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

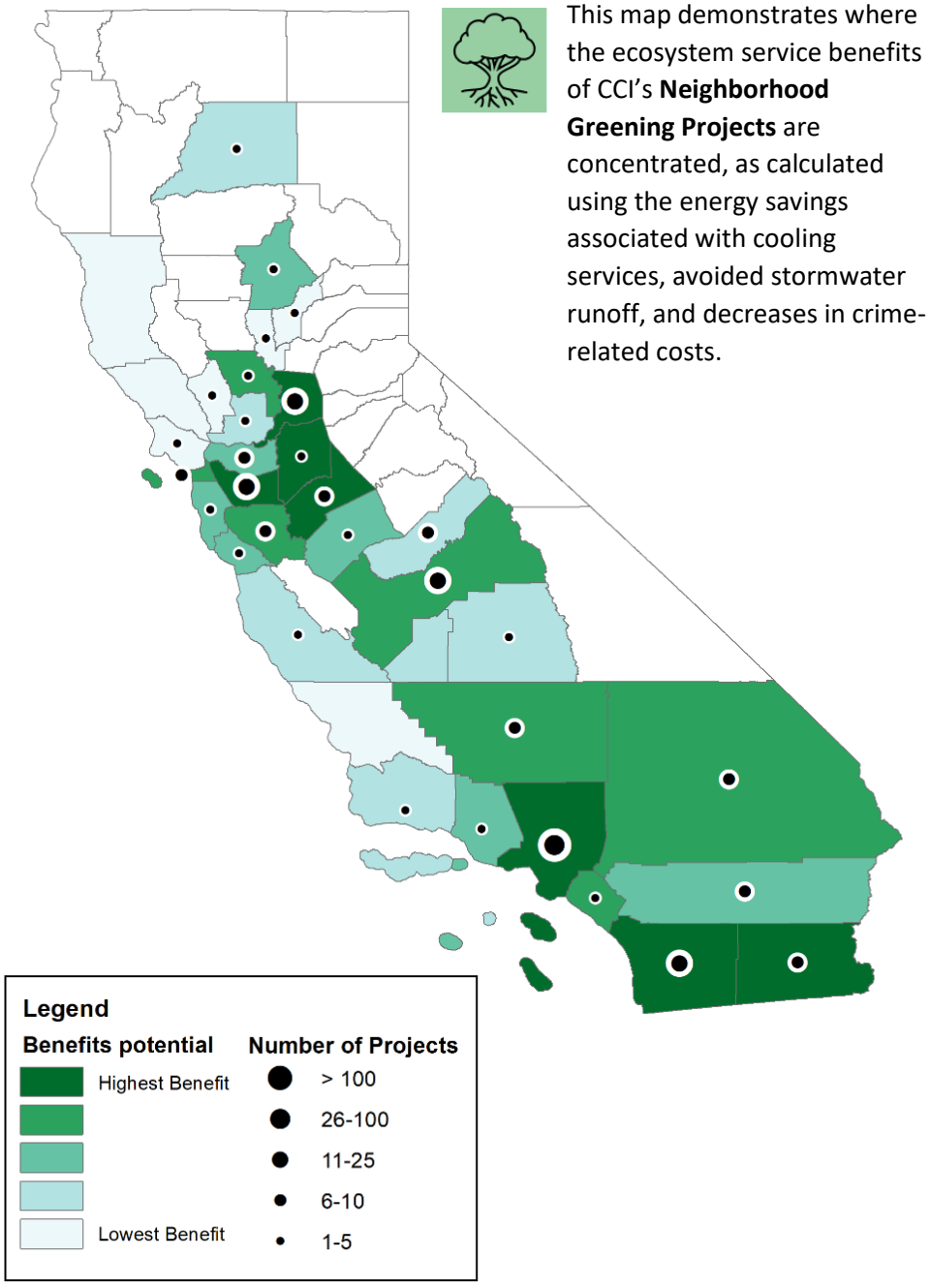
County	Total Trees Planted[a]	Avoided Cooling Energy Costs (Annual)[b]	Value of Stormwater Managed (Annual)[b]	Value of Decreased Violent Crime (Annual)[b]	Value of Decreased Property Crime (Annual)[b]	Increased Property Values (Annualized)[b]
Sutter	33	$1,300	$1,300	$2,100	$2,600	$490
Tulare	240	$9,500	$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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