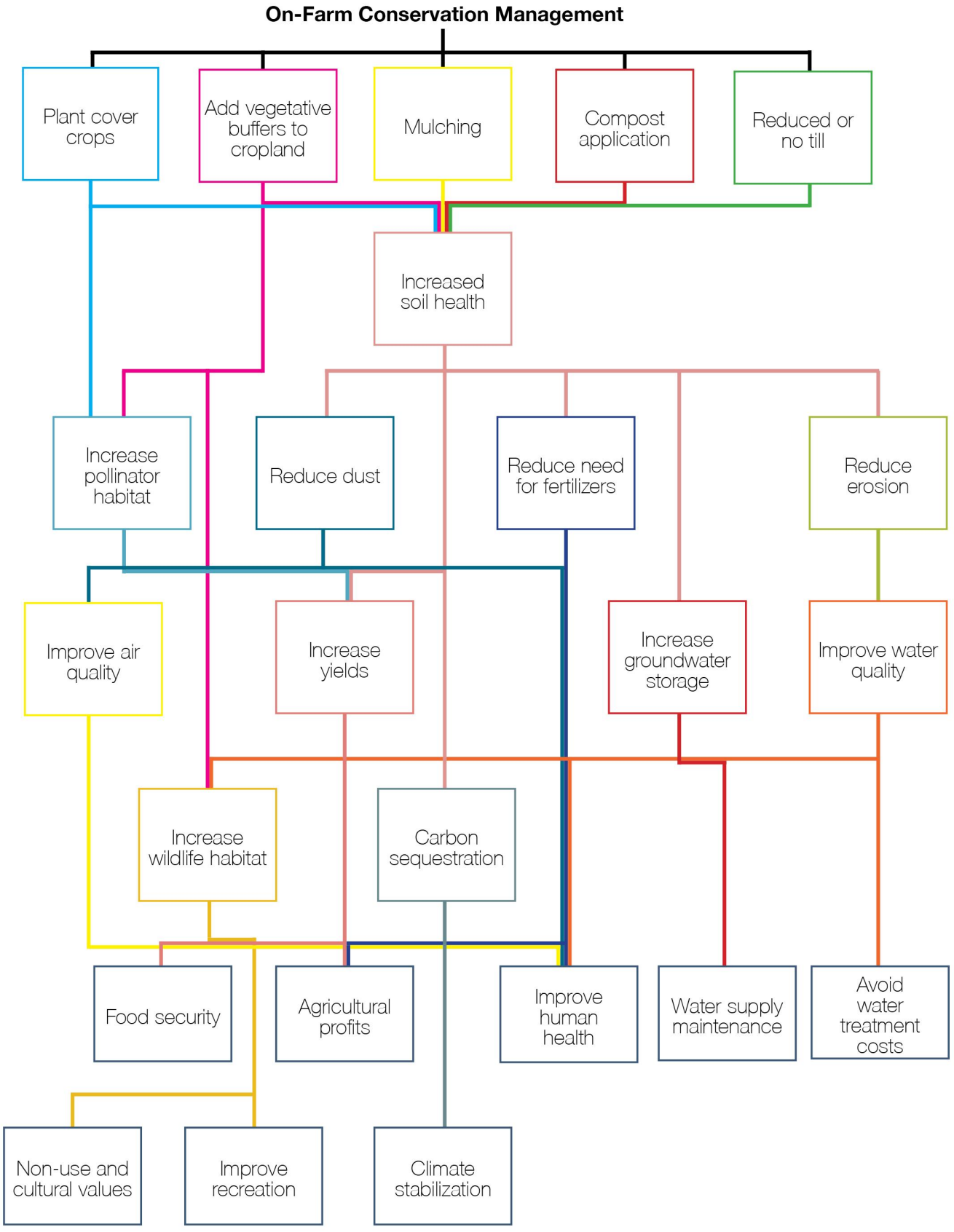
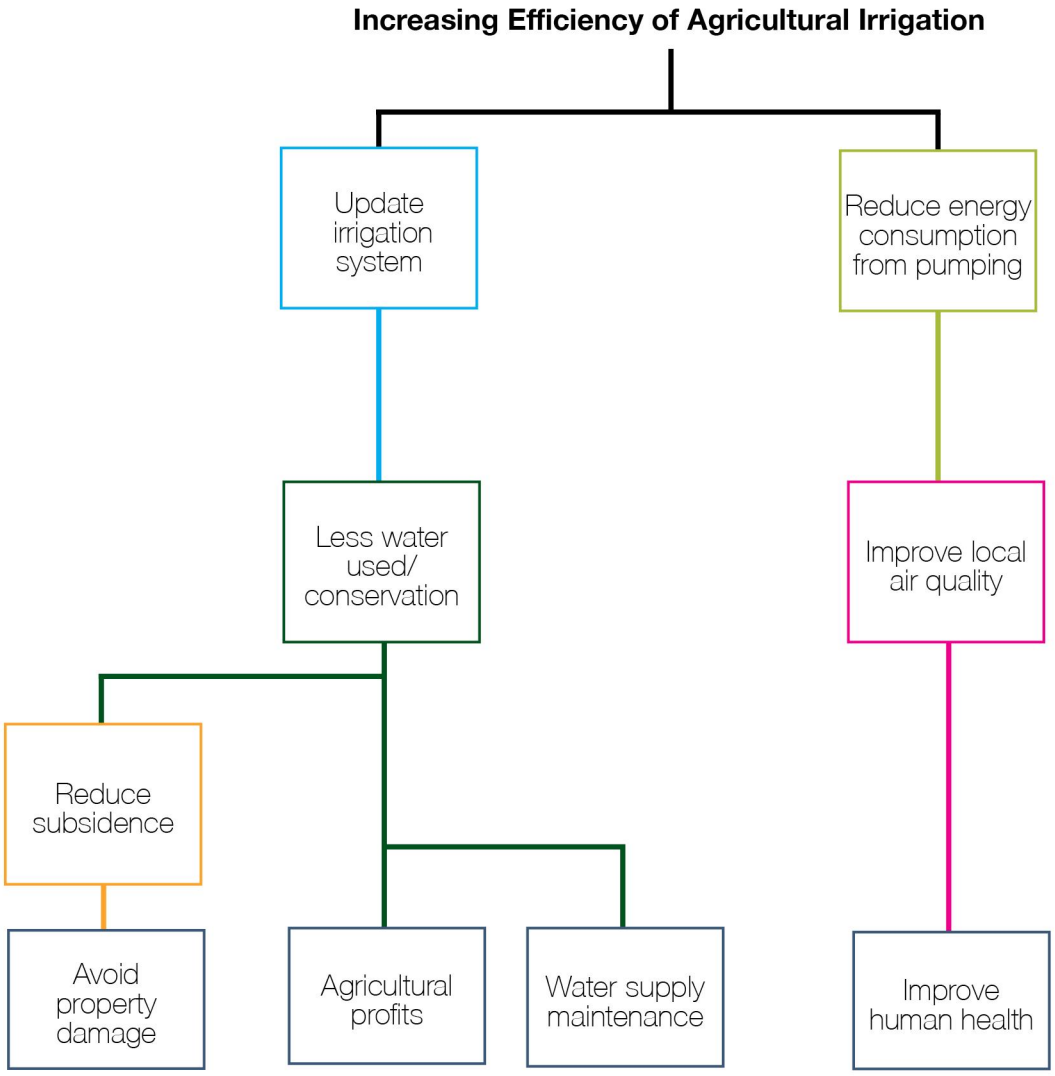
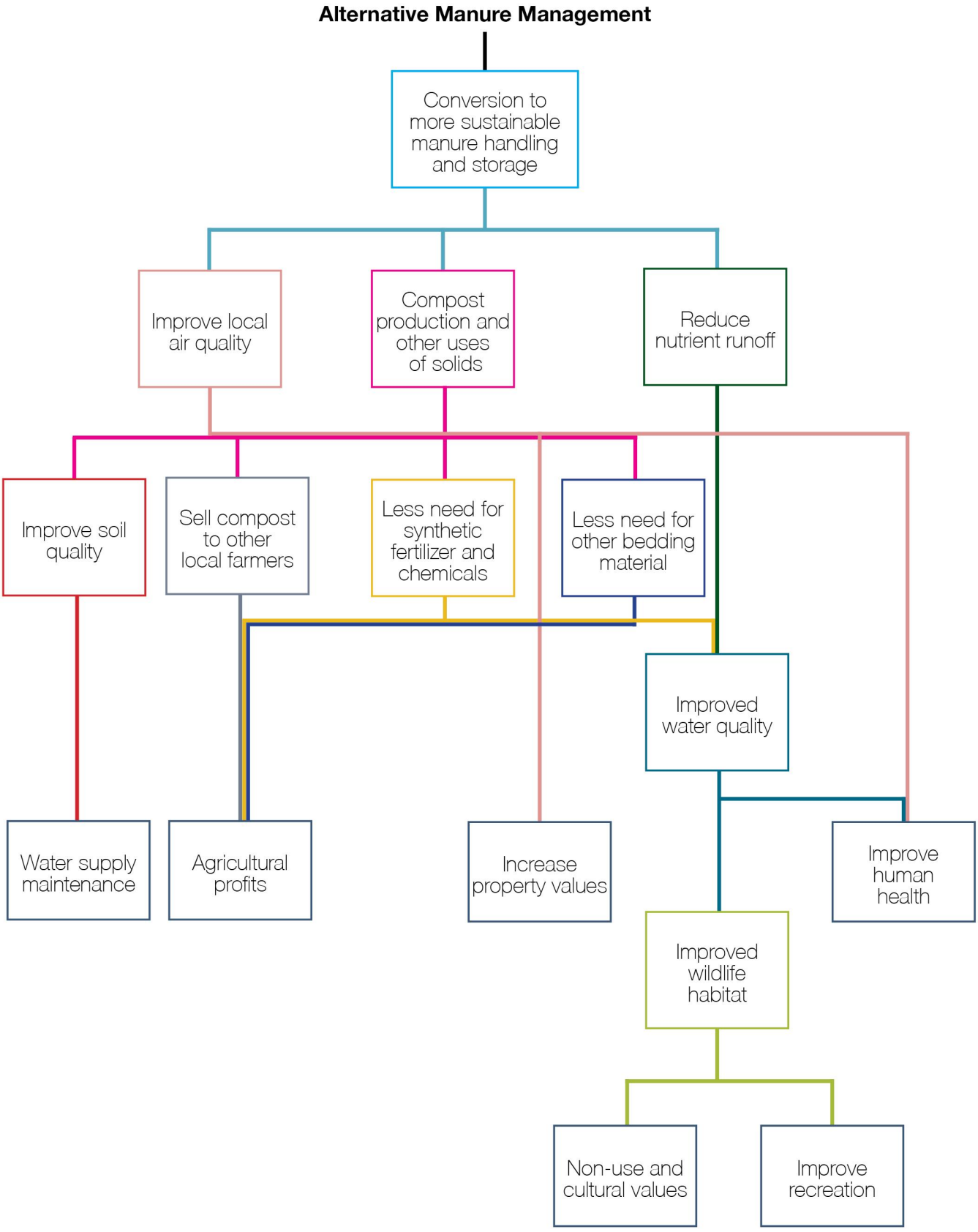
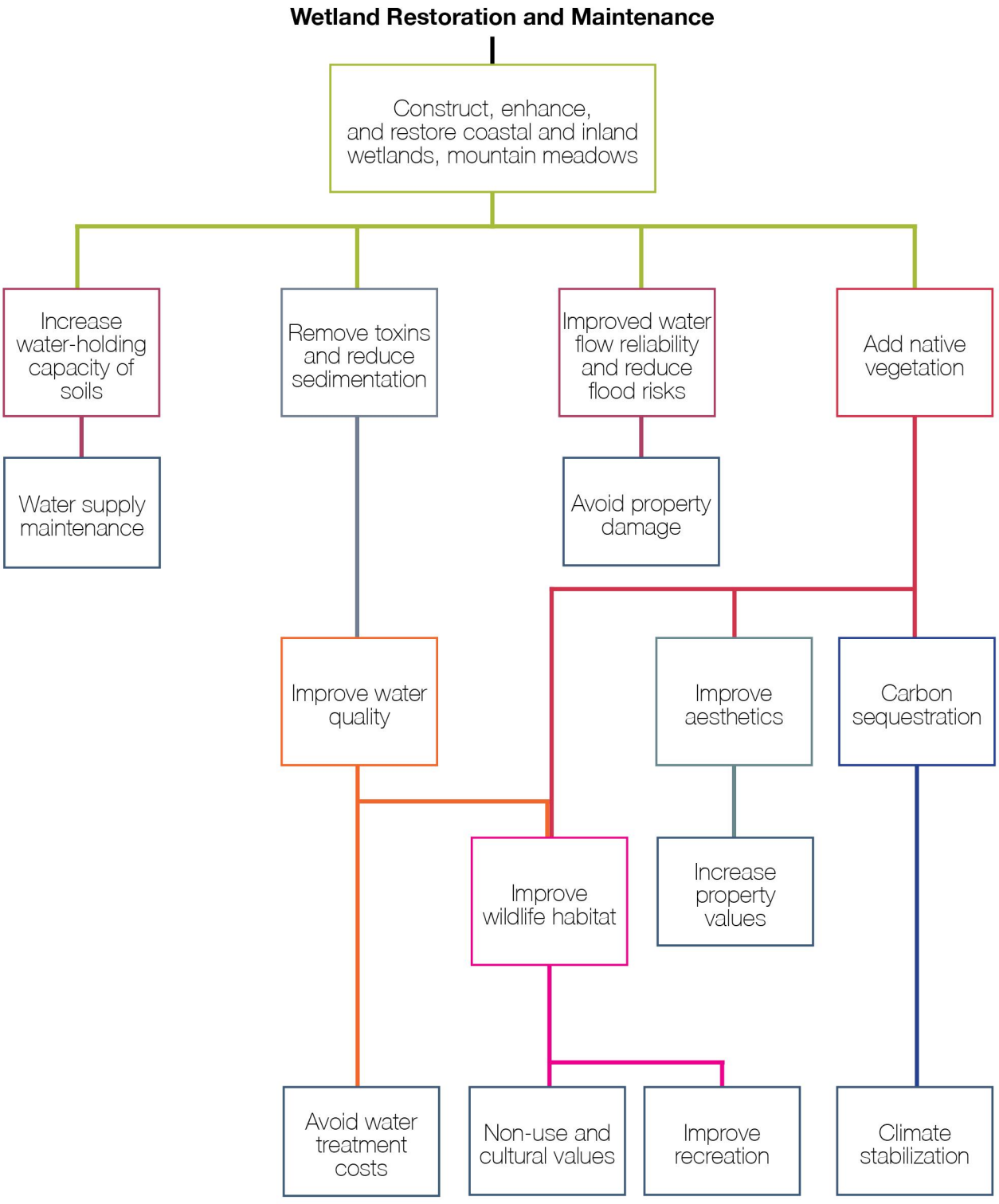
Appendix: Conceptual Flow Diagrams

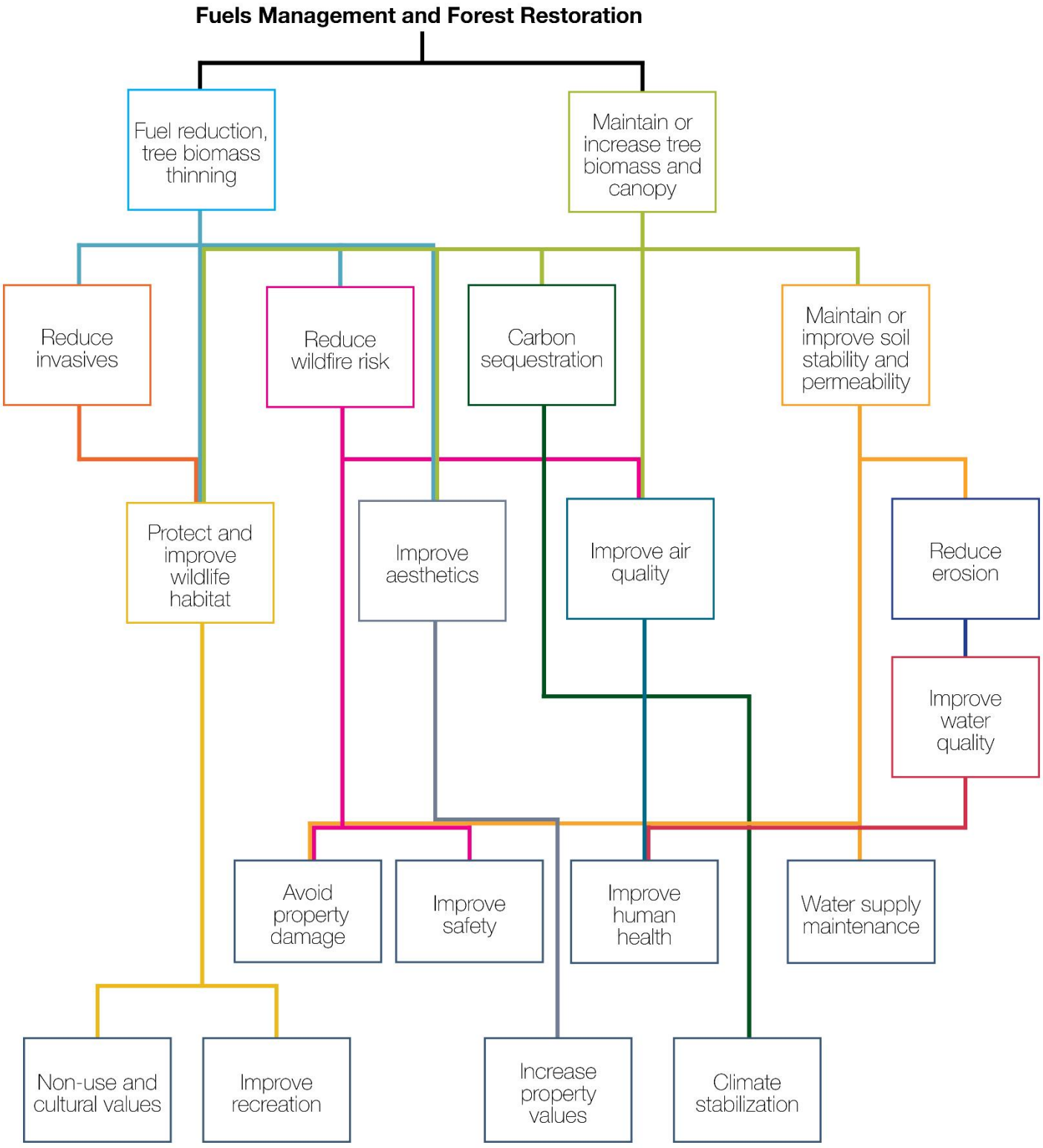

Agricultural Lands Conservation
Conserve farmland and ranchland under threat of development
Maintain soil carbon
Maintain crop and fodder productivity
Protect wildlife habitat
Maintain soil as catchment for stormwater
Maintain green/open space
Agricultural profits
Food supply security
Water supply maintenance
Improve aesthetics
Climate stabilization
Improve recreation
Non-use and cultural values
Increase property values

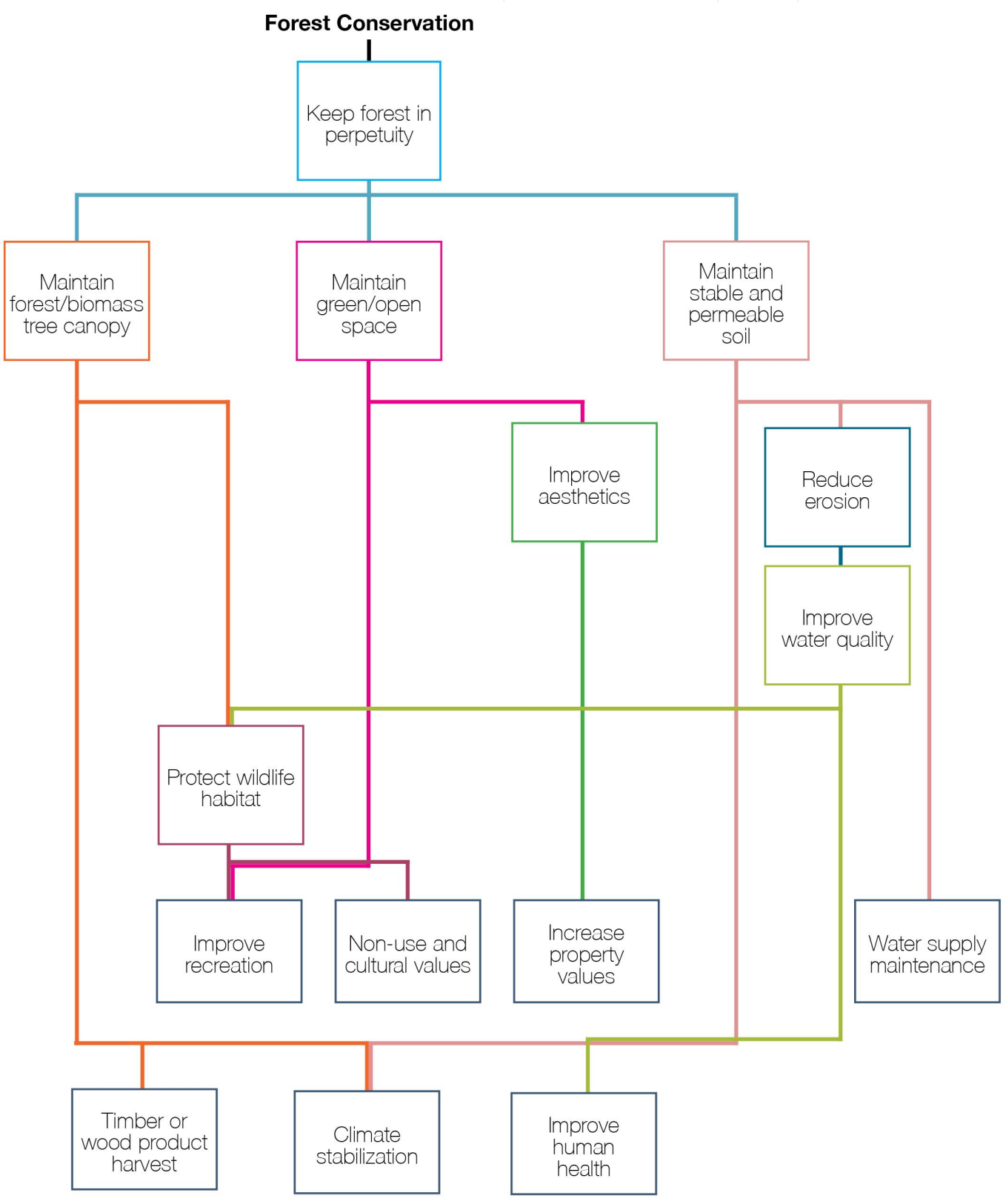

On-Farm Conservation Management
Plant cover crops
Add vegetative buffers to cropland
Mulching
Compost application
Reduced or no till
Increased soil health
Increase pollinator habitat
Reduce dust
Reduce need for fertilizers
Reduce erosion
Improve air quality
Increase yields
Increase groundwater storage
Improve water quality
Increase wildlife habitat
Carbon sequestration
Food security
Agricultural profits
Improve human health
Water supply maintenance
Avoid water treatment costs
Non-use and cultural values
Improve recreation
Climate stabilization

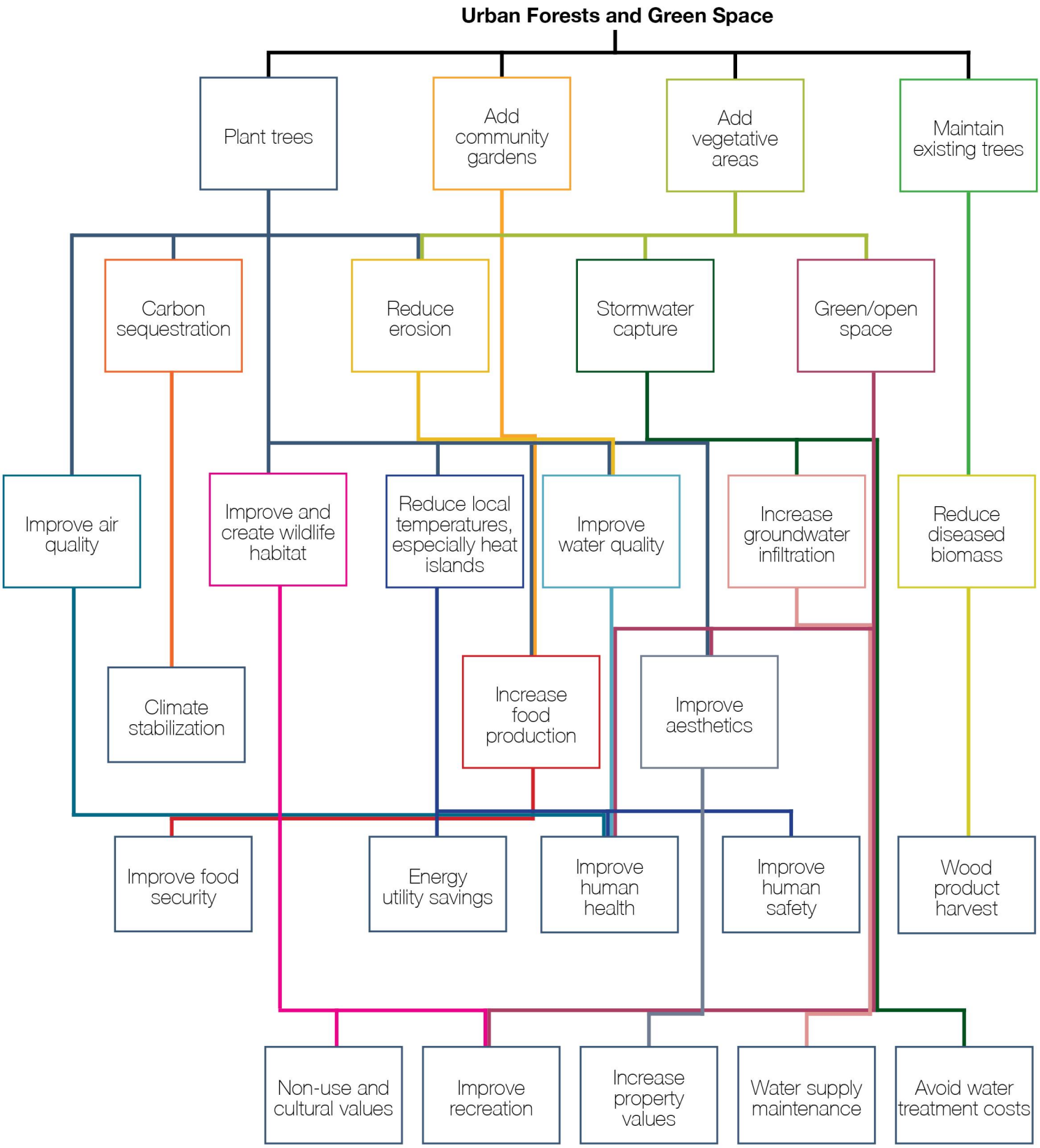

Increasing Efficiency of Agricultural Irrigation
Update irrigation system
Reduce energy consumption from pumping
Less water used/ conservation
Improve local air quality
Reduce subsidence
Avoid property damage
Agricultural profits
Water supply maintenance
Improve human health

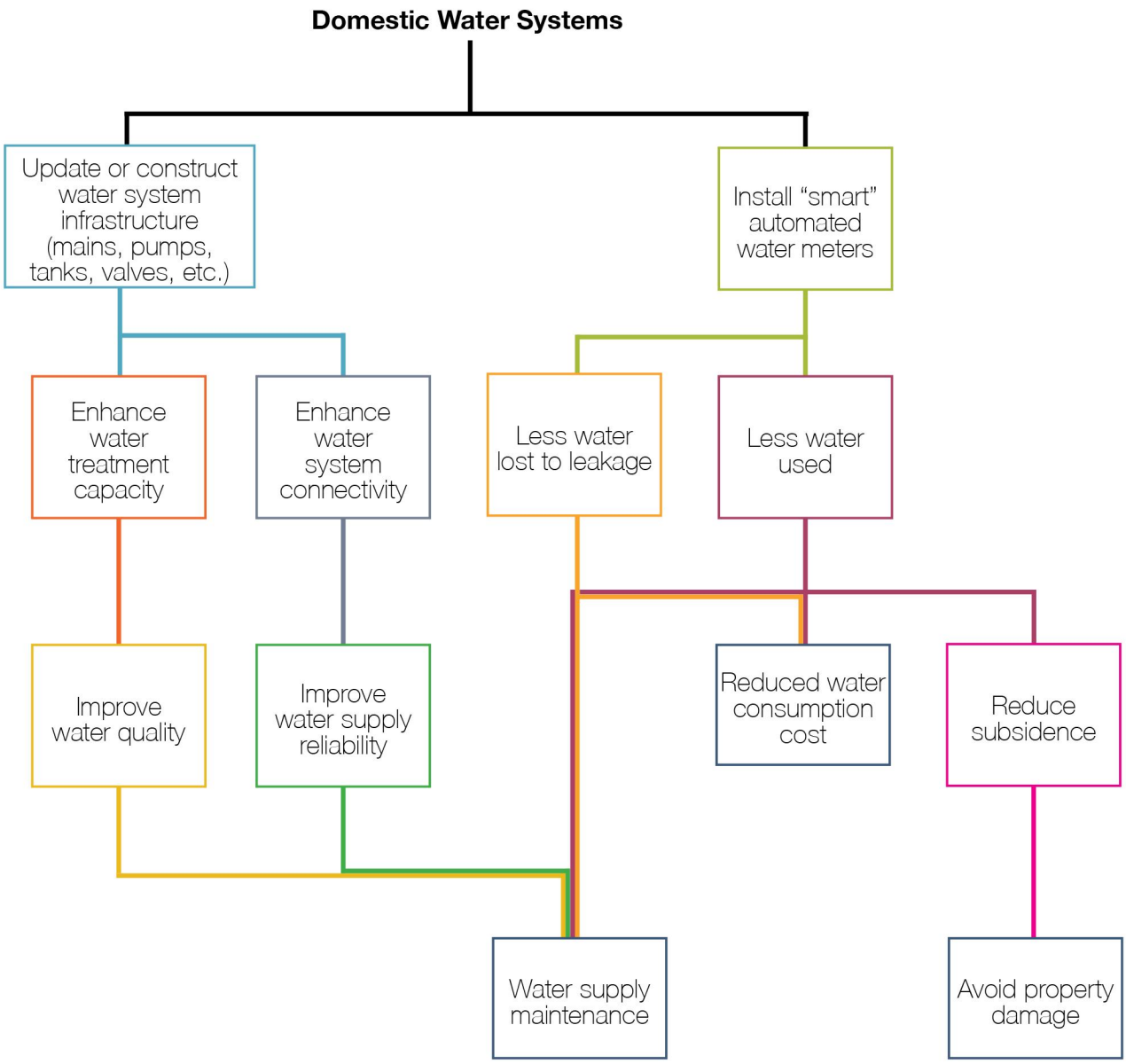

Alternative Manure Management
Conversion to more sustainable manure handling and storage
Improve local air quality
Compost production and other uses of solids
Reduce nutrient runoff
Improve soil quality
Sell compost to other local farmers
Less need for synthetic fertilizer and chemicals
Less need for other bedding material
Improved water quality
Water supply maintenance
Agricultural profits
Increase property values
Improve human health
Improved wildlife habitat
Non-use and cultural values
Improve recreation

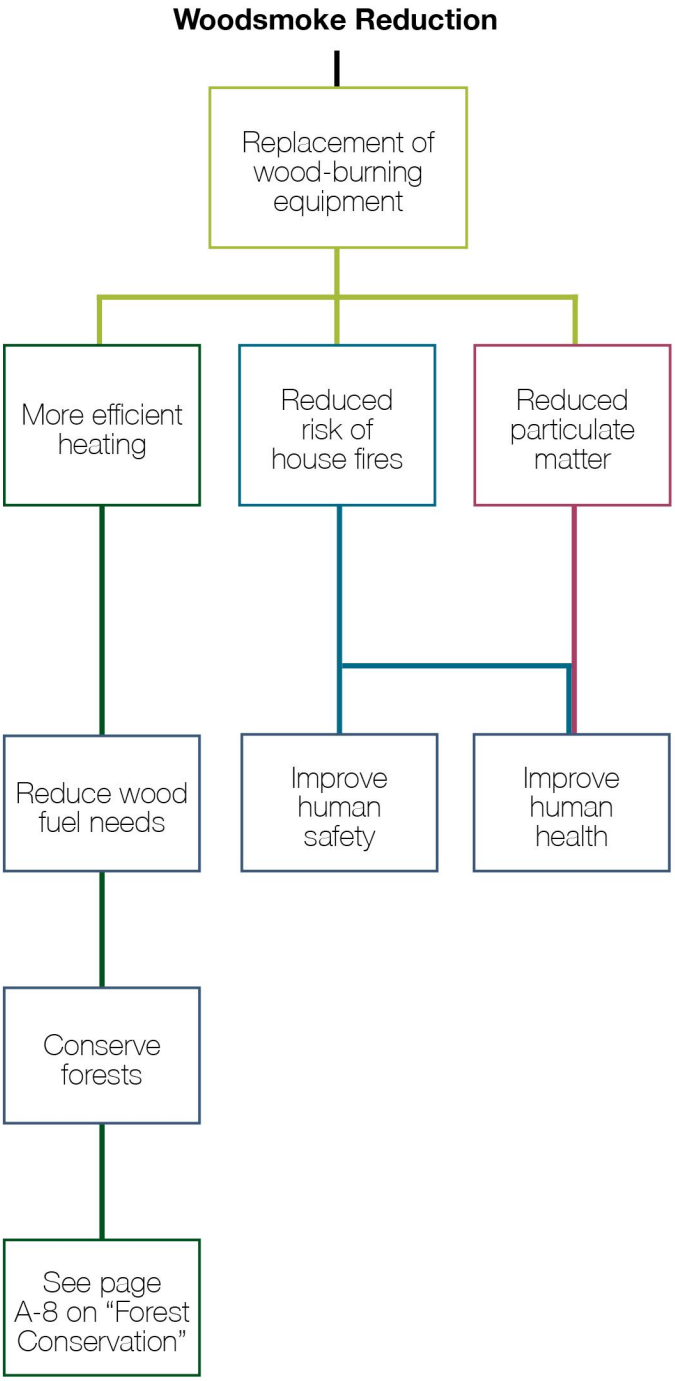

Wetland Restoration and Maintenance
Construct, enhance, and restore coastal and inland wetlands, mountain meadows
Increase water-holding capacity of soils
Remove toxins and reduce sedimentation
Improved water flow reliability and reduce flood risks
Add native vegetation
Water supply maintenance
Avoid property damage
Improve water quality
Improve aesthetics
Carbon sequestration
Improve wildlife habitat
Increase property values
Avoid water treatment costs
Non-use and cultural values
Improve recreation
Climate stabilization

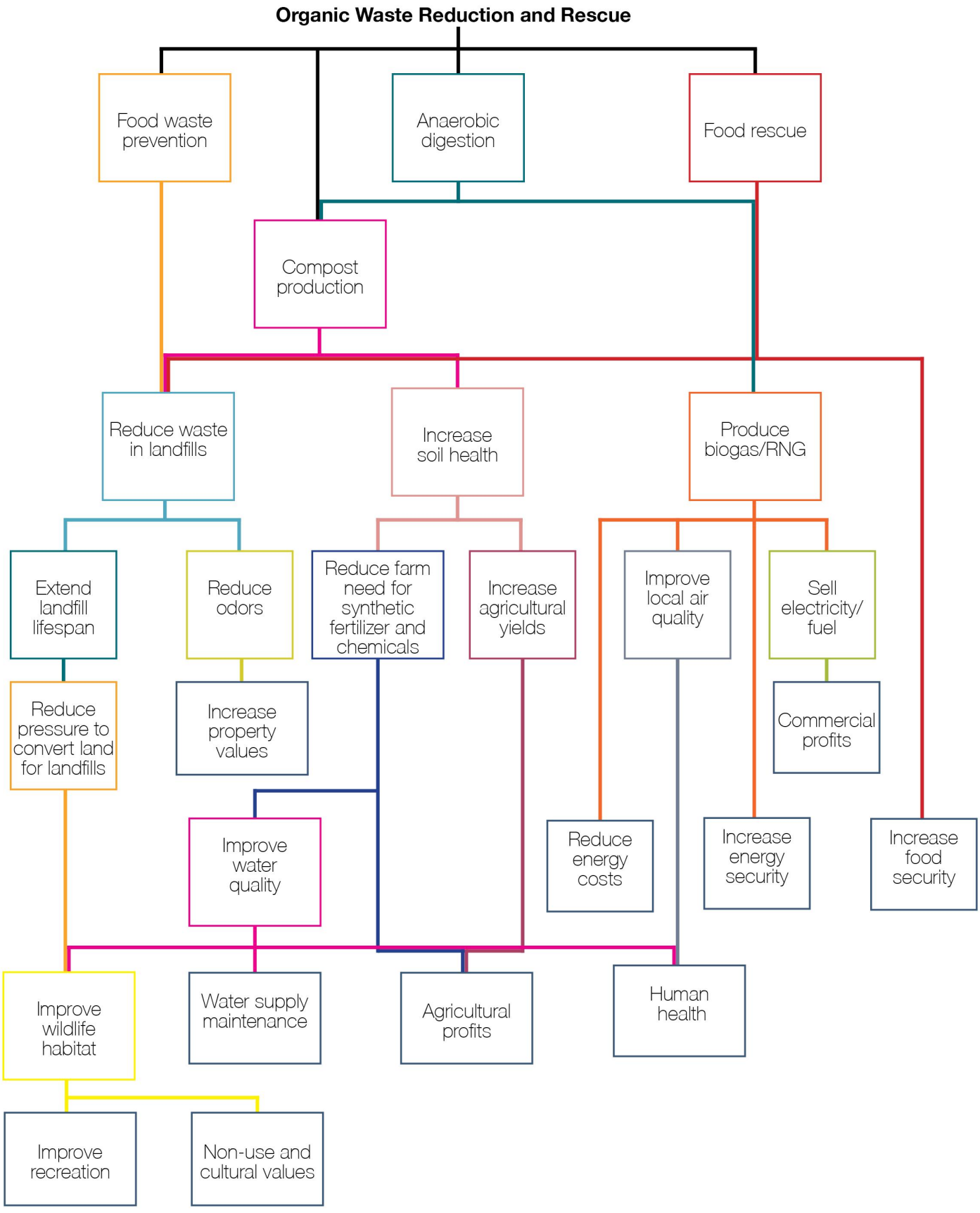

Fuels Management and Forest Restoration
Fuel reduction, tree biomass thinning
Maintain or increase tree biomass and canopy
Reduce invasives
Reduce wildfire risk
Carbon sequestration
Maintain or improve soil stability and permeability
Protect and improve wildlife habitat
Improve aesthetics
Improve air quality
Reduce erosion
Improve water quality
Avoid property damage
Improve safety
Improve human health
Water supply maintenance
Non-use and cultural values
Improve recreation
Increase property values
Climate stabilization

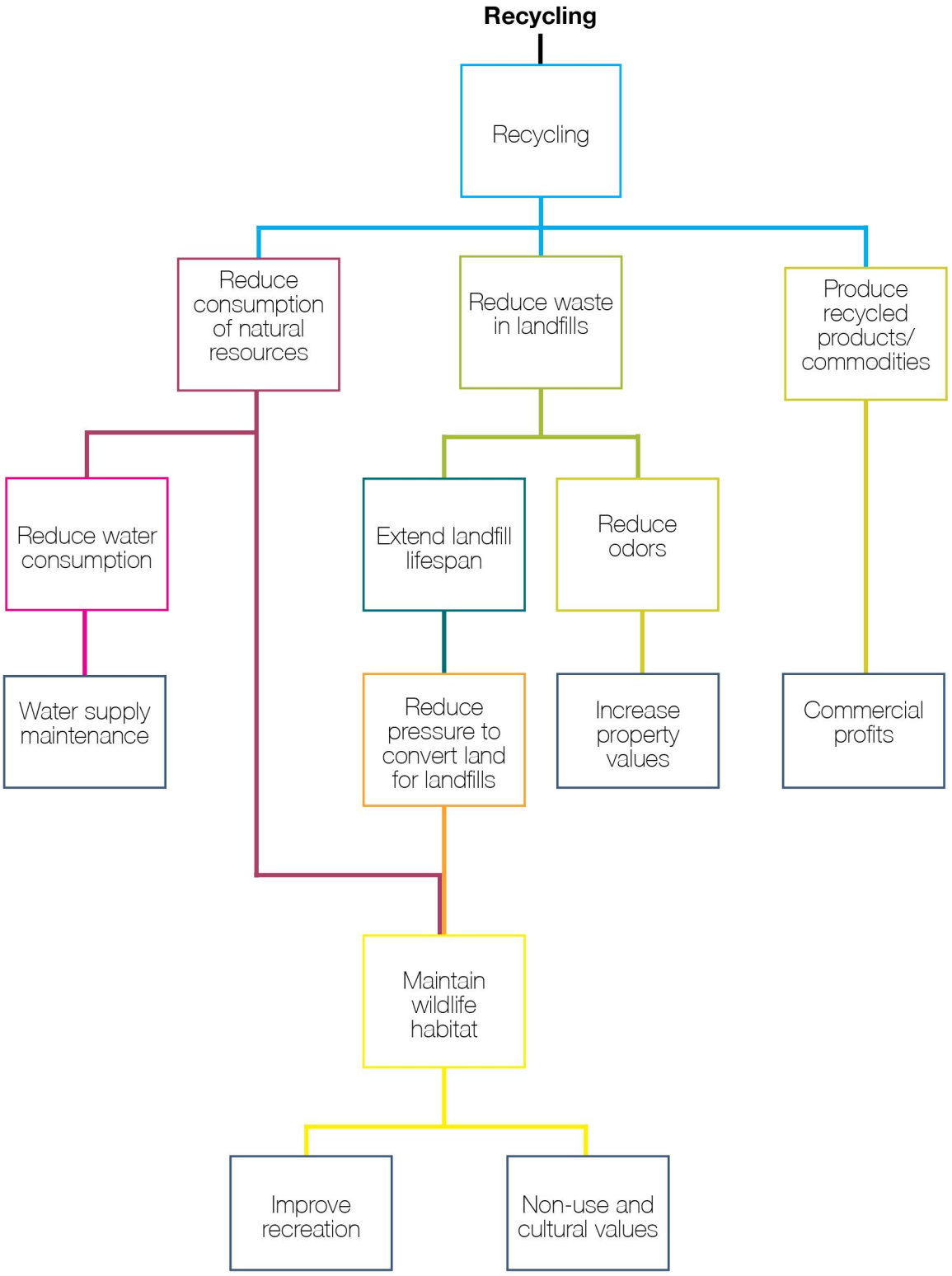

Forest Conservation
Keep forest in perpetuity
Maintain forest/biomass tree canopy
Maintain green/open space
Maintain stable and permeable soil
Improve aesthetics
Reduce erosion
Improve water quality
Protect wildlife habitat
Improve recreation
Non-use and cultural values
Increase property values
Water supply maintenance
Timber or wood product harvest
Climate stabilization
Improve human health


Urban Forests and Green Space
Plant trees
Add community gardens
Add vegetative areas
Maintain existing trees
Carbon sequestration
Reduce erosion
Stormwater capture
Green/open space
Improve air quality
Improve and create wildlife habitat
Reduce local temperatures, especially heat islands
Improve water quality
Increase groundwater infiltration
Reduce diseased biomass
Climate stabilization
Increase food production
Improve aesthetics
Improve food security
Energy utility savings
Improve human health
Improve human safety
Wood product harvest
Non-use and cultural values
Improve recreation
Increase property values
Water supply maintenance
Avoid water treatment costs


Domestic Water Systems
Update or construct water system infrastructure (mains, pumps, tanks, valves, etc.)
Install "smart" automated water meters
Enhance water treatment capacity
Enhance water system connectivity
Less water lost to leakage
Less water used
Improve water quality
Improve water supply reliability
Reduced water consumption cost
Reduce subsidence
Water supply maintenance
Avoid property damage


Woodsmoke Reduction
Replacement of wood-burning equipment
More efficient heating
Reduced risk of house fires
Reduced particulate matter
Reduce wood fuel needs
Improve human safety
Improve human health
Conserve forests
See page A-8 on "Forest Conservation"


Organic Waste Reduction and Rescue
Food waste prevention
Anaerobic digestion
Food rescue
Compost production
Reduce waste in landfills
Increase soil health
Produce biogas/RNG
Extend landfill lifespan
Reduce odors
Reduce farm need for synthetic fertilizer and chemicals
Increase agricultural yields
Improve local air quality
Sell electricity/ fuel
Reduce pressure to convert land for landfills
Increase property values
Commercial profits
Improve water quality
Reduce energy costs
Increase energy security
Increase food security
Improve wildlife habitat
Water supply maintenance
Agricultural profits
Human health
Improve recreation
Non-use and cultural values


Recycling
Recycling
Reduce consumption of natural resources
Reduce waste in landfills
Produce recycled products/ commodities
Reduce water consumption
Extend landfill lifespan
Reduce odors
Water supply maintenance
Reduce pressure to convert land for landfills
Increase property values
Commercial profits
Maintain wildlife habitat
Improve recreation
Non-use and cultural values