Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Northern Research Station | Resource Bulletin NRS-134 | December 2024

San Diego's Urban Forest, 2017

Citation

Baer, Kathryn C.; Nowak, David J.; Brandeis, Thomas J.; Dooley, Kerry; Hellman, Kurt; Henning, Jason; Herrick, Christina; Hoehn, Robert E., III; Jennings, Katie; Lepine, Lucie, C.; Lister, Tonya W.; Majewsky, Mark; Owen, Suzanne; Sonti, Nancy F.; Schanning, Sjana; Zehnder, Rebekah J. 2024. **San Diego's urban forest, 2017.** Resource Bulletin NRS-134. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 95 p. https://doi.org/10.2737/NRS-RB-134.

Abstract

A 2017 analysis of the urban forest in San Diego, California, reveals that this area has an estimated 4.9 million live trees across all ownerships. The most common tree species by number are Chinese banyan, arroyo willow, Japanese cheesewood, Aleppo pine, and pygmy date palm. Trees in San Diego are estimated to store about 289,000 tons of carbon (1.1 million tons of carbon dioxide [CO_2]) valued at $49.3 million. In addition, it is estimated that these trees remove about 34,600 tons of carbon per year (or 127,000 tons CO_2 per year, valued at $5.9 million per year, an amount roughly equivalent to the annual emissions associated with 24,891 passenger vehicles or energy usage by 13,295 homes [https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator]) and about 421 tons of air pollution per year (valued at $3.9 million per year). San Diego's urban forest is estimated to reduce annual energy costs of residential buildings by $3.5 million per year. The overall compensatory value of the urban forest is estimated at $4.7 billion. Compensatory value describes the replacement value of trees as a structural asset, which tends to increase with tree size and health. The information presented in this report can be used to support urban forest management programs and to inform policy and planning to improve environmental quality and human health in San Diego. The analysis also provides a basis for monitoring changes in the urban forest over time.

Keywords: i-Tree; My City's Trees; tree volume and biomass; carbon sequestration and storage; urban Forest Inventory and Analysis; urban forest structure and health; urban forest values and ecosystem services

Cover photo: A South African coral tree (*Erythrina caffra*) overlooks the San Diego marina from Embarcadero Marina Park North. Courtesy photo by Brian Widener, City of San Diego, CA.

Published by:
USDA Forest Service
One Gifford Pinchot Drive
Madison, WI 53726
December 2024

Visit our website at: https://research.fs.usda.gov/nrs

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Acknowledgments

The authors would like to thank the many individuals who contributed to the collection, processing, management, and analysis of San Diego's urban forest inventory data. Primary field crew staff included Jessica Deans, Aric Devins, Michelle Gerdes, Ian Kottke, Brian Lewis, and Matthew O'Driscoll with help from Michelle Silva and John Mills. Special thanks to Paul Sowers and Deborah Boyer who were responsible for field sample selection and to Mark Hatfield for his expert assistance with the Universal National Information Management System (UNIMS) database. The authors also appreciate the contributions of Daniel C. Buckler, Elizabeth B. Larry, Phillip Rodbell, Natalie van Doorn, and Brian Widener who served as report reviewers and provided insightful, constructive comments.

EXECUTIVE SUMMARY

A row of Chinese banyan (*Ficus microcarpa*) and various palm trees in downtown San Diego. USDA Forest Service photo by John Mills.

The 2017 Urban Forest Inventory and Analysis (Urban FIA) assessment of the City of San Diego includes estimates of the magnitude, composition, and value of its urban forest resource. The sampled area of the city (representing a total of 169,844 acres) is estimated to contain 4.9 million live trees, 63.4 percent of which are less than 5.0 inches in **diameter.**[1] The most common tree species[2] of at least one inch in diameter are Chinese banyan, arroyo willow, Japanese cheesewood, Aleppo pine, and pygmy date palm. Of these species, all but pygmy date palm are among the five most common species in the smallest diameter class (less than 5.0 inches). The most common large-diameter tree species (11.0+ inches in diameter) are Washington fan palm, melaleuca, queen palm, Canary Island pine, and date palm. The most important species based on the number of trees and tree size are Chinese banyan, arroyo willow, and queen palm.

[1] See glossary for definition of bolded terms.

[2] Common and scientific names for all tree species observed in the Urban FIA inventory of San Diego are reported in Appendix 2.

While less numerous, native species such as California live oak, California sycamore, arroyo willow, and Torrey pine are also valued components of the forest.

More than half of San Diego's trees are found on single family residential land (51.7 percent; 2.6 million trees) even though this land use occupies only 23.2 percent of the study area. This highlights the importance of engaging private landowners in the health and maintenance of the city's urban forest. Overall, 63.4 percent of trees are classified as growing in maintained areas. Trees on public lands total 1.2 million and account for 25.2 percent of the total live tree population.

Urban forest ecosystem services were evaluated in terms of air pollution removal, carbon sequestration, reduction in stormwater runoff, and effects on building energy use. The compensatory value of the urban forest (roughly equivalent to the replacement value of all trees in the urban forest) is estimated at $4.7 billion, with the urban forest producing over $14.1 million in annual benefits (Table 1).

The tree species with the greatest estimated percent dieback and rot (16.5 and 5.1 percent, respectively) is arroyo willow, with 47.7 percent of the trees of this species classified as standing dead. The relatively large number of standing dead trees is likely due to this species mainly being found in more natural, unmaintained areas where dead trees are not removed. For example, there are 958,261 total live and dead arroyo willow trees in developed-open land cover areas. The most common infrastructure issues affecting all tree species in the sampling area are improper planting (8.9 percent of trees) and root/stem girdling (7.7 percent of trees). These issues are particularly pronounced in Chinese banyan, for which 43.2 percent of trees were affected.

Several insects and diseases threaten San Diego's urban forest. The greatest threats based upon the percentage of the city's trees that are potential hosts come from the invasive shot hole borer-Fusarium dieback complex (29.5 percent), the California fivespined Ips (10.0 percent), and pine bark beetles (10.0 percent). The latter two insects threaten San Diego's population of Torrey pine, America's rarest pine species, which occurs naturally only in San Diego and Santa Barbara counties.

Invasive plant species also threaten to alter forest composition. In San Diego, invasive plant species were found on 11.4 percent of the sampled plots. Brazilian peppertree is estimated to cover the largest area (296 acres) of any invasive plant species in the city.

These natural and anthropogenic threats, along with forces such as drought and fire, may affect the health and composition of San Diego's urban forest. Through better understanding of the benefits conferred by and potential threats to the urban forest, resource managers, arborists, and city planners can improve forest management, leading to healthier urban forests and more livable communities.

Table 1.–Summary of the urban forest estimates, San Diego, 2017

Feature	Estimate
Number of trees[a]	
Total live trees	4.9 million (982,000)[b]
Live saplings (1 to 4.9 inches in diameter)	3.1 million (884,000)[b]
Live trees (at least 5.0 inches in diameter)	1.9 million (246,000)[b]
Standing dead saplings (1 to 4.9 inches in diameter)	704,000 (632,000)[b]
Standing dead trees (at least 5.0 inches in diameter)	69,000 (38,000)[b]
Most abundant species by:	
Number of live trees	Chinese banyan
Leaf area	queen palm
Ecosystem Impacts and Services	
VOC emissions	364 tons/year
Pollution removal	421 tons/year ($3.9 million/year)
Reduction in acute respiratory symptoms	967 cases/year ($82,000/year)
Avoided runoff	7.1 million cubic feet ($474,000/year)
Carbon storage[c]	289,000 tons ($49.3 million)
Carbon sequestration	34,600 tons/year ($5.9 million/year)
Net aboveground volume	19 million cubic feet
Reduced building energy use [c,d]	67,000 GJ/year ($3.5 million/year)
Reduced carbon emissions [c,d]	1,700 tons/year ($292,000/year)
Compensatory value	$4.7 billion

Due to rounding, not all values will add up exactly.

VOC = volatile organic compound (a negative ecosystem impact)

Ton = short ton (U.S.) (2,000 lbs.)

To convert carbon estimates to CO_2, multiply carbon value by 3.667.

GJ = gigajoule (one billion [10^9] joules)

[a] Diameter measurements were taken at breast height (d.b.h) or root collar (d.r.c.) for woodland species.

[b] Standard error in parentheses.

[c] Estimates are for the live and dead tree population. All other estimates are based on the live tree population only, except where noted.

[d] Estimates are calculated using trees greater than or equal to 5 inches in diameter.

Contents

BACKGROUND

A Forest Inventory and Analysis crew member measures the height of date palm trees (*Phoenix dactylifera*) near the San Diego waterfront. USDA Forest Service photo by John Mills.

Urban forests offer a wide range of environmental, social, and public health benefits, such as wildlife habitat, aesthetic appeal, social cohesion, enhanced recreational opportunities, reduced air temperatures, improved water quality, mitigated air and noise pollution, and benefits to mental health and well-being. Since 1930, the U.S. Department of Agriculture (USDA), Forest Service, Forest Inventory and Analysis (FIA) program has provided information on the amount, status, and character of **forest land**[1] across the country. The 2014 U.S. Farm Bill[2] directed FIA to explore possibilities to expand the scope of the FIA inventory to include forest monitoring in U.S. urban areas. This effort led to the development of the current FIA Strategic Plan (USDA Forest Service 2016a) that includes a special focus on the Nation's most populous cities.

[1] See glossary for definition of bolded terms.

[2] The Agricultural Act of 2014 (H.R. 2642; Pub. L. 113-79, also known as the 2014 Farm Bill).

In this report, the term "urban forest" describes all trees located in the city on both public and private ownerships, including planted trees along streets and boulevards, trees in parks and residential yards, remnant forest along railroads and riparian areas, small woodlots, and larger forested areas. FIA has partnered with the Forest Service's i-Tree team, which has a long tradition of conducting urban forest inventories and delivering data about urban forests and their associated ecosystem services. This combined national urban forest inventory effort leverages the strengths of both groups, drawing on the urban data processing and reporting strengths of the i-Tree program and FIA's strengths in quality, consistency, and comprehensiveness of data collection.

San Diego, California, is the third city to complete a full inventory cycle under the FIA Urban Inventory Program (Urban FIA) and the first inventory administered by the Forest Service's Pacific Northwest Research Station. San Diego's "Climate Action Plan" (City of San Diego 2015) and "Urban Forestry Program Five Year Plan" (City of San Diego 2017) set goals of 15 percent urban tree canopy cover by 2020 and 35 percent by 2035 in an effort to improve air quality, control stormwater runoff, and reduce the city's carbon footprint. The Urban FIA inventory of San Diego's urban forest resource and the estimated values associated with this resource described in this report support these objectives by providing a baseline assessment of the extent and composition of the urban forest and associated ecosystem services. This information can inform future management decisions aimed at enhancing forest health, sustainability, and benefits.

The aim of providing accurate data describing San Diego's urban forest resource is underpinned by increased recognition of the numerous environmental, economic, and public health benefits conferred by urban forests and the potential threats to these forests. Urban inventory data can help managers address interrelated challenges such as population increases, fire, drought stress, and emerging risks from pests and pathogens. For example, the population of San Diego County is projected to increase by approximately 300,000 people in the 20 years following this inventory (2017-2037) (California Department of Finance Demographic Research Unit 2020), and the city faces potential risks from pests and pathogens including the invasive shot hole borer-Fusarium dieback complex (*Euwallacea* spp. and *Fusarium* spp.), ficus canker (*Botryosphaeria dothidea*), California fivespined ips (*Ips paraconfusus*), sycamore anthracnose (*Apiognomonia veneta*), and gold-spotted oak borer (*Agrilus auroguttatus*). Data describing San Diego's urban forest can be used to help develop management strategies, forecasts, and programs for improving forest health and resilience in partnership with state agencies, city government, nonprofit organizations, and consultants.

METHODS

To evaluate the extent, composition, and benefits of San Diego's urban forest and establish a baseline for future monitoring, a sample-based inventory was conducted following Urban FIA monitoring methods and reporting tools described in the Urban FIA Field Guide Version 7.1 for San Diego, California (USDA Forest Service 2017) and online supplement (Baer et al. 2024), along with i-Tree Eco modeling software (www.itreetools.

org; Nowak 2024). This process established survey plots across San Diego and aims to revisit those plots every 5 years. Future reports can build on these data and consistently provide information on urban forest extent, diversity, health condition, and benefits. During the 2017 field season, San Diego's 5-year measurement cycle was accelerated and completed during a single field season. The sampling area for San Diego was limited to U.S. Census Bureau Urbanized Area/Urban Clusters, hereafter urban areas (highlighted in white in Fig. 1a) within the U.S. Census Bureau Designated Places boundary for San Diego (highlighted in red and white in Fig. 1a). This approach was taken because the Designated Places boundary included a large area of ocean as well as forest land and range land associated with the Marine Corps Air Station Miramar that were deemed inaccessible. In total, 169,844 acres were surveyed throughout the designated sampling area in San Diego; the Urban FIA sample consisted of 195 plots located within the sampling boundary (Fig. 1b). Data were collected on 185 of these plots between August and December 2017. The remaining 10 plots were not sampled due to hazardous conditions or lack of permission to access the plot.

New methods were implemented in the inventory of San Diego's urban forest to allow for flexibility in the estimation of tree characteristics for forked trees. In this inventory, all stems of forked trees are quantified and characterized as part of the same tree. All extrapolated estimates for forked trees are based on this approach except for estimates of tree merchantability and volume estimation. Refer to Baer et al. (2024) for more detailed information. Throughout this report, except where explicitly noted, trees refer to woody plants with **diameters** of at least 1.0 inch, and results are given for live trees.

To evaluate the extent, composition, and benefits of the city's urban forest, the collected data were analyzed using FIA methodology and i-Tree Eco modeling software outlined in Baer et al. (2024). Additional analyses were conducted using R Statistical software version 4.2.1 (R Core Development Team 2022) and Microsoft Excel; figures presented in this report were generated using the base, dplyr (Wickham et al. 2022), and ggplot2 (Wickham 2016) packages within the R Statistical Software platform and Microsoft Excel. Maps throughout this document were created using ArcGIS® software by Esri (ESRI 2021a, b). ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license.

This report summarizes the findings of these analyses and includes information on forest structure, ecosystem services, and associated monetary values. Structure describes various physical attributes of the urban forest, including tree species composition, number of trees, tree density, tree health, leaf area, biomass, and species diversity. Ecosystem services discussed in this report were evaluated based on forest structure in conjunction with local environmental variables and include such attributes as air pollution removal and carbon storage and sequestration. Monetary values are an economic estimate of various ecosystem services or structural attributes. In addition to this report, information from this analysis is accessible via My City's Trees, an online interactive tool that allows users to explore results and print data queries. Data tables are also available for download from FIA's Urban DataMart (https://research.fs.usda.gov/products/dataandtools/tools/urban-datamart).

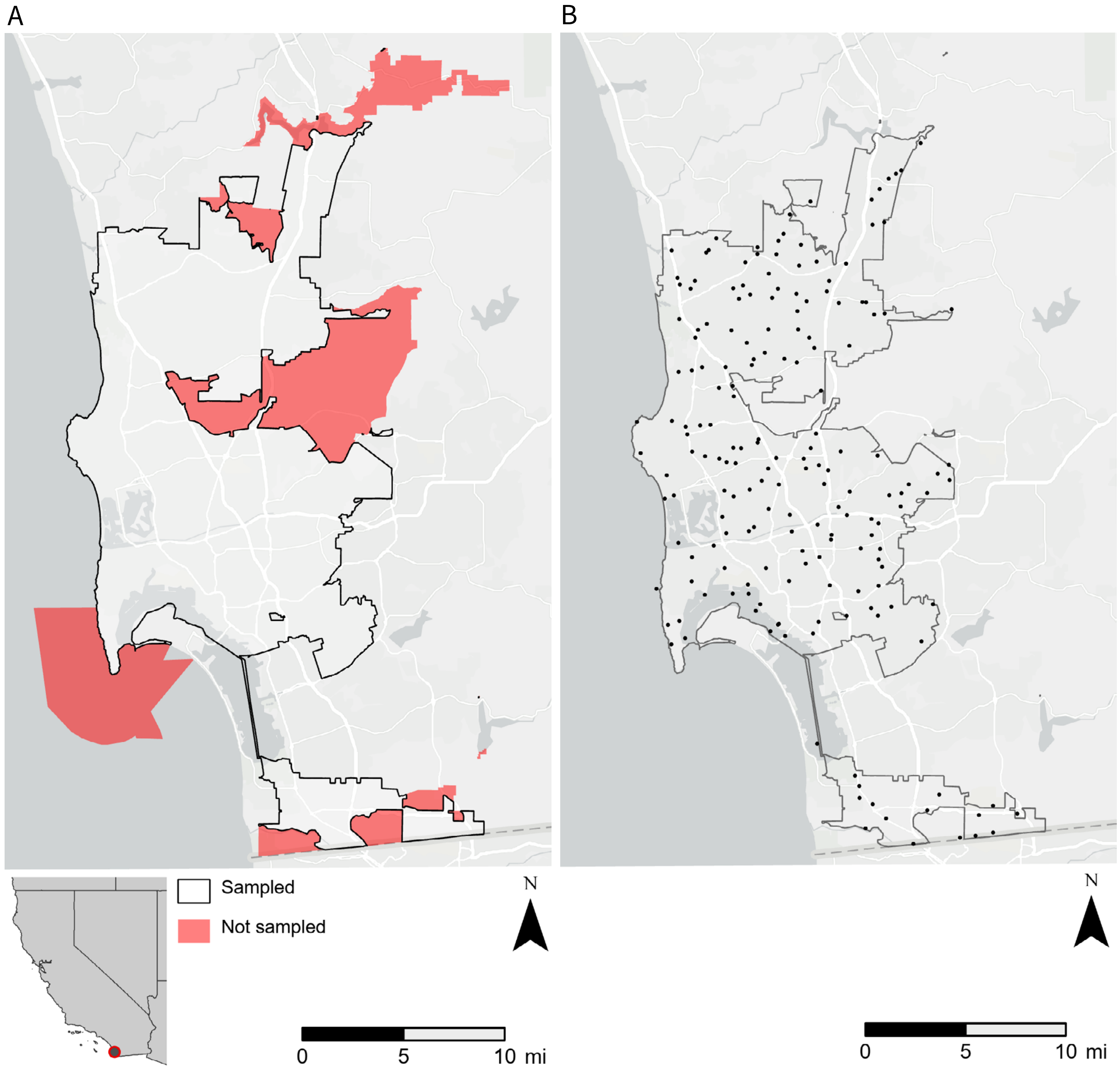

Figure 1.— Study area (A) and approximate plot locations (B) for the Urban Forest Inventory and Analysis inventory of San Diego, 2017. Basemap: Esri (2017). Plot locations are approximate.

AREA AND COVER CHARACTERISTICS

Residents take advantage of shade from urban trees in a plaza near the Seaport Village complex in San Diego. Courtesy photo by Brian Widener, City of San Diego, CA.

In 2010, California had 5,263,000 acres of urban land that covered 5.3 percent of the state area, and this urban area is projected to increase to 14.4 percent by the year 2060 (Nowak and Greenfield 2018). In San Diego, California's second-largest city by population (1,307,400 residents with a population density of 4,020 per square mile in 2010), urban land development was projected to increase by 4 percent in the decade from 2011-2020, with a concurrent population increase of 12 percent (Bounoua et al. 2018). This projection likely overestimates population growth in the city, which has grown to 1,426,900 residents in 2019 (+8.9 percent over 9 years) (US Census Bureau 2020b), but the rapid rate of population growth in the city is nonetheless notable.

Land Cover

National land cover data were used to analyze the variability of the urban forest across the city by land cover class (Homer et al. 2015, MRLC 2018). Plots were categorized into general land cover classes (Table 2), and Figure 2 shows the distribution of land cover classes across the city.

The land cover definitions are based on the 2011 National Land Cover Database (NLCD) (Homer et al. 2015) (See Table 33 in Appendix 1). **Forested land** within the city is concentrated in the Carmel Valley and Torrey Pines State Reserve in the northwest corner of the city; in Mission Trails Regional Park at its eastern edge; in the Mt. Soledad National Veterans Memorial, Marian Bear Memorial Park, and Tecolote Canyon Natural Park and Nature Preserve in the west; and along the I-8 corridor through the middle of the city (Fig. 2). Developed land is more concentrated near the city center at the southern end of the city, along the southwestern coastline, and in areas surrounding the I-5 and I-805 corridors near the center of the city.

Developed land is the most common land cover throughout the sampling area. The most prevalent land cover classification is developed-medium, followed by developed-low, developed-open, and developed-high (Table 3).

Table 2.—Description of aggregated National Land Cover Database (NLCD) land cover classes in San Diego, 2017

NLCD label	Description
Water/Barren	Open Water and Barren Land
Developed-open	Developed, Open Space
Developed-low	Developed, Low Intensity
Developed-medium	Developed, Medium Intensity
Developed-high	Developed, High Intensity
Grass/Herb/Crop	Herbaceous and Pasture/Hay and Cultivated Crops and Emergent Herbaceous Wetlands
Forest/Shrub	Evergreen Forest and Mixed Forest and Shrub/Scrub and Woody Wetlands

Source: Homer et al. 2015

Table 3.—Sample area and count of plots within National Land Cover Database (NLCD) land cover classes in San Diego, 2017

Land cover	Area (acres)	City land area (percent)	Plots (number)
Developed-medium	68,451	40.3	75
Developed-low	27,452	16.2	24
Developed-open	20,960	12.3	29
Developed-high	20,757	12.2	29
Forest/Shrub	17,250	10.2	12
Water/Barren	8,202	4.8	5
Grass/Herb/Crop	6,772	4.0	11
Total	**169,844**	**100.0**	**185**

Due to rounding, not all values will add up exactly.

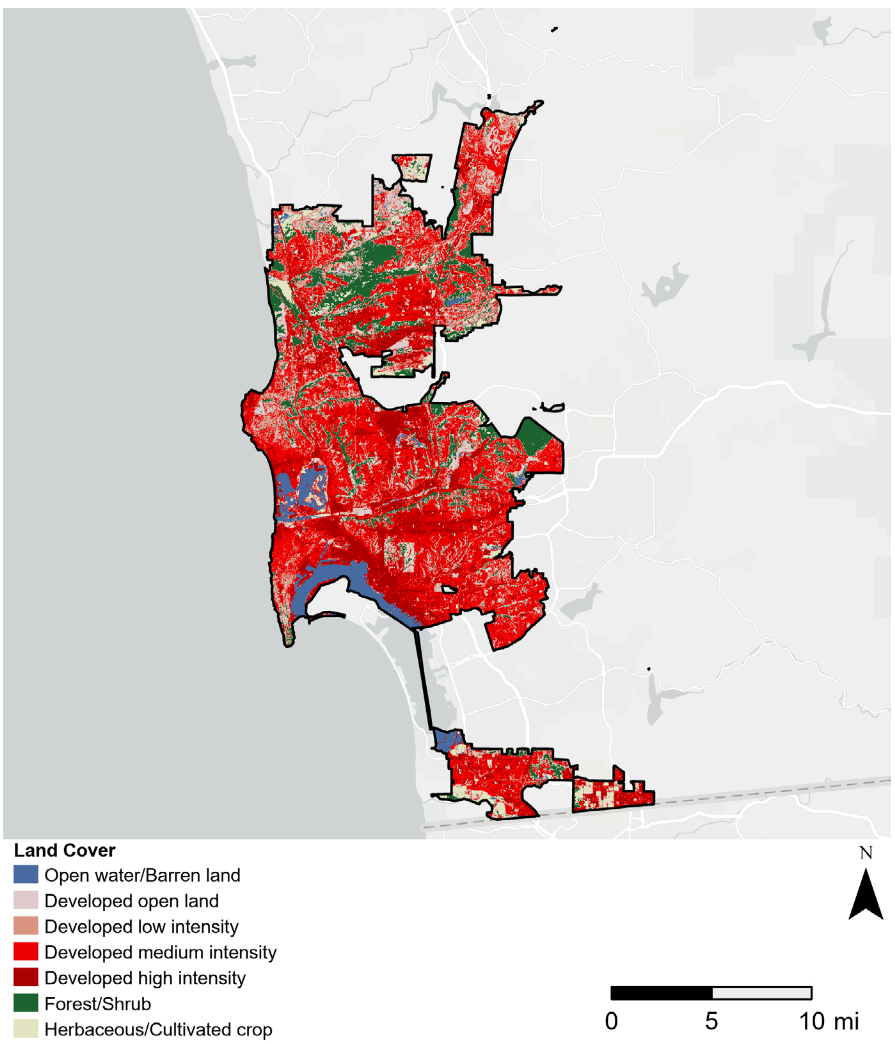

Figure 2.— Distribution of National Land Cover Database (NLCD) (Homer et al. 2015, MRLC 2018) land cover classes, San Diego, 2017. Basemap: Esri (2017).

FIA Land Use

In addition to categorization according to NLCD land cover classes, plots were also classified in the field based on FIA land use classes (Table 4). These categories provide a specific look at how the land is being used by the local population in San Diego. Single family residential (hereafter, residential) land is the most prevalent land use in San Diego. Residential land covers 23.2 percent of the city area (containing nearly 52 percent of the city's trees), followed by rangeland/chaparral (20.2 percent of the city area), commercial/industrial (19.7 percent), **rights-of-way** (18.3 percent), and recreation/cemetery land uses (7.1 percent) (Table 5).

Table 4.—Description of Forest Inventory and Analysis (FIA) land use classes and subclasses, San Diego, 2017

FIA land use	FIA land use subclasses
Agriculture	Agriculture, Christmas tree plantation, cropland, idle farmland, maintained wildlife openings, nursery, orchard, pasture, shelterbelt, windbreak
Commercial/Industrial	Commercial, cultural, developed, industrial, institutional, mining, wasteland
Forest[a]	None
Multi-family residential	None
Natural lands	Beach, nonvegetated land, other, wetland
Rangeland/Chapparal	None
Recreation/Cemetery	Cemetery, golf course, park, recreation
Residential	None
Right-of-way[a]	Right-of-way, transportation, utility
Water	None

[a] FIA land uses defined within the glossary.
Source: National Urban FIA field guide Version 7.1 (USDA Forest Service 2017)

Table 5.—Sample area and plot counts within Forest Inventory and Analysis (FIA) land use classes, San Diego, 2017

FIA land use	Area (acres)	Standard error (acres)	City land (percent)	Plots (number)
Forest land	1,954	1,356	1.2	3.0
Agriculture	58	66	0.0	0.1
Rangeland/Chaparral	34,311	3,749	20.2	36.1
Commercial/Industrial	33,528	4,624	19.7	40.2
Multi-family residential	7,683	2,370	4.5	8.5
Residential	39,394	4,410	23.2	42.9
Recreation/Cemetery	12,117	3,128	7.1	12.4
Rights-of-way	31,034	3,695	18.3	34.8
Natural lands	332	382	0.2	0.5
Water	9,433	800	5.6	6.5
Total	**169,844**	**1,571**	**100.0**	**185.0**

Due to rounding, not all values will add up exactly.

Tree, Shrub, and Ground Cover

Tree cover in San Diego is estimated at 7.1 percent and shrub cover is estimated at 18.4 percent based on field crew assessments. Field plot estimates are used to evaluate tree cover and can have a relatively high degree of uncertainty due to the nature of tree cover data collection in the field and effects of sample size. Generally, better tree cover estimates can be derived from photointerpretation or high-resolution tree cover maps. In 2014, canopy cover of trees and shrubs 8 feet and taller in the City of San Diego was estimated at 13 percent when measured using LiDAR technology (City of San Diego 2020).

Overall, mean tree cover ranges from 0.36 to 70 percent on plots where trees are present (Fig. 3a). Shrub cover ranges from 0.3 percent to 98 percent on plots where shrubs are present (Fig. 3b). Average tree cover is highest on forest (47.0 percent tree cover), multi-family residential (15.2 percent), and residential lands (11.3 percent) (Table 6). Shrub cover is highest on rangeland/chaparral (58.6 percent shrub cover), forest (41.0 percent), and recreation/cemetery lands (35.0 percent). Impervious cover is highest on rights-of-way (78.5 percent), commercial/industrial (50.8 percent), and multi-family residential lands (23.9 percent) (Table 6).

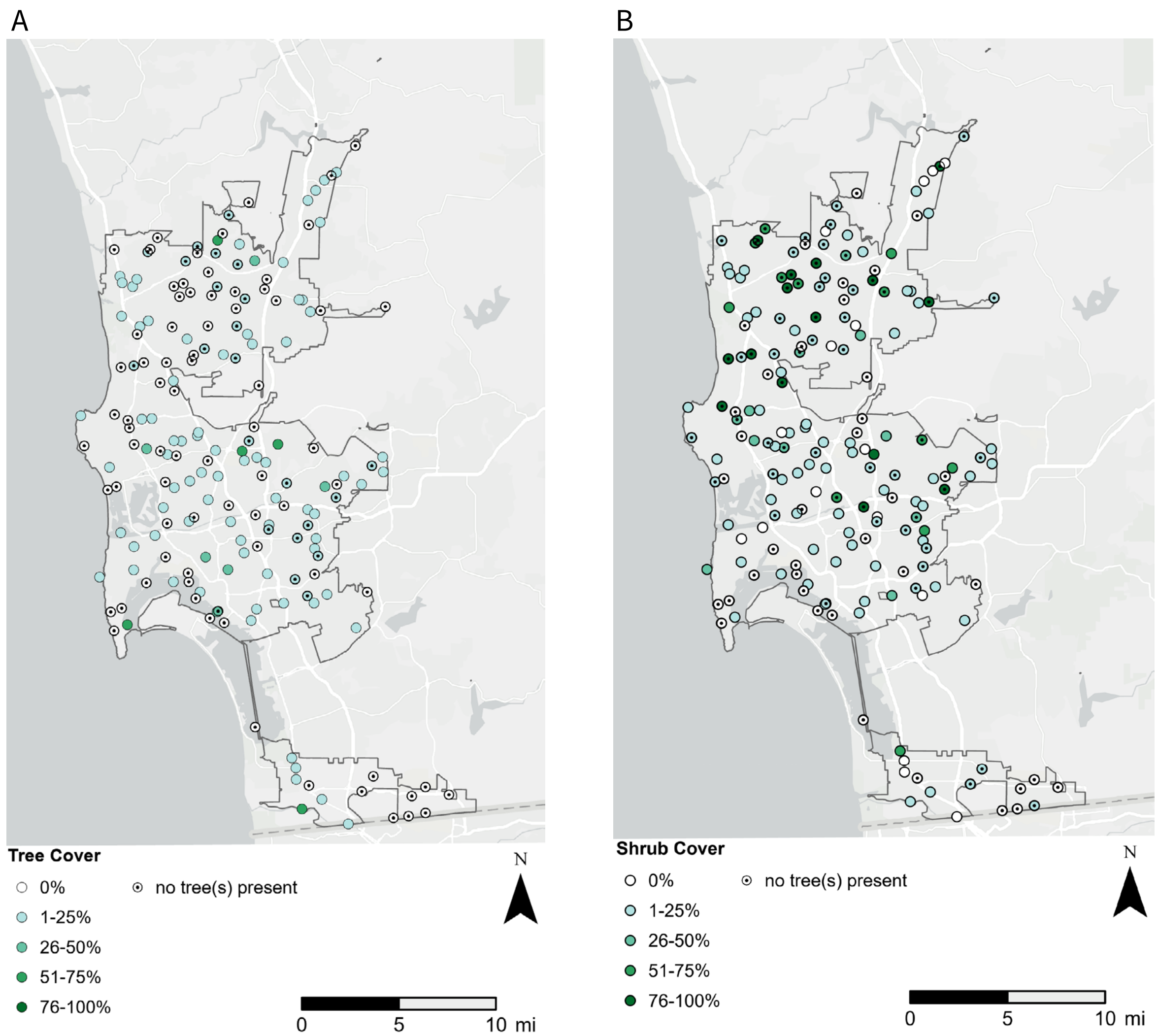

Figure 3.— Tree (A) and shrub (B) cover estimates by plot, San Diego, 2017. Plot locations are approximate.

Field crews categorize ground surface cover on each field plot according to five classes: (i) building, (ii) low vegetation, (iii) permeable (soil, leaf litter, mulch, gravel, etc.), (iv) impervious (nonbuilding), or (v) water. Permeable and herbaceous ground covers account for 50.1 percent of all ground covers in San Diego, while building and other impervious cover account for 44.3 percent. An additional 5.7 percent of the city is classified as water (Figs. 4 and 5). Note that percentages may not add up to 100 percent due to rounding.

Table 6.—Average percent tree, shrub, and impervious cover by Forest Inventory and Analysis (FIA) land use class, San Diego, 2017

FIA land use	Tree (percent)	Shrub (percent)	Impervious (percent)
Forest land	47.0	41.0	0.0
Agriculture	0.0	0.0	0.0
Rangeland/Chaparral	4.1	58.6	0.6
Commercial/Industrial	5.7	5.3	50.8
Multi-family residential	15.2	6.3	23.9
Residential	11.3	7.8	19.2
Recreation/Cemetery	5.4	35.0	12.7
Rights-of-way	4.9	2.6	78.5
Natural lands	0.0	1.0	0.0
Water	0.0	0.0	0.0
Total average	**7.1**	**18.4**	**30.9**
Total standard error	**0.9**	**1.5**	**1.9**

Due to rounding, not all values will add up exactly.

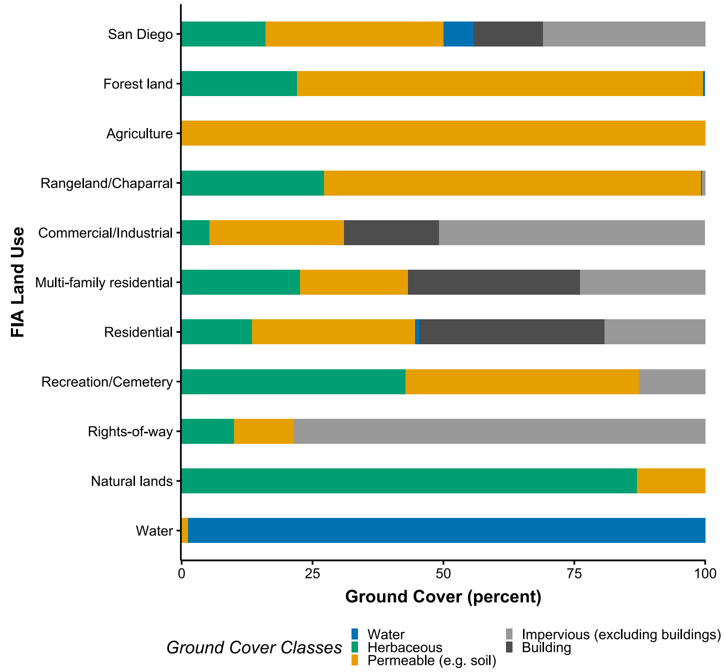

Figure 4.— Ground cover distribution by Forest Inventory and Analysis (FIA) land use class, San Diego, 2017.

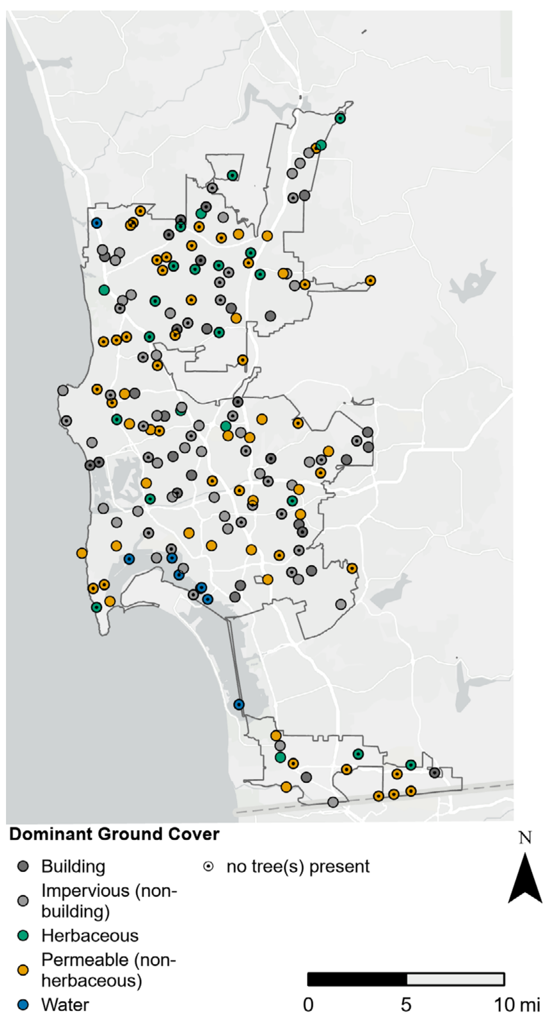

Figure 5.— Dominant ground cover by plot, San Diego, 2017. Basemap: Esri (2017).

Ownership

Plot ownership was divided into private, State and local government, Federal government, and unknown (water) classes. The most dominant ownership in San Diego is private (53 percent), followed by State and local (36.9 percent), Federal (4.6 percent), and unknown (water, 5.6 percent) (Table 7). Percent tree cover is greatest in Federal land (11.5 percent), followed by private lands (7.8 percent), and State and local land (6.5 percent). In San Diego, there are a total of 3.7 million trees (74.8 percent of the live tree population) on private land, 1.1 million trees (22.9 percent) on State and local land, and 109,000 trees (2.2 percent) on Federal land (Table 7). San Diego's sapling population is mostly found on private lands (78.0 percent), followed by State and local land (19.1 percent), and Federal land (3.0 percent) (Table 7).

Table 7.—Distribution of percent of live trees within diameter classes by ownership, San Diego, 2017

Ownership class	1-4.9 in. diameter trees (percent)	5-10.9 in. diameter trees (percent)	11+ in. diameter trees (percent)	Total (percent)	City land area (percent)
Private	78.0	72.2	62.4	74.8	53.0
State and Local	19.1	27.5	34.6	22.9	36.9
Federal	3.0	0.3	3.0	2.2	4.6
Unknown (water)	0.0	0.0	0.0	0.0	5.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Due to rounding, not all values will add up exactly.

FOREST STRUCTURE

Data collected by Forest Inventory and Analysis crews describe urban forest structure, including the number and sizes of trees in a forest stand and its species composition. Other metrics such as leaf area are calculated from the data collected in the field. USDA Forest Service photo by John Mills.

Number of Trees

San Diego's urban forest has an estimated 4.95 million live trees and 773,000 standing dead trees. The number of trees varies by land use and diameter class. Most of the trees in San Diego are located on residential land (51.7 percent, 2.56 million trees) (Table 8). Overall, 62.4 percent of San Diego's trees are saplings (1.0-4.9 inches in diameter), while the remaining 28.1 percent and 9.5 percent are medium trees (5.0-10.9 inches in diameter) and large trees (≥ 11.0 inches in diameter), respectively. The greatest proportion of trees (47.3 percent) is found within the developed-medium land cover class. The highest tree density (46 trees per acre) is found on the developed-low cover class (Table 9).

Table 8.— Distribution of live trees by Forest Inventory and Analysis (FIA) land use class and diameter class, San Diego, 2017

FIA land use	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total SE (number)	Density (no./ac)
Forest land	138,000	85,000	17,000	240,000	171,000	123
Rangeland/Chaparral	379,000	51,000	65,000	494,000	501,000	14
Commercial/Industrial	202,000	222,000	124,000	548,000	174,000	16
Multi-family residential	606,000	46,000	53,000	706,000	490,000	92
Residential	1,600,000	817,000	144,000	2,560,000	683,000	65
Recreation/Cemetery	89,000	54,000	29,000	172,000	134,000	14
Rights-of-way	73,000	117,000	38,000	228,000	91,000	7
Natural lands	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0
Water	0	0	0	0	0	0
Total	**3,080,000**	**1,390,000**	**469,000**	**4,950,000**	**–**	**29**
Total standard error (SE)	**884,000**	**212,000**	**73,000**	**982,000**	**–**	**–**

Due to rounding, not all values will add up exactly.
– = no value for cell

Table 9.—Distribution of live trees by National Land Cover Database (NLCD) land cover class and diameter class, San Diego, 2017

Land cover	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total SE (number)	Density (no./ac)
Water/Barren	0	0	0	0	0	0
Developed-open	379,000	117,000	61,000	558,000	502,000	27
Developed-low	713,000	439,000	106,000	1,260,000	502,000	46
Developed-medium	1,470,000	668,000	205,000	2,340,000	623,000	34
Developed-high	387,000	130,000	67,000	585,000	219,000	28
Grass/Herb/Crop	138,000	37,000	3,700	179,000	156,000	26
Forest/Shrub	0	0	26,000	26,000	21,000	2
Total	**3,080,000**	**1,390,000**	**469,000**	**4,950,000**	**–**	**29**
Total standard error (SE)	**884,000**	**212,000**	**73,000**	**982,000**	**–**	**–**

Due to rounding, not all values will add up exactly.
– = no value for cell

Species Composition

The 10 most common tree species[3] by number account for 61.9 percent of all recorded live trees and are Chinese banyan, arroyo willow, Japanese cheesewood, Aleppo pine, pygmy date palm, Tasmanian bluegum, Annona cherimola, California sycamore, whiteflower kurrajong, and queen palm (Table 10; Fig. 6). A breakdown of the estimated number of each recorded tree species by diameter classes is presented in Appendix 2. Small diameter trees (saplings) are generally the most abundant of the three tree size classes for the 10 most common tree species, comprising 76.2 percent of the total number of trees, while large diameter trees comprised only 4.3 percent of the total (Table 11; Fig. 7). When broken down into 2-inch diameter classes, the five most common species by number showed an abundance distribution similarly skewed toward smaller diameter trees (Fig. 8).

Table 10.—Urban forest species composition in San Diego, 2017

Species	Trees (number)	Percent
Chinese banyan	848,000	17.2
arroyo willow	598,000	12.1
Japanese cheesewood	466,000	9.4
Aleppo pine	343,000	6.9
pygmy date palm	195,000	4.0
Tasmanian bluegum	147,000	3.0
Annona cherimola	135,000	2.7
California sycamore	112,000	2.3
whiteflower kurrajong	110,000	2.2
queen palm	109,000	2.2
Italian cypress	101,000	2.0
Corymbia citriodora	96,000	1.9
Chinese juniper	88,000	1.8
Japanese black pine	85,000	1.7
carrotwood	84,000	1.7
southern magnolia	80,000	1.6
crapemyrtle	78,000	1.6
melaleuca	75,000	1.5
guava	73,000	1.5
loquat	73,000	1.5

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[3] Common and scientific names for all species observed in the Urban FIA inventory of San Diego are reported in Appendix 2.

Table 10 (continued).

Species	Trees (number)	Percent
peach	73,000	1.5
Washington fan palm	67,000	1.4
Brazilian peppertree	64,000	1.3
ngaio tree	64,000	1.3
Callery pear	54,000	1.1
California live oak	54,000	1.1
Canary Island pine	49,000	1.0
red ironbark	40,000	0.8
vinegartree	38,000	0.8
olive	35,000	0.7
Bangalow palm	35,000	0.7
yellowwood	35,000	0.7
Peruvian peppertree	31,000	0.6
Sydney golden wattle	29,000	0.6
date palm	28,000	0.6
redbox	26,000	0.5
sugargum	26,000	0.5
camphortree	26,000	0.5
tipa	24,000	0.5
black poui	23,000	0.5
sentrypalm	18,000	0.4
weeping bottlebrush	14,000	0.3
Western Australian floodedgum	13,000	0.3
feijoa	12,000	0.2
Japanese privet	12,000	0.2
Torrey pine	12,000	0.2
bronze loquat	12,000	0.2
sweetgum	12,000	0.2
river redgum	8,700	0.2
saltcedar	7,100	0.1
East African yellowwood	7,100	0.1
New Caledonia pine	7,100	0.1
weeping willow	5,900	0.1
European fan palm	5,900	0.1
white ironbark	5,900	0.1

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Table 10 (continued).

Species	Trees (number)	Percent
apricot	5,900	0.1
brush cherry	5,900	0.1
Norfolk Island pine	5,900	0.1
bauhinia	5,900	0.1
pink flame tree	5,900	0.1
Roxburgh fig	5,900	0.1
cherry and plum spp.	5,900	0.1
South African wild plum	5,900	0.1
Jerusalem thorn	5,900	0.1
sweet orange	5,900	0.1
loquat	4,500	0.1
gold medallion tree	4,500	0.1
pine spp.	4,300	0.1
velvet ash	4,300	0.1
Total	**4,950,000**	**100**

Due to rounding, not all values will add up exactly.
For common and scientific names and a breakdown of species composition by diameter classes, please refer to Appendix 2.

Table 11.—Live trees by size class for the 10 most common tree species by number in San Diego, 2017

Species	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)
Chinese banyan	800,000	42,000	5,900	848,000
arroyo willow	464,000	114,000	21,000	598,000
Japanese cheesewood	440,000	26,000	0	466,000
Aleppo pine	267,000	50,000	26,000	343,000
pygmy date palm	0	185,000	10,000	195,000
Tasmanian bluegum	89,000	35,000	23,000	147,000
Annona cherimola	129,000	5,900	0	135,000
California sycamore	73,000	38,000	0	112,000
whiteflower kurrajong	73,000	36,000	0	110,000
queen palm	0	62,000	47,000	109,000
Total of top 10	**2,340,000**	**594,000**	**133,000**	**3,060,000**

Due to rounding, not all values will add up exactly.
Standard errors for each estimate are reported in Appendix 2.

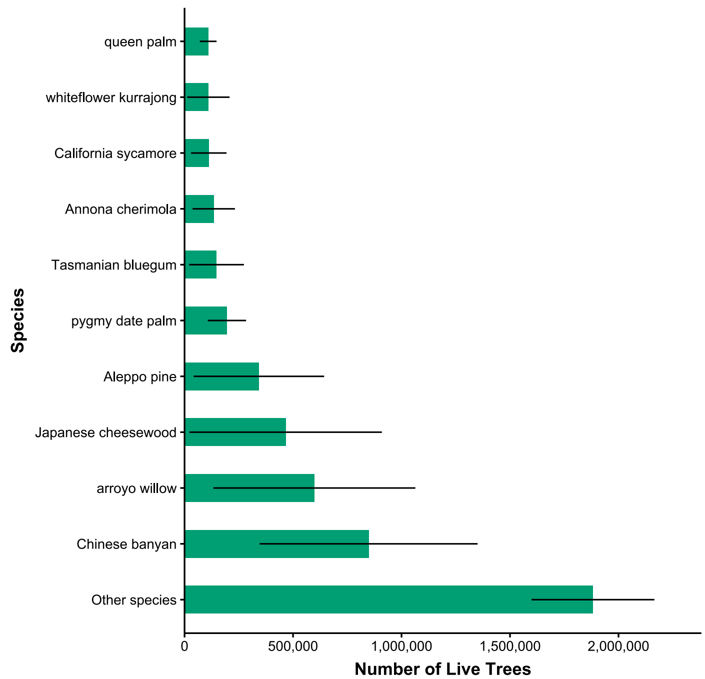

Figure 6.— The 10 most common tree species by number of trees, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

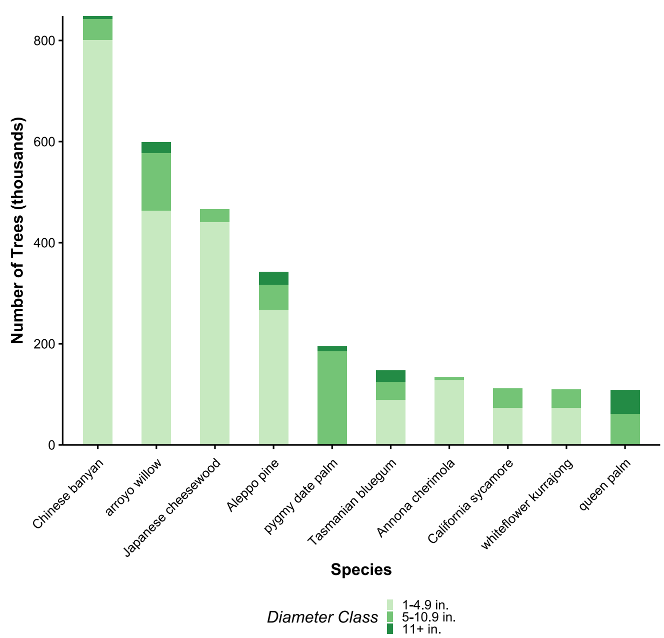

Figure 7.— Trees by size class for the 10 most common tree species by number of trees, San Diego, 2017.

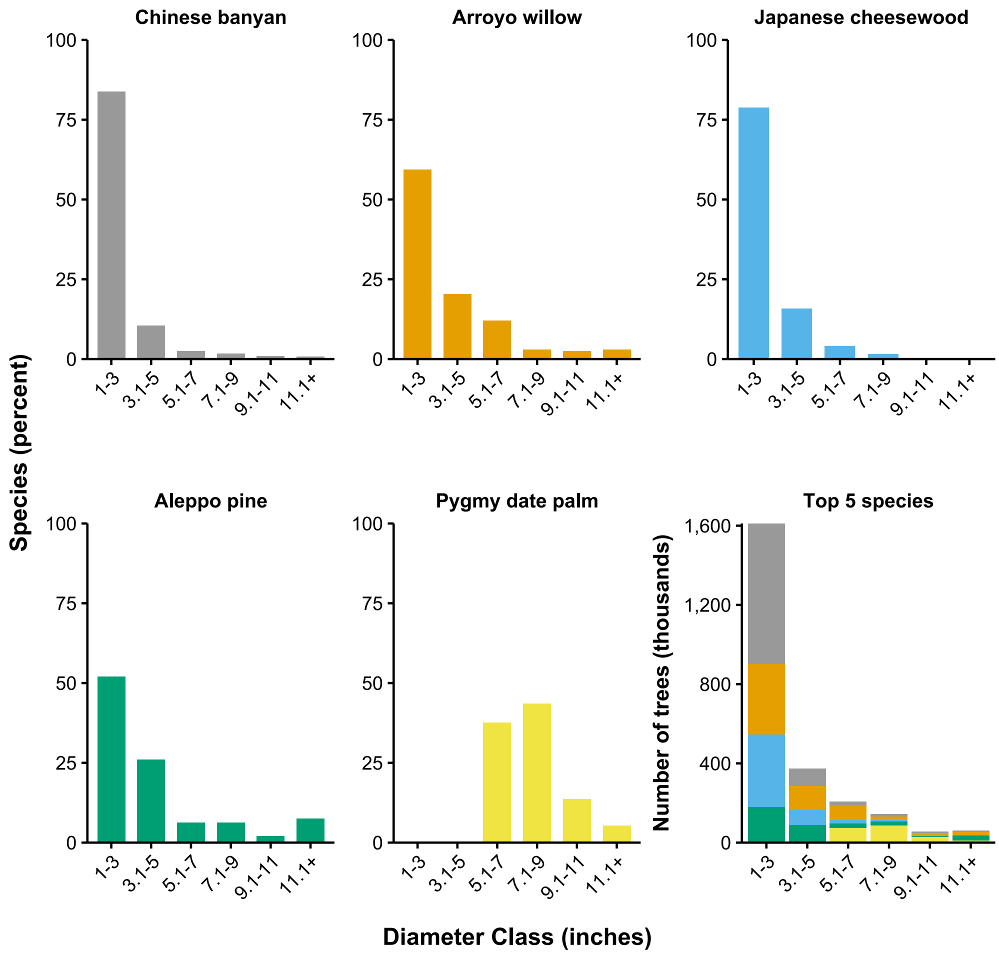

Figure 8.— Percentage of species population by diameter class for the five most common tree species by number of trees, San Diego, 2017.

The preceding table and figures highlight the most prominent species by number for all trees 1.0 inch in diameter and larger. As smaller diameter trees are generally more abundant per unit area, the overall species composition may be more reflective of the smaller diameter species when analyzing estimates based on number of trees. For this reason, it is also helpful to rank species according to other metrics such as the number of trees within various size classes, leaf area, importance value, volume, or biomass. The three most common species in terms of stem numbers in the smallest-diameter size classes (less than 5.0 inches in diameter) are Chinese banyan, arroyo willow, and Japanese cheesewood, together representing more than half (55.2 percent) of all live trees greater than 5.0 inches in diameter (Table 12; Appendix 2). Pygmy date, arroyo willow, and Japanese black pine are the most common species in intermediate diameter size classes, representing 27.1 percent of all live trees between 5.0 and 10.9 inches in diameter. Dominant species in the largest diameter classes, often the most recognizable component of the urban forest canopy, are Washington fan palm, melaleuca, and queen palm, comprising 35.9 percent of live trees at least 11.0 inches in diameter (Table 12; Appendix 2).

Table 12.—Top five tree species by number of trees within each diameter class, San Diego, 2017

Species name	Tree (number)
1.0 - 4.9 in. diameter class	
Chinese banyan	800,000
arroyo willow	464,000
Japanese cheesewood	440,000
Aleppo pine	267,000
Annona cherimola	129,000
5.0 - 10.9 in. diameter class	
pygmy date palm	185,000
arroyo willow	114,000
Japanese black pine	78,000
queen palm	62,000
ngaio tree	57,000
11+ in. diameter class	
Washington fan palm	61,000
melaleuca	60,000
queen palm	47,000
Canary Island pine	37,000
date palm	28,000

In San Diego, tree species composition on private land is dominated by Chinese banyan (22.9 percent), Japanese cheesewood (12.6 percent), and Aleppo pine (9.3 percent) (Table 13). The most common tree species on public lands are arroyo willow (47.5 percent), Tasmanian bluegum (11.1 percent), and crape myrtle (5.9 percent) (Table 14). A total of 58 tree species have been recorded on private lands, which had a **Shannon-Wiener diversity index** value of 3.1. Crews recorded 30 species of trees on public lands, which had a Shannon-Wiener diversity index value of 2.2. The Shannon-Wiener diversity index takes into account tree species richness (total number of species) and species evenness (relative abundances among species) and ranges from approximately 2.0-3.5 within cities measured using the Urban FIA protocol. On private land, the three genera with the greatest number of trees are ficus (*Ficus*), pine (*Pinus*), and cheesewood (*Pittosporum*). On public land they are willow (*Salix*), eucalyptus (*Eucalyptus*), and crape myrtle (*Lagerstroemia*) (Fig. 9). Species composition within NLCD land cover classes is detailed in Appendix 3.

Table 13.—Species composition on private lands in San Diego, 2017

Species	Trees (percent)	Species	Trees (percent)	Species	Trees (percent)
Chinese banyan	22.9	Brazilian peppertree	1.5	apricot	0.2
Japanese cheesewood	12.6	Canary Island pine	1.2	arroyo willow	0.2
Aleppo pine	9.3	red ironbark	1.1	bauhinia	0.2
pygmy date palm	4.7	Callery pear	1.0	brush cherry	0.2
Annona cherimola	3.6	Bangalow palm	0.9	cherry and plum spp.	0.2
whiteflower kurrajong	3.0	vinegartree	0.9	East African yellowwood	0.2
California sycamore	2.7	Peruvian peppertree	0.8	European fan palm	0.2
Italian cypress	2.7	tipa	0.7	Jerusalem thorn	0.2
Corymbia citriodora	2.6	camphortree	0.6	New Caledonia pine	0.2
carrotwood	2.3	Washington fan palm	0.5	Norfolk Island pine	0.2
Japanese black pine	2.3	yellowwood	0.5	pink flame tree	0.2
Chinese juniper	2.2	weeping bottlebrush	0.4	Roxburgh fig	0.2
southern magnolia	2.2	black poui	0.3	saltcedar	0.2
loquat	2.1	bronze loquat	0.3	sweet orange	0.2
guava	2.0	feijoa	0.3	Tasmanian bluegum	0.2
melaleuca	2.0	Japanese privet	0.3	weeping willow	0.2
peach	2.0	redbox	0.3	white ironbark	0.2
queen palm	1.8	sugargum	0.3	crapemyrtle	0.1
ngaio tree	1.7	Sydney golden wattle	0.3	date palm	0.1

Due to rounding, not all values will add up exactly.

Table 14.—Species composition on public lands in San Diego, 2017

Species	Trees (percent)	Species	Trees (percent)	Species	Trees (percent)
arroyo willow	47.5	sentrypalm	1.4	Brazilian peppertree	0.7
Tasmanian bluegum	11.1	Sydney golden wattle	1.4	river redgum	0.7
crapemyrtle	5.9	yellowwood	1.3	Canary Island pine	0.5
California live oak	4.4	redbox	1.1	South African wild plum	0.5
Washington fan palm	3.8	sugargum	1.1	vinegartree	0.5
queen palm	3.4	W. Australian floodedgum	1.0	camphortree	0.4
olive	2.8	black poui	0.9	Chinese juniper	0.4
date palm	1.9	California sycamore	0.9	gold medallion tree	0.4
pygmy date palm	1.8	sweetgum	0.9	pine spp.	0.3
Callery pear	1.4	Torrey pine	0.9	velvet ash	0.3

Due to rounding, not all values will add up exactly.

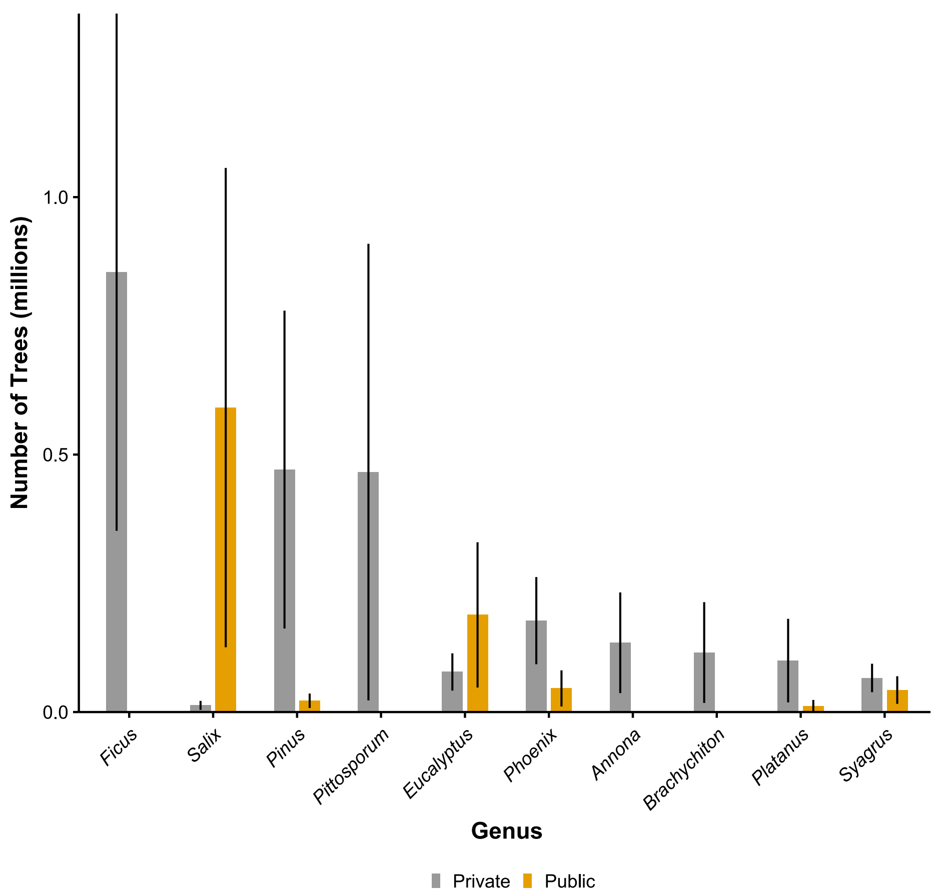

Figure 9.— The 10 most common genera by number of trees within ownership classes, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

Maintained Trees

Overall, 63.4 percent of trees in San Diego are classified as growing in maintained areas. Maintained areas are those which are regularly impacted by mowing, weeding, cutting, brush clearing, herbicide applications, and other treatments. Examples of maintained areas include, but are not limited to, lawns, maintained shrub beds, rights-of-way, and manicured parks. However, a tree found in a maintained area has not necessarily received care. In San Diego, the most common tree species in maintained areas are Chinese banyan (17.2 percent of all trees in maintained areas), Japanese cheesewood (14.9 percent), and pygmy date palm (6.2 percent) (Table 15). The most common California native tree species in maintained areas is California sycamore (3.6 percent) (Table 15; Appendix 4).

Table 15.—Top 10 tree species in maintained areas by number of trees, San Diego, 2017

Common name	Trees (number)	Portion of maintained trees (percent)
Chinese banyan	539,000	17.2
Japanese cheesewood	466,000	14.9
pygmy date palm	195,000	6.2
Annona cherimola	135,000	4.3
California sycamore	112,000	3.6
queen palm	109,000	3.5
whiteflower kurrajong	104,000	3.3
Italian cypress	101,000	3.2
Chinese juniper	88,000	2.8
Japanese black pine	85,000	2.7

Due to rounding, not all values will add up exactly.

Leaf Area

Leaf area is correlated with many ecosystem services provided by the urban forest. It is estimated as the surface area (on one side) of the leaves on a given tree or in an area. Although larger trees have more leaf area than smaller trees, total leaf area in a given inventory is often greatest in smaller diameter classes because smaller diameter trees are generally more abundant. This was the case in San Diego, where leaf area tended to be proportionally higher in trees of 9.0 inches in diameter or less. This is not surprising, as the majority of trees in the city occur within diameter classes of 9.0 inches or less, with the vast majority in the 1.0-3.0 inch and 3.1-5.0 inch diameter classes. The proportion of total leaf area is greatest for trees 7.1-9.0 inches in diameter (14.1 percent), followed by 3.1-5.0 inches in diameter (13.0 percent), and 5.1-7.0 inches in diameter (12.6 percent) (Fig. 10). In San Diego, leaf area is greatest in residential land uses (43.3 percent of total leaf area), followed by commercial/industrial (19.2 percent), and rangeland/chaparral land uses (10.7 percent) (Fig. 11).

Leaf Area Index (LAI) refers to a standardized measure of leaf surface area per unit of tree cover and is calculated as the total leaf area divided by the total ground area covered by tree canopies. Higher LAI values indicate a greater depth or layering of leaves in the tree canopy. As each land use class has a different amount of area covered by trees, LAI allows for standardized comparison of leaves per unit canopy area among land use classes (acres of leaves per acre of tree cover). The leaf area index in land uses with trees ranged from 4.0 in commercial/industrial land use to 1.9 in rights-of-way (Fig. 11).

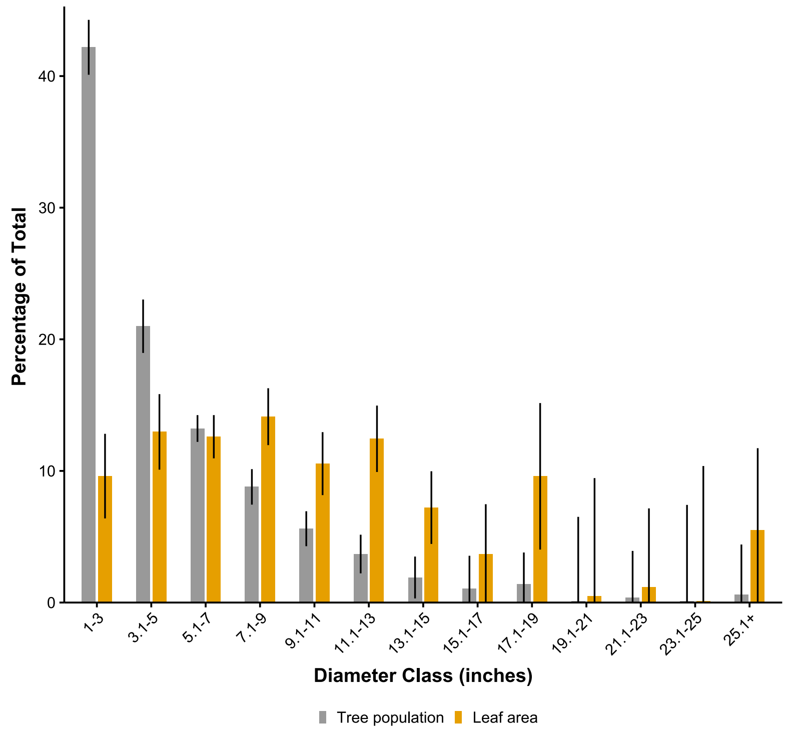

Figure 10.— Percentage of tree population and leaf area by 2-inch diameter class, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

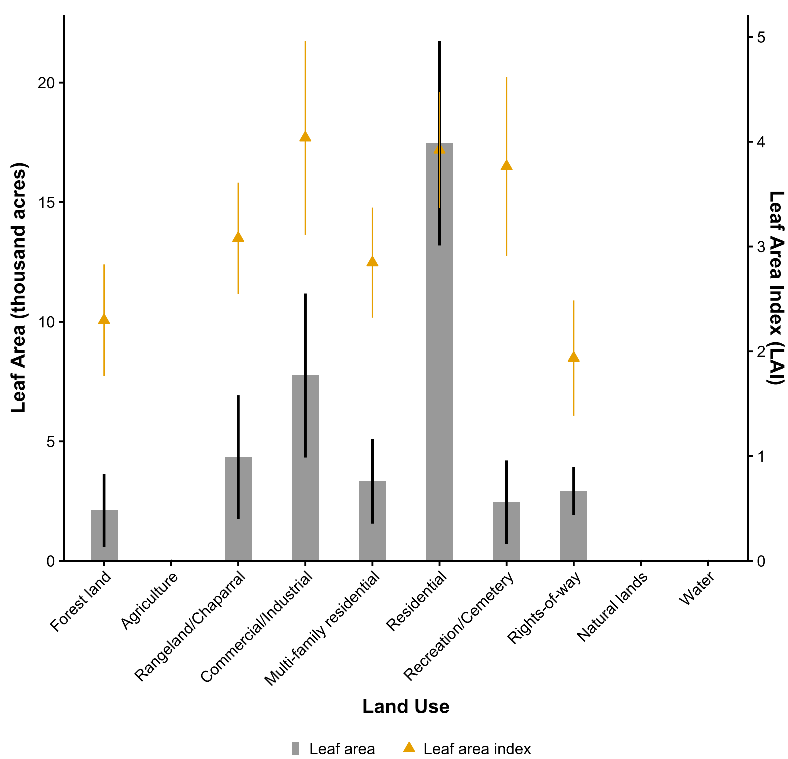

Figure 11.— Leaf area and leaf area index (LAI) by Forest Inventory and Analysis (FIA) land use, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

Species Importance

Importance values (IVs) establish the relative contribution of the observed species to the overall species composition of the urban forest and are calculated by summing the values of its relative leaf area and relative abundance. High importance values do not mean that these trees should be encouraged in the future, but rather that they currently dominate the urban forest structure in terms of their population size and leaf area. The species in San Diego's urban forest with the greatest IVs are Chinese banyan (22.6), arroyo willow (20.2), and queen palm (13.3) (Table 16).

Table 16.—Ten most common species by Importance Value (IV), San Diego, 2017

Common name	Population (percent)	Leaf area (percent)	IV
Chinese banyan	17.2	5.5	22.6
arroyo willow	12.1	8.1	20.2
queen palm	2.2	11.1	13.3
Aleppo pine	6.9	5.6	12.5
Japanese cheesewood	9.4	1.7	11.2
Tasmanian bluegum	3.0	5.5	8.5
date palm	0.6	7.5	8.1
pygmy date palm	4.0	2.1	6.0
Washington fan palm	1.4	4.6	5.9
California sycamore	2.3	3.1	5.3

Due to rounding, not all values will add up exactly.
IV = Population (%) + Leaf area (%).

VOLUME AND BIOMASS

A wide variety of native and ornamental trees on both privately and publicly owned lands contribute to the volume and biomass of San Diego's urban forest. USDA Forest Service photo by John Mills.

Wood Volume and Value

Wood volume is a measure of the solid content of the tree stem and is used to estimate wood quantity. A detailed description of methods used to compute wood volume in terms of net cubic foot volume and sawtimber volume for this report is presented in Baer et al. (2024). Understanding the net volume of wood provided by a community's trees can serve a variety of purposes. From a management perspective, a thorough knowledge of wood volume can help predict potential storm damage and support planning for post-disaster recovery, including debris removal and cost. Volume data can also inform urban wood markets, which add value to traditional wood waste derived from tree removal, storm damage, and general tree maintenance. Such data can incentivize repurposing wood waste into traditional wood products such as lumber, handcrafted furniture, nature-based landscape supplies, and biofuel (e.g., Nowak et al. 2019).

In San Diego, live trees at least 5.0 inches in diameter are estimated to contain 19.0 million cubic feet of net volume and 11.3 million board feet of net sawtimber volume. To put this value in perspective, the median size of American homes constructed in 2019 is 2,301 square feet (US Census Bureau 2020a), which would require roughly 14,500 board feet to construct, assuming 6,300 board feet are required to construct 1,000 square feet of living space. Thus, the net sawtimber volume of San Diego's urban forest is roughly equivalent to the amount of wood needed to construct 779 median-sized homes. Sugargum contributed the greatest net cubic-foot volume at 18.8 percent of the city total (Table 17). Tasmanian bluegum contributed 100 percent of the total net board-foot sawtimber volume (Table 18). By diameter class, the greatest net cubic-foot volume is provided by trees 25.1 inches or greater in diameter (Fig. 12).

Table 17.—Net cubic-foot volume for tree species with greatest net volume, San Diego, 2017

Common name	Net volume (cubic feet)	Standard error (cubic feet)	Net volume (percent)
sugargum	3,570,000	3,170,000	18.8
Tasmanian bluegum	1,970,000	1,930,000	10.4
Canary Island pine	1,670,000	824,000	8.8
Washington fan palm	1,570,000	846,000	8.3
Aleppo pine	1,420,000	856,000	7.5
melaleuca	1,020,000	664,000	5.3
queen palm	913,000	321,000	4.8
date palm	763,000	657,000	4.0
pygmy date palm	530,000	237,000	2.8
arroyo willow	516,000	395,000	2.7
Other species	5,090,000	919,000	26.7
Total	**19,040,000**	**4,100,000**	**100.0**

Due to rounding, not all values will add up exactly.

Table 18.—Net board-foot sawtimber volume for tree species with greatest net volume, San Diego, 2017

Common name	Net volume (board feet)	Standard error (board feet)	Net volume (percent)
Tasmanian bluegum	11,340,000	12,140,000	100
Total	**11,340,000**	**12,140,000**	**100**

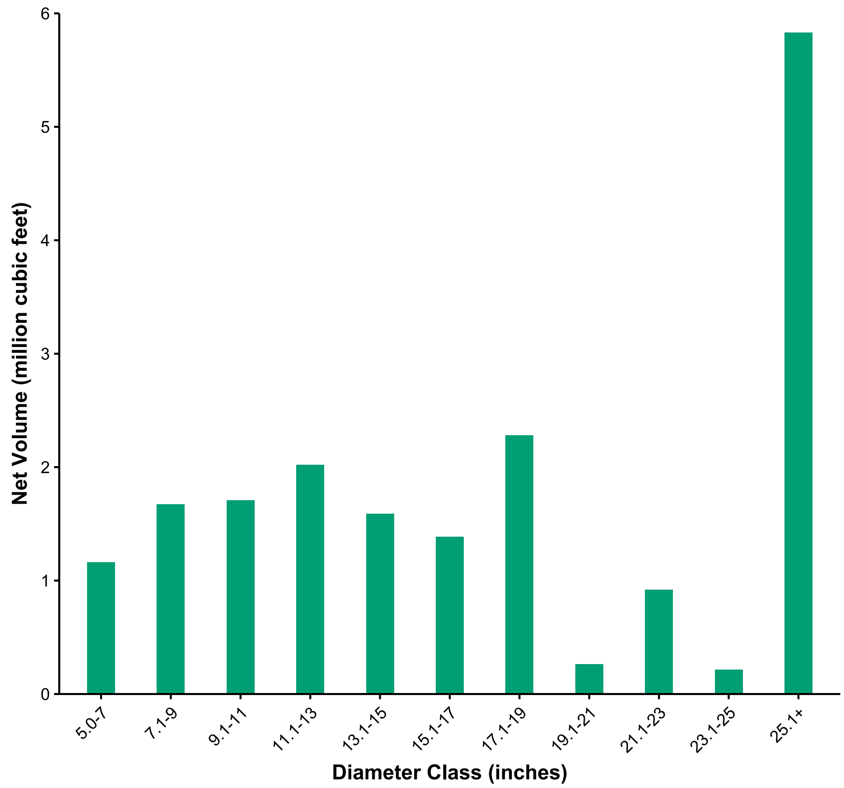

Figure 12.— Net cubic volume by tree diameter class, San Diego, 2017.

While sawtimber could potentially be derived from urban forests to provide economic value, the broader social-ecological value of this forest is derived from healthy trees. Healthy urban forests provide benefits that support environmental and human health and well-being and are valued at over $18 billion per year nationally (Nowak and Greenfield 2018). Harvesting healthy urban trees will reduce these local annual benefits. Utilizing urban wood waste, however, does not affect the healthy tree canopy and augments the value of the urban forest. Urban wood waste could produce between $89 to $786 million per year nationally, depending on the product derived (e.g., wood chips to lumber) (Nowak et al. 2019).

Increasing public interest in environmentally responsible and sustainable products presents opportunities for urban wood utilization programs. In urban settings, trees generally only become a source for wood products after removal for development purposes or because of safety factors including age, pest and disease, or storm events. Many of these urban trees are unsuitable for traditional sawtimber products but may still have economic and cultural value.

Methods to evaluate the quality of urban wood for potential products are not well defined since wood markets and products are quite varied across different geographic areas. Research is needed to develop metrics for evaluating urban wood waste for specialty products. For example, many consumers of urban wood are interested in wood with grain character. Character wood that contains knots, insect damage, and distorted grain is often highly desirable for specialty products, but these are the same wood qualities that make for less desirable traditional lumber. Urban wood waste utilization programs and markets may be better informed by drawing upon available FIA information about net growth, removals, and mortality.

Biomass

Like wood volume, tree biomass information is important in estimating both wood production and carbon storage. The overall aboveground biomass of all live trees in San Diego is estimated at 825,000 green tons (Table 19). The amount of biomass stored by live trees in San Diego varies by species. The tree species with the greatest total above-ground biomass are sugargum (17.3 percent), Tasmanian bluegum (9.8 percent), and Washington fan palm (8.0 percent) (Table 19).

Table 19.—Aboveground biomass (green tons) for tree species with the greatest biomass, San Diego, 2017

Common name	Biomass (green tons)	Standard error (green tons)	Biomass (percent)
sugargum	143,000	127,000	17.3
Tasmanian bluegum	81,000	76,000	9.8
Washington fan palm	66,000	36,000	8.0
Canary Island pine	57,000	28,000	6.9
Aleppo pine	50,000	30,000	6.0
melaleuca	44,000	29,000	5.3
queen palm	40,000	14,000	4.9
arroyo willow	34,000	28,000	4.1
date palm	29,000	25,000	3.5
pygmy date palm	23,000	10,000	2.8
Other species	259,000	41,000	31.4
Total	**825,000**	**166,000**	**100.0**

Due to rounding, not all values will add up exactly.

URBAN FOREST VALUES

Urban trees such as floss silk tree (*Ceiba speciosa*) provide many benefits to residents, including shading that reduces cooling costs during the warmer months of the year. Courtesy photo by Brian Widener, City of San Diego, CA.

Urban forest values can be quantified as functional or structural. Social and biophysical functional values, either positive (e.g., decreased energy use) or negative (e.g., increased energy use) are based on the annual functions the trees perform, including sequestering carbon, removing air pollutants, and influencing surrounding microclimates, which affects the amount of energy used to heat or cool buildings. The forest may provide many other functional values that are not quantified in this report (e.g., reduction in ultraviolet radiation, wildlife habitat, enhanced recreational opportunities, fostering social cohesion, or community health and well-being). Thus, the functional estimates provided in this report represent only a portion of the total forest functional values. Structural values include the amount of carbon stored by a tree and the tree's compensatory value, which can be thought of as the replacement value of the tree. Structural and functional values tend to increase as the number and size of healthy trees increases and are usually on the order of several million dollars per year at a city scale.

Forest management activities can increase the values and services provided by the urban forest. However, these values and benefits can also decrease if the amount of healthy tree cover declines. Various costs associated with urban forest management, such as tree pruning, inspection, removal and disposal, are not accounted for in this assessment and may offset some of the estimated monetary benefits described here (McPherson et al. 2005).

Urban forest ecosystem services associated with air pollution removal, avoided runoff, carbon sequestration, and compensatory value exclude dead trees, as these benefits are mainly based on existing leaf area, leaf biomass, or live tree conditions. However, standing dead trees do contribute to carbon storage and energy effects and are included in estimates for these values.

Air Pollution Removal

Poor air quality is a common problem in urban areas. Air pollution can adversely affect human health by increasing rates of pulmonary, cardiac, vascular, and neurological diseases and mortality (Pope et al. 2002), along with negatively impacting ecosystem processes and reducing visibility. Urban forests can improve air quality by directly removing pollutants from the air and reducing energy consumption by buildings, which consequently reduces air pollution emissions from power plants and other energy sources. While trees emit volatile organic compounds (VOCs) that can contribute to ozone (O_3) formation (Fehsenfeld et al. 1992, Karlik and Pittenger 2012), integrative studies have revealed that an increase in tree cover tends to reduce O_3 formation, although the extent to which this is the case depends upon species composition (Calfapietra et al. 2013; Manes et al. 2012; Nowak et al. 2000, 2006).

Pollution removal by the urban forest in San Diego is greatest for O_3 (349.6 tons per year), followed by nitrogen dioxide (NO_2; 53.0 tons per year), carbon monoxide (CO; 14.2 tons per year), particulate matter less than 2.5 microns ($PM_{2.5}$; 2.5 tons per year), and sulfur dioxide (SO_2; 2.1 tons per year) (Fig. 13). The economic value of this pollution removed is estimated using i-Tree methodology in one of two ways, depending on the pollutant. For NO_2, SO_2, O_3, and $PM_{2.5}$, estimates are based on avoided health effects due to lower pollution concentrations. For CO, the estimated value is based on the avoided externality costs of air pollution to society (Nowak 2024). The estimated value associated with pollution removal is greatest for O_3 (\$2.95 million), followed by $PM_{2.5}$ (\$927,000), NO_2 (\$46,000), CO (\$21,000), and SO_2 (\$600) (Table 20). It is estimated that trees in San Diego remove a total of 421 tons of air pollution per year with an associated value of \$3.9 million.

Decreases in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in San Diego (Nowak et al. 2014, U.S. EPA 2012). Using measured field data and pollution data from 2015, air quality improvements from trees resulted in numerous health effects including an estimated 967 fewer cases of acute respiratory symptoms with an associated value of over $82,000 (Table 20).

Trees in San Diego emitted an estimated 364.0 tons of VOCs (293.4 tons of isoprene and 70.5 tons of monoterpenes). Emissions vary among species based on species characteristics (e.g., some genera such as oaks are high isoprene emitters) and leaf biomass. Species of eucalyptus (*Eucalyptus* spp.) and palm (*Syagrus* spp.) contributed 58.5 percent of VOC emissions (Fig. 14). These VOCs are precursor chemicals to ozone formation.

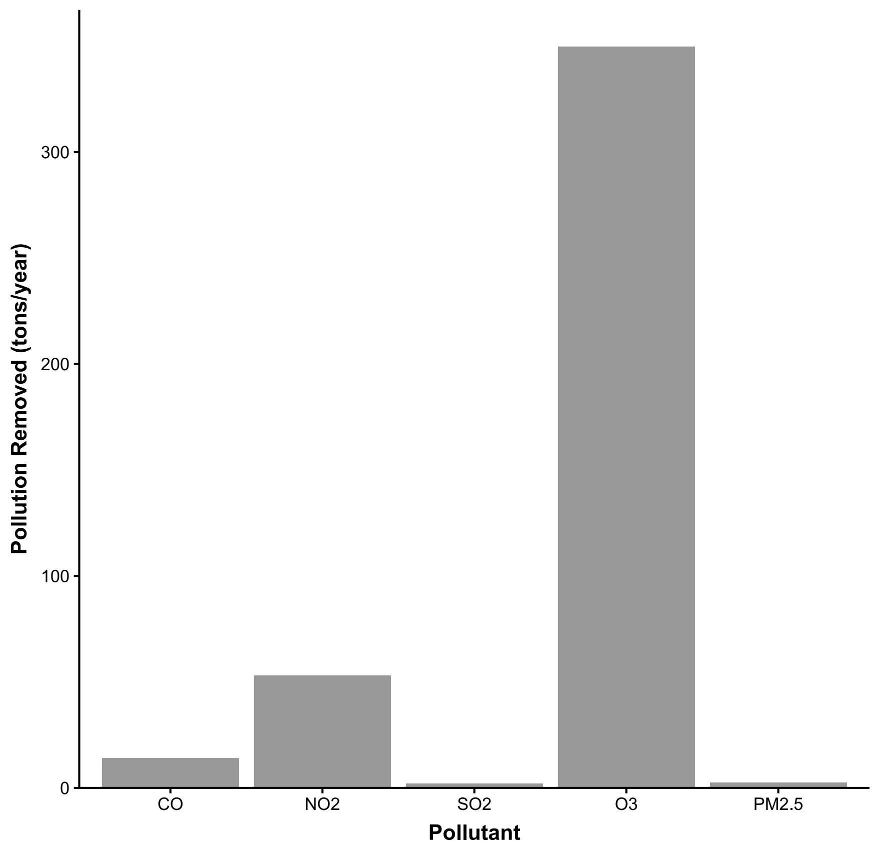

Figure 13.— Air pollution removal in urban forests, San Diego, 2017.

Table 20.—Incidence (number of cases per year) and associated value (dollars per year) of avoided health effects from changes in pollution concentrations due to pollution removal by trees in San Diego's urban forest using 2015 atmospheric conditions

Health effect	NO_2 cases/yr	NO_2 \$/yr	SO_2 cases/yr	SO_2 \$/yr	O_3 cases/yr	O_3 \$/yr	$PM_{2.5}$ cases/yr	$PM_{2.5}$ \$/yr
Acute Bronchitis	–	–	–	–	–	–	0.1	6.2
Acute Myocardial Infarction	–	–	–	–	–	–	<0.1	1,800.0
Acute Respiratory Symptoms	23.8	750.0	0.4	11.8	900.0	77,000	46.7	4,600.0
Asthma Exacerbation	360.0	30,000.0	3.3	260.0	–	–	32	2,600.0
Chronic Bronchitis	–	–	–	–	–	–	<0.1	10,000.0
Emergency Room Visits	0.2	96.8	<0.1	4.6	0.3	120	<0.1	14.3
Hospital Admissions	0.5	15,000.0	<0.1	320.0	0.6	18,000	–	–
Hospital Admissions, Cardiovascular	–	–	–	–	–	–	<0.1	410.0
Hospital Admissions, Respiratory	–	–	–	–	–	–	<0.1	270.0
Lower Respiratory Symptoms	–	–	–	–	–	–	0.9	44.9
Mortality	–	–	–	–	0.4	2,820,000	0.1	905,000.0
School Loss Days	–	–	–	–	320.0	32,000	–	–
Upper Respiratory Symptoms	–	–	–	–	–	–	0.7	31.4
Work Loss Days	–	–	–	–	–	–	8.0	1,400.0
Total	**380.0**	**46,000.0**	**3.7**	**600.0**	**1,200.0**	**2,950,000**	**88.6**	**927,000.0**

Due to rounding, not all values will add up exactly.

Dash indicates that the value is not estimated for that pollutant and health effect. The same health effects were not analyzed for each pollutant.

Pollution removals for CO is $21,000 per year. This amount is based on externality values, not health values.

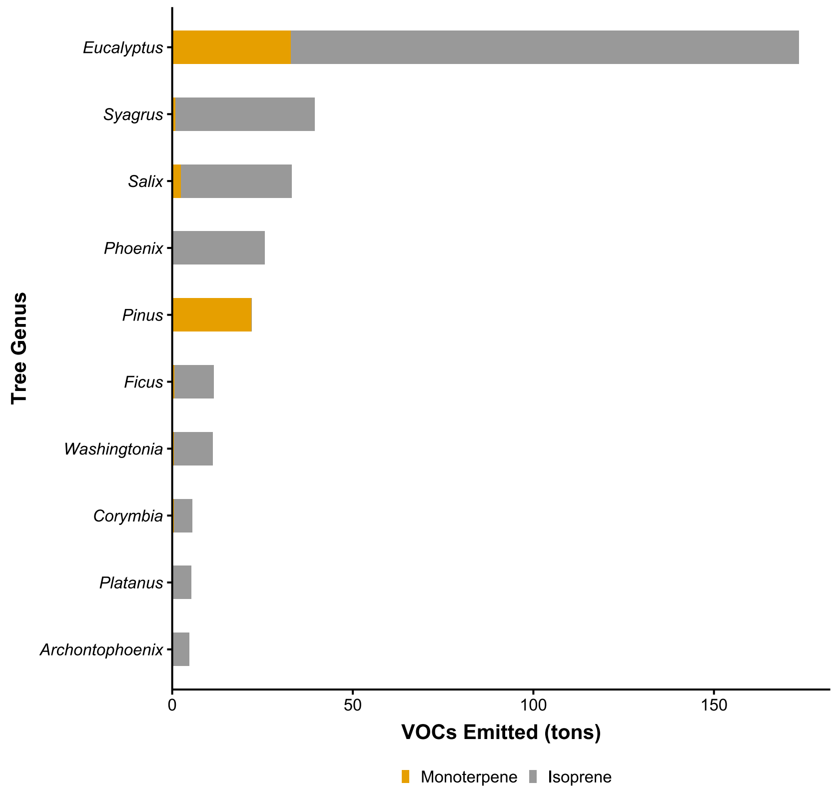

Figure 14.— Volatile organic compound (VOC) emissions by genus, San Diego, 2017.

Avoided Runoff

Surface water runoff (commonly referred to as surface runoff or stormwater runoff) can contribute to pollution in streams, wetlands, rivers, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation, while the remainder reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil or end up in surface depression storage becomes surface runoff (Hirabayashi 2013). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees can reduce surface runoff. Tree canopies intercept precipitation, while root systems promote infiltration and water storage in the soil. The amount of avoided runoff is less than the total amount intercepted because soils also absorb precipitation and thus reduce runoff in the absence of trees. The trees in San Diego are estimated to reduce runoff by 7.1 million cubic feet per year (roughly the equivalent of annual residential water consumption of 1,230 residents) (San Diego County Water Authority 2019), with an estimated value of $474,000 per year (Baer et al. 2024). The majority of this avoided runoff is attributable to interception by tree canopies. Tree species with the greatest overall impact on runoff are queen palm, arroyo willow, and date palm due to their large leaf surface area (Fig. 15).

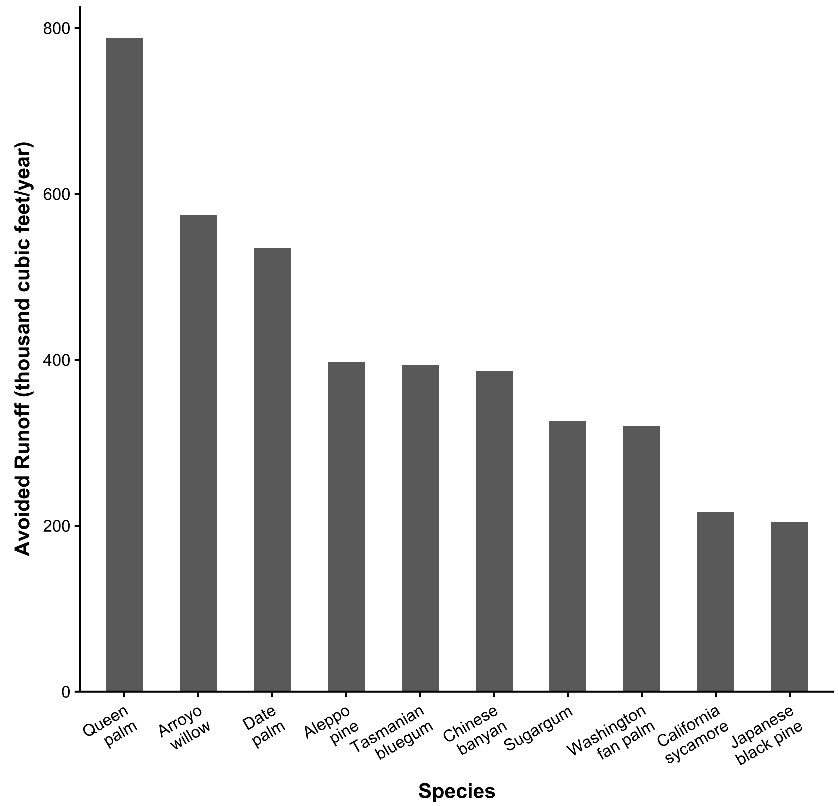

Figure 15.— Avoided runoff for 10 tree species with greatest leaf area, San Diego, 2017.

Energy Conservation

Trees can affect building energy use by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months (cooling season) and can either increase or decrease building energy use in the winter months (heating season), depending on the location of the trees around the building (Heisler 1986, Nowak et al. 2017). Estimates of tree effects on energy use are based on field measurements of the tree distance and directions to space-conditioned residential buildings (McPherson and Simpson 1999; Nowak et al. 2008; Nowak 2024; U.S. EIA 2012a, b; 2014a, b, c).

In San Diego, interactions between residential buildings and trees 5.0 inches in diameter and greater are projected to annually decrease energy requirements by 67,000 gigajoules (GJ) during the heating and cooling seasons (an energy equivalent of 450,000 gallons of home heating fuel oil) (Table 21), with an annual savings in energy costs of $3.5 million based on average energy costs in 2012 (Table 22). Trees in the urban forest also are estimated to reduce carbon dioxide (CO_2) emissions from fossil-fuel-based power sources by 6,300 tons annually (1,700 tons of carbon; $292,000), equivalent to the burning of over 6.2 million pounds of coal or roughly 13,000 barrels of oil (Hong and Slatick 1994, U.S. EPA 2020).

Table 21.—Annual energy savings[a] (GJ or tons) due to trees 5+ inches in diameter near residential buildings, San Diego, 2017

Reduced energy use and emissions	Cooling	Heating	Total
GJ[b]	97,000	-30,000	67,000
Carbon avoided (tons)[c]	2,200	-520	1,700

Due to rounding, not all values will add up exactly.
[a] Negative values indicate an increase in energy requirements.
[b] GJ = gigajoule (one billion [10^9] joules).
[c] To convert carbon estimates to CO_2, multiply carbon value by 3.667.

Table 22.—Annual monetary savings[a,b] due to trees 5+ inches in diameter near residential buildings during heating and cooling seasons, San Diego, 2017

Reduced energy use and emissions ($)	Cooling	Heating	Total
Energy effects	4,140,000	-622,000	3,520,000
Carbon avoided	381,000	-88,000	292,000

Due to rounding, not all values will add up exactly.
[a] Based on 2012 statewide energy costs (U.S. Energy Information Administration 2012a, 2012b, 2014b, 2014c) and 2015 social cost of carbon (Interagency Working Group 2013, U.S. Environmental Protection Agency 2015).
[b] Negative values indicate an increase in energy requirements.

Carbon Storage and Sequestration

Climate change is an issue of global concern that threatens vulnerable species and ecosystems (e.g., coral reefs, polar and coastal areas) along with food production, water resources, and human health (Intergovernmental Panel on Climate Change 2014). Reductions in the amount of energy required to heat or cool residential buildings described in the energy conservation section of this report lead to reduced CO_2 emissions from fossil-fuel based power sources (Abdollahi et al. 2000). Trees can also help mitigate climate change by annually sequestering atmospheric carbon (in the form of CO_2) and storing carbon in their accumulated tissue (i.e., biomass).

Carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose or are consumed in a fire event. Although tree maintenance practices (e.g., pruning) can contribute to carbon emissions, maintaining healthy trees helps to retain carbon stored in trees (Nowak et al. 2002b). Using removed trees for wood products is one way to help forestall carbon emissions related to wood decomposition. Wood from removed trees can also be used to produce energy (e.g., heat or cool buildings), helping to reduce fossil-fuel based carbon emissions. Trees in San Diego store an estimated 289,000 tons of carbon (1.1 million tons of CO_2) valued at $49.3 million (Table 23). Carbon storage varied across the city (Fig. 16), among land uses, and by species. The species that stored the most carbon are sugargum, Tasmanian bluegum, and Washington fan palm (Fig. 17).

Table 23.—Aboveground and belowground carbon in live and standing dead trees by Forest Inventory and Analysis (FIA) land use, San Diego, 2017

FIA land use	Aboveground in live trees (tons C)	Belowground in live trees (tons C)	Total in standing dead trees (tons C)	Total (tons C)	Standard error (tons C)
Residential	67,000	13,000	610	81,000	17,000
Rangeland/Chaparral	55,000	11,000	2,900	69,000	45,000
Commercial/Industrial	39,000	7,800	0	47,000	16,000
Recreation/Cemetery	24,000	4,600	290	29,000	26,000
Multi-family residential	23,000	4,500	0	28,000	13,000
Rights-of-way	18,000	3,500	830	22,000	10,000
Forest land	8,100	1,600	3,200	13,000	9,400
Total	235,000	46,000	7,800	289,000	–
Standard Error	47,000	9,000	4,200	56,000	–

Due to rounding, not all values will add up exactly.
– = no value for cell

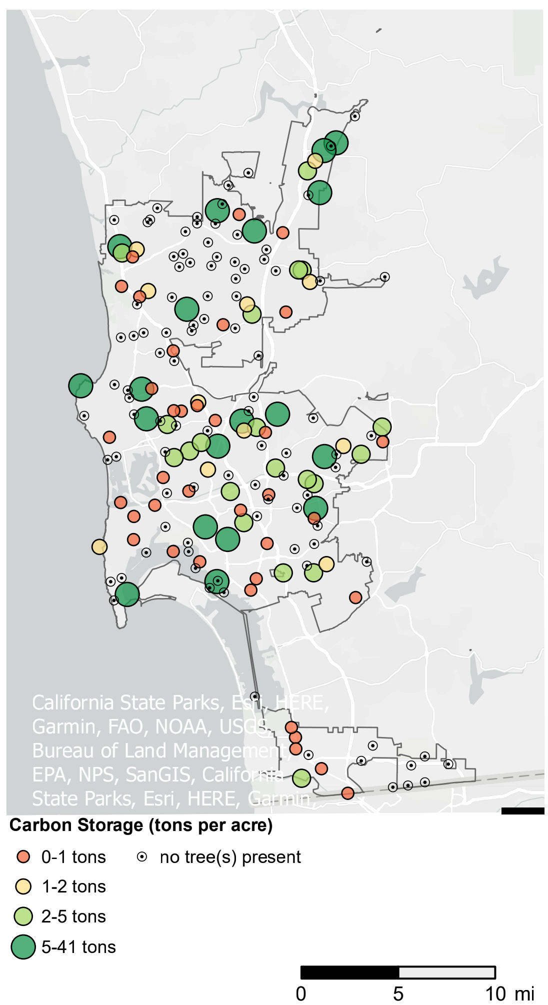

Figure 16.— Carbon storage per acre by plot, San Diego, 2017. Basemap: Esri (2017). Plot locations are approximate.

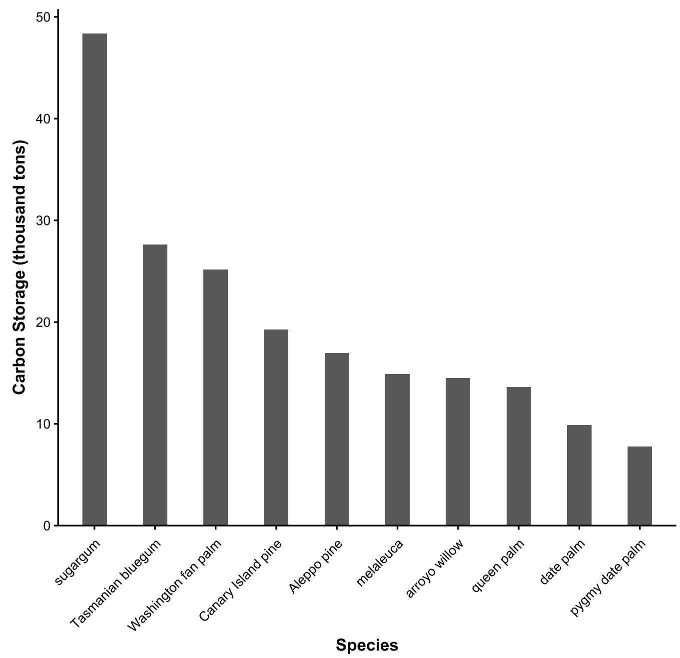

Figure 17.— Estimated carbon storage for 10 tree species with the greatest carbon storage, San Diego, 2017.

Larger trees store more carbon per tree due to their greater size. Accordingly, trees with diameters of 25.0 inches or greater store the greatest proportion of carbon in San Diego, both on a per tree basis and as a percentage of total carbon storage by the entire urban forest (Figs. 18 and 19).

In addition to carbon storage, which accounts for past carbon sequestration, healthy trees continue to annually sequester carbon in new tissue growth. Gross sequestration by urban trees in San Diego is about 34,600 tons of carbon per year (127,000 tons per year of CO_2), with an associated value of $5.9 million per year, which is roughly equivalent to the annual emissions associated with 24,891 passenger vehicles or energy usage by 13,295 homes (U.S. EPA 2020). Arroyo willow is estimated to sequester the most carbon of all species in the urban forest (6.6 percent of all sequestered carbon; Fig. 20).

Estimates of carbon storage and sequestration in developed and undeveloped land uses, along with evaluations of tree growth, removals, and mortality by ownership, can aid in assessing impacts of proposed land use changes and in developing climate change strategies and targets.

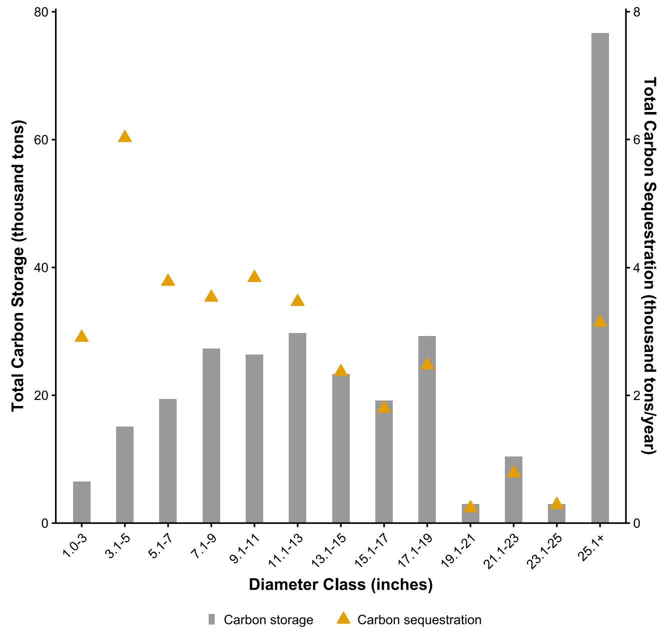

Figure 18.— Estimated total carbon storage and sequestration by diameter class, San Diego, 2017.

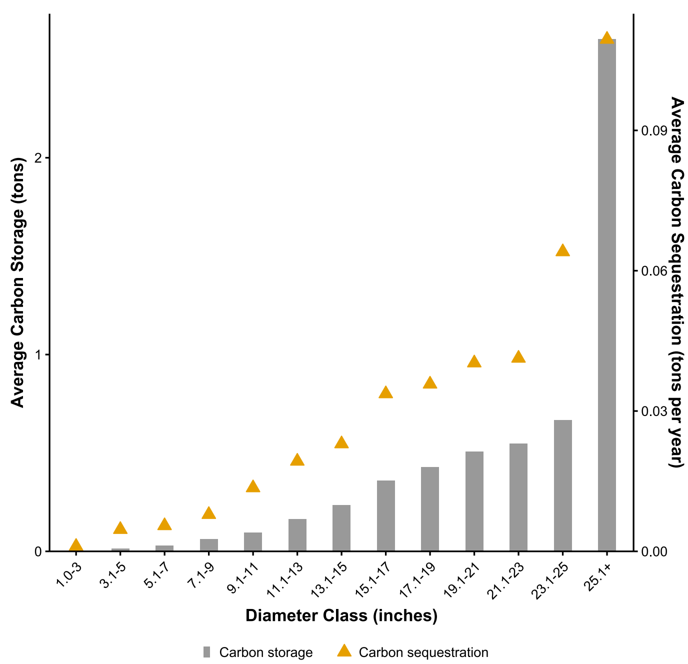

Figure 19.— Average per tree carbon storage and sequestration by diameter class, San Diego, 2017.

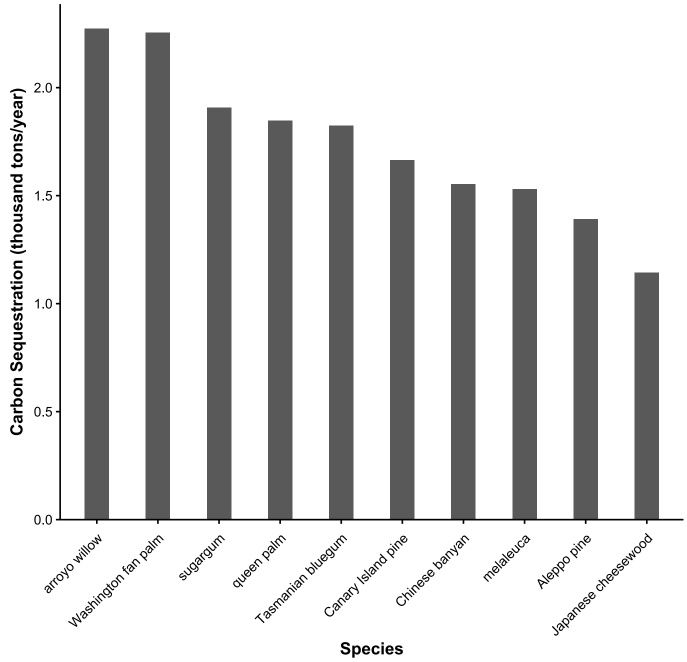

Figure 20.— Estimated annual carbon sequestration for 10 tree species with the greatest carbon storage, San Diego, 2017.

Structural Values

The city's forest has a structural value that includes the compensatory value and carbon storage value of each tree. The compensatory value is an estimate of the value of the tree as a structural asset (e.g., how much should one be compensated for the loss of the physical structure of the tree), which tends to increase with the size and health of the tree. For small trees, a replacement cost can be used; for larger trees, appraisal procedures are used (Council of Tree and Landscape Appraisers 2000, Nowak et al. 2002a). This appraisal is an estimate based on tree species, diameter, condition, and location and does not include many personal, social, functional, or future values that may be ascribed to a tree (e.g., Nowak and Aevermann 2019). Note that **invasive** tree species have compensatory values because the methods used to estimate compensatory value do not account for whether the species is native, nonnative, or invasive. Additionally, invasive species still contribute to ecosystem services. The compensatory value of the trees in San Diego is estimated to be about $4.7 billion. This compensatory value is a function of the number, health, diameter, and species of all trees measured, as well as the land use in which they are encountered. The species with the largest compensatory values are Aleppo pine, Canary Island pine, and melaleuca (Fig. 21). The mean compensatory value per acre for all surveyed plots in San Diego is $26,400; for the 46.4 percent of these plots that contain trees, the mean compensatory value per acre is $56,800 (Fig. 22). However, compensatory value per acre is estimated to exceed $75,000 for 22 plots in which the average tree diameter is 8.7 inches. The structural value of urban trees in San Diego is a combination of their compensatory value (estimated at $4.7 billion) and the value associated with carbon storage by the trees (estimated at $49.3 million).

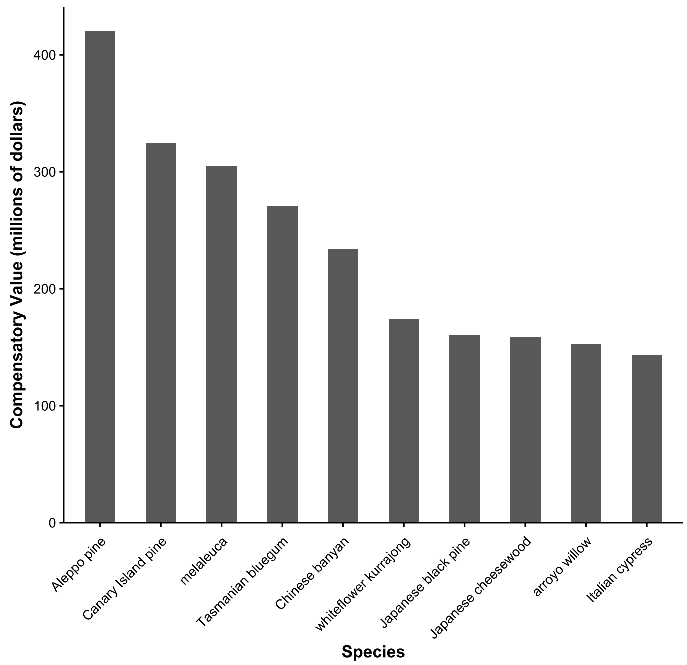

Figure 21.— Compensatory value by tree species, San Diego, 2017.

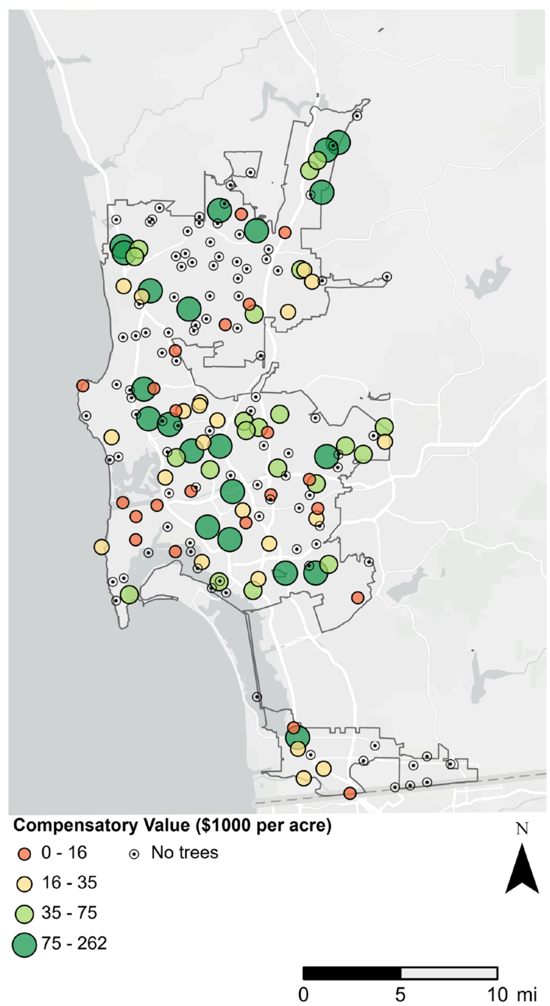

Figure 22.— Compensatory value per acre by plot throughout the sampling area, San Diego, 2017. Plot locations are approximate.

URBAN FOREST HEALTH

Urban Forest Inventory and Analysis crew members survey the edge of a forested plot bordering a railroad track for invasive species. USDA Forest Service photo by John Mills.

A healthy urban forest provides greater benefits to society than an unhealthy one. This section highlights crown dieback, tree damages and rot, the number of standing dead trees, and the presence and prevalence of invasive plant species as indicators of urban forest health in San Diego. Detailed methods of invasive species as indicators of urban forest health metrics are presented in the Urban FIA Field Guide Version 7.1 for San Diego, California (USDA Forest Service 2017).

Crown Dieback and Bole Rot

Tree crown condition can be used as an indicator of tree health. Large, dense crowns are often indicative of vigorously growing trees, while small, sparsely foliated crowns signal trees with little or no growth. Crown dieback is one of the initial indications that a tree may be in a state of decline. Crown dieback is measured as a percentage of the crown volume with recent mortality of small fine branches and twigs in the upper and outer portion of the tree's crown. Trees with more than 25 percent crown dieback may be in decline (Steinman 2000). High levels of dieback may indicate an insect, disease, or environmental problem associated with a particular tree species.

Of the tree species that have a minimum sample size of 10 trees and show evidence of dieback, arroyo willow has the highest average dieback (16.5 percent) (Table 24). Approximately 22.9 percent of arroyo willows display greater than 25 percent crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in San Diego.

In addition to crown dieback, the amount of rot present in the trunk of a tree may indicate tree health issues and serve as a predictor of potential hazardous trees in urban areas. The percent of the main stem that was **rotten or cull** between 1 foot above the ground and approximately 4.0-inch top diameter outside of bark was recorded for all trees at least 5.0 inches in diameter. Of species with a minimum sample size of 10 trees, the species with the highest average rotten/cull amounts is arroyo willow and Callery pear (Table 25).

Table 24.—Tree species with greatest average dieback, San Diego, 2017

Species	Average dieback (percent)	Standard error (percent)	Trees with more than 25 percent dieback (percent)
arroyo willow	16.5	23.4	22.9
Callery pear	2.9	3.2	0.0
Tasmanian bluegum	2.3	2.0	0.0
melaleuca	0.4	0.5	0.0

Due to rounding, not all values will add up exactly.
Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.

Table 25.—Tree species with the greatest average rot, San Diego, 2017

Species	Average rot (percent)	Standard error (percent)	Trees with more than 15 percent rot (percent)
arroyo willow	5.1	6.3	25.3
Callery pear	0.3	0.7	0.0

Due to rounding, not all values will add up exactly.
Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.
Rot is only measured on trees greater than or equal to 5 inches in diameter.

Tree Damage and Potential Infrastructure Issues

Urban trees are susceptible to a wide range of insect, disease, and abiotic (e.g., soil compaction) damage agents that may affect tree survival, growth, and wood quality. Many damage agents are host specific, and their impacts may vary by regional and local growing conditions. Live trees greater than 1.0 inch in diameter were examined for indications of several damage agents. Up to three damage agents were recorded per tree; each recorded agent was required to meet a minimum severity threshold (e.g., 20 percent of the foliage affected). If more than three damage agents were observed on a tree, the top three were prioritized according to their ability to do the following: (1) prevent the tree from surviving more than 1-2 years, (2) reduce the tree's growth in the near term, and (3) negatively affect a tree's marketable wood products. The full list of potential damage agents is presented in the Urban FIA Field Guide Version 7.1 (USDA Forest Service 2017). Stem decay and open wounds are the most common causes of damage, affecting 7.1 and 6.5 percent of trees, respectively (Table 26).

In addition to damage agents, each live tree greater than 1.0 inch in diameter was evaluated for the presence of the following infrastructure issues that affect urban trees:

1. Root/stem girdling
2. Conflict with roots (sidewalk-root conflict/infrastructure damage)
3. Topping/pruning
4. Conflict with crown (branches within 5 feet of overhead wires)
5. Trunk/bark inclusion
6. Improper planting
7. Excessive mulch

Improper planting is the most common issue, occurring in 8.9 percent of trees. Root/stem girdling and topping/pruning are the second and third most common urban specific infrastructure issues, occurring in 7.7 and 6.0 percent of trees, respectively (Fig. 23).

Table 26.—Percentage of trees with observed damage, San Diego, 2017

Damage type	Percent
Root/butt diseases	1.1
Cankers	2.6
Stem decay	7.1
Wild animals	1.8
Abiotic damage	0.2
Human activities	6.1
Other Damages and Symptoms	
Broken top	0.2
Dead top	5.3
Forked top	0.1
Forked below merch top	0.8
Foliage discoloration	0.3
Dieback	1.5
Open wound	6.5
Resinosis	5.8

Due to rounding, not all values will add up exactly.

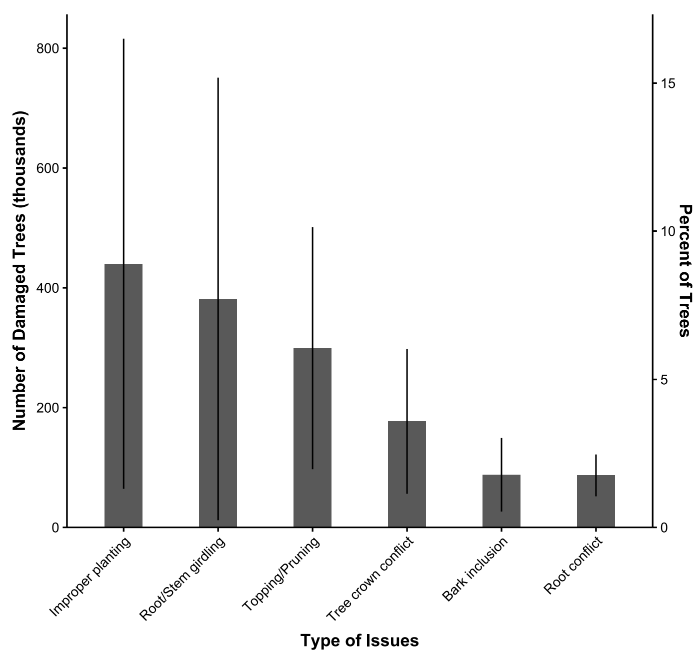

Figure 23.— Number and percentage of trees by urban infrastructure issue category, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

Differences exist in the prevalence of these issues among the FIA-designated land uses and may further inform forest health and management priorities. While most issues are fairly uncommon, 23.5 percent of trees suffer from severe topping or poor pruning on multi-family residential land, 22.6 percent of trees on **forest land** have bark inclusion, and 17.2 and 14.3 percent of trees on residential land show evidence of improper planting and stem girdling, respectively.

Urban infrastructure issues also vary by tree species. For example, 43.2 percent of Chinese banyan show evidence of stem girdling and improper planting, while conflict with roots is associated with 30.0 percent of melaleuca sampled in San Diego (Table 27, Appendix 5).

Standing Dead Trees

The number of standing dead trees serves as another measure of urban forest health and can be useful data for management planning. The extent to which a standing dead tree poses a threat to humans, infrastructure, or both depends on the location of the tree. Standing dead trees in maintained areas where human activity is likely high, such as residential and institutional land uses or transportation corridors, will generally be considered hazardous trees and prioritized for removal. Conversely, standing dead trees in patches of forest away from heavy human use are of minimal risk but beneficial for wildlife habitat, and their removal may be deemed undesirable. Because of the variability of removal rates among land use classes, caution is advised when interpreting forest health issues based on numbers of standing dead trees.

Table 27.—Species with greatest proportion of their population with infrastructure issues, by damage type, San Diego, 2017

Damage type and species	Percent
Root/Stem girdling	
Chinese banyan	43.2
Conflict with roots	
melaleuca	30.0
Chinese banyan	0.7
Topping/pruning	
Chinese banyan	19.6
Callery pear	10.8

Damage type and species	Percent
Conflict with crown	
queen palm	5.4
Chinese banyan	2.5
Aleppo pine	1.7
Trunk/bark inclusion	
Callery pear	10.8
arroyo willow	8.3
Chinese banyan	0.7
Improper planting	
Chinese banyan	43.2

Due to rounding, not all values will add up exactly.
Only species with minimum sample size of 10 live trees are included in this analysis to minimize effect of small sample size on percentage estimates.

Standing dead trees were found on four plots in San Diego. Of the total live and dead tree population, 13.5 percent is estimated to be standing dead trees. The tree species with the highest percentage of standing dead trees is unknown dead conifer, redbox, and arroyo willow (Table 28). The species that comprises the largest proportion of the dead tree population is arroyo willow (Table 29). Land uses with the highest estimated number of standing dead trees are rangeland/chaparral, residential, and recreation/cemetery (Fig. 24). The majority of standing dead trees were observed on unmaintained land in rangeland/chaparral land uses. The large number of dead trees in rangeland/chaparral land uses is likely due in large part to these trees not being removed by humans (as these areas are not maintained). Past droughts or fires may have played a role in killing these trees. The large estimate of dead trees could also be an artifact of a small sample size of dead trees, which yields a relatively high degree of uncertainty in the estimate (Baer et al. 2024).

Table 28.—Number of trees classified as standing dead by species, San Diego, 2017

Common name	Standing dead trees (number)	Standard error (number)	Percent of species
unknown dead conifer	97,000	97,000	100.0
redbox	28,000	26,000	52.3
arroyo willow	546,000	627,000	47.7
Tasmanian bluegum	89,000	81,000	37.7
river redgum	4,300	5,000	33.3
Washington fan palm	8,700	10,000	11.5

Due to rounding, not all values will add up exactly.

Table 29.—Proportion of total dead tree population by species, San Diego, 2017

Common name	Standing dead trees (percent)
arroyo willow	70.6
unknown dead conifer	12.5
Tasmanian bluegum	11.5
redbox	3.7
Washington fan palm	1.1
river redgum	0.6
Total	**100**

Due to rounding, not all values will add up exactly.

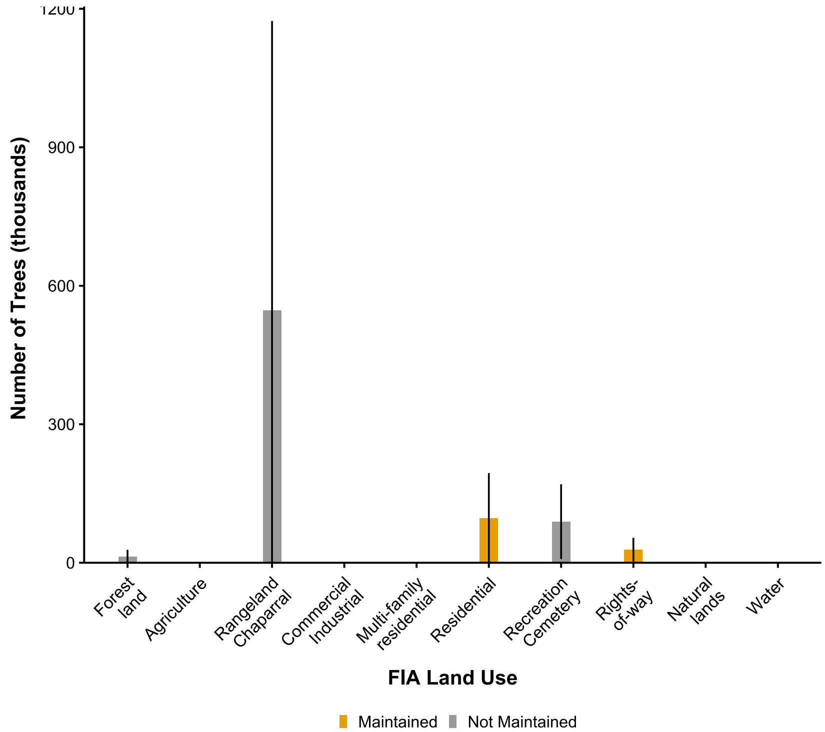

Figure 24.— Proportion of standing dead trees by land use and maintenance status, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

Invasive Plant Species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproduction capacity, and lack of natural enemies. These factors may enable them to displace native plants and threaten natural areas (Davis 2009, Simberloff 2013). In accordance with Executive Order 13112 (1999), the USDA Forest Service defines an invasive species as a nonnative species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Important considerations for invasive plant control efforts include weighing short- and long-term trade-offs in terms of ecosystem services provided or disrupted by invasive species. The removal of invasive species and loss of ecosystem services they provide may lead to a subsequent need to increase the abundance of desirable species to offset these losses. Field crews in San Diego examined each plot for the presence of select invasive species based on a species list developed for the city (Appendix 6). Of the 185 plots examined, invasive species were identified on 11.4 percent (21 plots).

Brazilian peppertree, punktree, Peruvian peppertree, koelreuteria, and tamarisk were each found at least once by field crews (Fig. 25). Although not considered invasive in California, melaleuca is listed as an aquatic noxious weed on the federal noxious weed list (USDA APHIS 2017) and was therefore included in the list of invasive species for San Diego. Beyond noting simple presence or absence, crews noted the percentage of the plot area covered by the invasive species, allowing for the estimation of total area covered by each species within the city (Bechtold and Scott 2005). These estimated areas may offer insights into which species are having the greatest impact in the city. Of the invasive species recorded, Brazilian peppertree (296 acres; 0.2 percent of the sampling area) and punktree (216 acres; 0.1 percent of the sampling area) covered the largest area. covered the largest area. Of particular concern is the potential for these and other invasive species to spread beyond their current distribution into the surrounding landscape, potentially displacing native species and altering local ecosystems (Pimentel et al. 2000).

Additional measurements are recorded in the field for most tree species. As some of the species on the invasive plants list for San Diego are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. Data on goldenrain trees were not collected by crews as they were not included on the tally list for the city, but data were collected on individual saltcedar, Brazilian peppertree, Peruvian peppertree, and melaleuca. Taken together, these invasive trees are estimated to account for roughly 3.6 percent of all live trees surveyed (estimated total trees: 176,829) and 3.3 percent of the total leaf area.

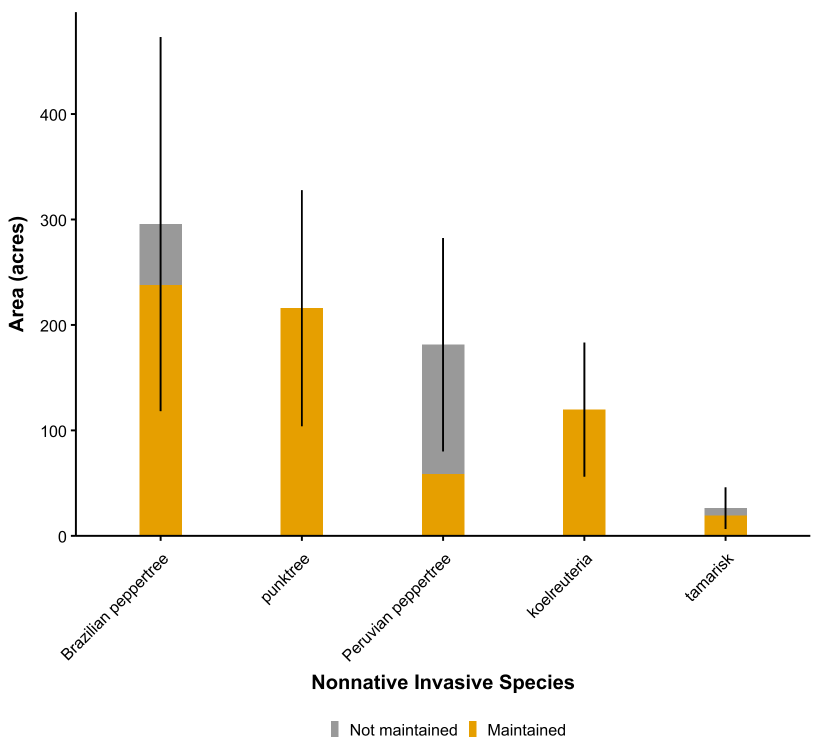

Figure 25.— Nonnative invasive species by maintained and unmaintained land, San Diego, 2017. Error bars represent 68 percent confidence intervals around the estimated means.

Pests and Pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and pests of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. To determine the pests and pathogens that may represent important threats to San Diego's urban forest, we consulted the City Forester for San Diego (Widener 2020), the 2018 California Forest Pest Conditions Report (CFPC 2018), and maps of the distributions of common forest pests and diseases that were included in the National Insect and Disease Risk Maps (USDA Forest Service 2019). Taken together, this approach yielded 11 individual insect pests, pathogens, or pest-pathogen complexes that may have substantial negative effects on common tree species in San Diego. Along with their tree hosts in the San Diego area, these pests, pathogens, or pest-pathogen complexes were evaluated to quantify their potential impact on the urban forest (Table 30). Where pathogens are spread by insect vectors, diseases are grouped with insects in our analysis. For each pest, pathogen, or pest-pathogen complex, we estimated the number of potential host trees within the sampling area, the proportion of the total urban forest resource represented by those trees, and the compensatory value associated with those trees. The number of trees at risk (Fig. 26) reflects only the known host tree species that could experience damage or mortality as a direct or indirect result of the pest or pathogen and does not necessarily include only trees that are known to be directly at risk of attack or infection. As FIA crews did not attribute tree damage or mortality to specific pests or pathogens, it was not possible to identify what portion of each host tree's population was directly at risk from or affected by the focal pests and pathogens. Pest and pathogen range maps (USDA Forest Service 2018, 2019) were used to determine the proximity of each pest, pathogen, or pest-pathogen complex to the area. For San Diego, proximity was classified for insects and diseases in San Diego County; within 250 miles of the County; between 250 and 750 miles of the County; or greater than 750 miles away. For species with no developed range maps, reported locations of the pests, pathogens, or pest-pathogen complexes were queried from additional sources (Hodel et al. 2016, Mayorquin et al. 2012, UC-ANR 2019, UCR-CISR 2019). Proximity data for the insect pests, pathogens, and pest-pathogen complexes, along with the numbers of trees potentially affected and their compensatory values, are illustrated in Table 30.

Based on the host tree species for each pest and the current range of the pest, it is possible to estimate the relative risk faced by each tree species sampled in the urban forest to attack by each of these pests, pathogens, or pest-pathogen complexes and assign each tree species a relative risk weight. In Table 31, each pest that could attack a tree species is scored as 3 points if it occurs within the county, 2 points if it occurs within 250 miles of the county, and 1 point if it occurs within 750 miles of the county. These values are summed across each row to determine the relative risk weight for each tree species recorded in the city.

Table 30.—Potential risk associated with various insects and diseases, San Diego, 2017

Code	Scientific Name	Common Name	Trees at Risk (number)	As proportion of all trees (percent)	Compensatory Value ($ millions)	Source
ISHB-FD	*Euwallacea* sp. / *Fusarium* sp.	Invasive shot hole borer & Fusarium dieback complex	1,458,041	29.5	1126	Eskalen et al. 2013; 2018; UC-ANR 2020
FC	*Neofusicoccum* spp. & *Botryosphaeria dothidea*	Ficus Canker[a]	1,150,063	23.3	842	Mayorquin et al. 2012
CFI	*Ips paraconfusus*	California fivespined ips	492,787	10.0	1005	USDA Forest Service 2019
PBB	*Dendrochtonus valens* / *Hylurgus ligniperda*	Pine Bark Beetles	492,787	10.0	1005	USDA Forest Service 2019
SA	*Apiognomonia veneta*	Sycamore anthracnose	111,633	2.3	115	USDA Forest Service 2019
CO	*Phryganidia californica*	California oakworm[a]	54,182	1.1	25	USDA Forest Service 2019
GSOB	*Agrilus auroguttatus*	Goldspotted oak borer	54,182	1.1	25	USDA Forest Service 2019
SOD	*Phytophthora ramorum*	Sudden oak death[a]	54,182	1.1	25	USDA Forest Service 2019
SAPW	*Rhynchophorus palmarum*	South American palm weevil	27,924	0.6	30	Hodel et al. 2016
ASP/HLB	*Diaphorina citri* & *Candidatus Liberibacter africanus, asiaticus, & americanus*	Asian citrus psyllid & Huanglongbing	5,857	0.1	8	UCR-CISR 2019
PE	*Ips pini*	Pine engraver[a]	4,350	0.1	5	USDA Forest Service 2019

[a] Pests and pathogens not present in San Diego County.

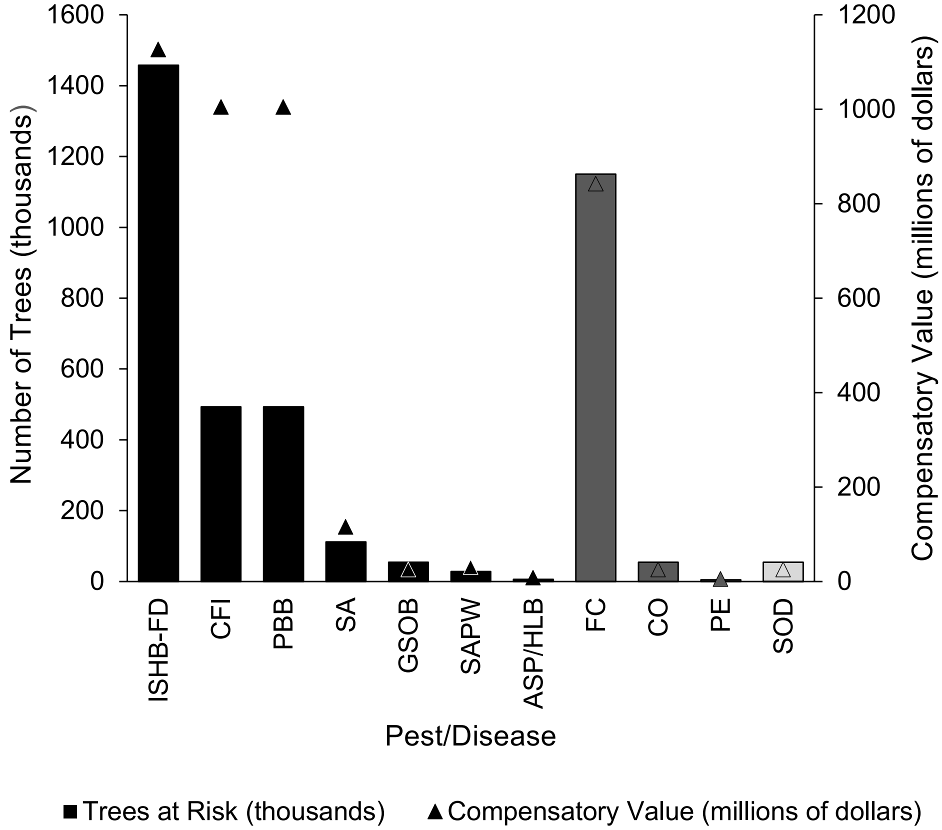

Figure 26.— Number of trees in San Diego at risk due to pests and pathogens and their associated compensatory values. Black bars denote pests and pathogens that have been recorded in San Diego County, gray bars denote pests and pathogens recorded within 250 miles of the County, and light gray bars denote pests and pathogens recorded within 750 miles of the County. Pest abbreviations are presented in Table 30.

Table 31.—Pest risk rating by tree species in San Diego, 2017

Risk Weight[a]	Common Name	Pests[b]										
		GSOB	SA	CO	PBB	ASP/HLB	ISHB-FD	FC	CFI	PE	SAPW	SOD
9	California live oak	3		2			3					1
8	Pine spp.				3				3	2		
6	Aleppo pine				3				3			
6	California sycamore		3				3					
6	Canary Island pine				3				3			
6	Japanese black pine				3				3			
6	Sweet orange					3	3					
6	Torrey pine				3				3			

continued on next page

Table 31 (continued).

Risk Weight[a]	Common Name	Pests[b]										
		GSOB	SA	CO	PBB	ASP/HLB	ISHB-FD	FC	CFI	PE	SAPW	SOD
5	Redbox						3	2				
5	Red ironbark						3	2				
5	River redgum						3	2				
5	Sugargum						3	2				
5	Sydney golden wattle						3	2				
5	Tasmanian bluegum						3	2				
5	Western Australian flooded gum						3	2				
5	White ironbark						3	2				
3	Arroyo willow						3					
3	Bangalow palm						3					
3	Bauhinia						3					
3	Black poui						3					
3	Camphor tree						3					
3	Carrotwood						3					
3	Chinese juniper						3					
3	Date palm										3	
3	Jerusalem thorn						3					
3	Olive						3					
3	Peach						3					
3	Pink flame tree						3					
3	Saltcedarc						3					
3	Sentrypalm						3					
3	Southern magnolia						3					
3	Sweetgum						3					
3	Tipa						3					
3	Whiteflower kurrajong						3					
2	Chinese banyan							2				
2	Roxburgh fig							2				

[a] Risk weight: Numerical scoring system based on sum of points assigned to pest risks for species.

[b] Each pest that could attack species is scored as 3 points if within the county, 2 points if within 250 miles of the county, and 1 point if within 750 miles of the county.

[c] Species in bold text indicate that the species is on the local invasive species list.

MANAGEMENT IMPLICATIONS

San Diego's population of California live oak (*Quercus agrifolia*) is susceptible to damage and mortality following attacks by the goldspotted oak borer (*Agrilus auroguttatus*). Damage to the oak tree shown here is attributable to both goldspotted oak borer and woodpecker foraging on the infesting insects. Licensed photo by Mark S. Hoddle, University of California Riverside, bugwood.org.

The primary goal of Urban FIA is to provide an accurate estimate of the composition, distribution, health, and values of urban forests to aid in sustainable urban forest management and planning. This report presents a baseline against which future monitoring efforts can be compared, including remeasurement of the Urban FIA plots. These comparisons will allow managers to assess rates of tree growth and mortality, as well as changes in species composition, the distribution of size classes, and the benefits associated with the urban forest. Effective monitoring allows for the formulation of data-driven management strategies to maximize the benefits of San Diego's urban forest while minimizing the cost associated with its maintenance.

Identifying priority areas for the enhancement or maintenance of tree growth, survival, and cover may assist in managing the benefits of urban forests. Tree density and its benefits are highly variable among NLCD land classes in San Diego, with density ranging from only 0 and 2 trees per acre in water/barren and forest/shrub land covers, respectively, to 46 trees per acre in the developed-low land cover class (Table 9). The low tree density in forest/shrub land is most likely due to this class being mostly shrub land (e.g., coastal sage scrub, chaparral); the only tree species recorded on plots of this land cover class is Washington fan palm (Appendix 3, Fig. 32). Understanding the relationship between land cover or land use, species composition and density of trees, and the potential benefits associated with conserving or augmenting tree resources may be useful in developing plans to enhance or protect urban forests.

In addition to identifying areas of high priority for management, it is also essential to understand the forces that may alter the future condition, composition, or benefits of the urban forest. Human activities such as population growth, changing infrastructure, increased development, or activities related to natural resource management may affect the amount or species composition of trees in the urban forest. Changes in climate, land cover, species composition, or interactions with pests or pathogens can also shape urban forests. Using this Urban FIA inventory, it is possible to estimate which species may be more or less threatened by changing land use, human activity, or host-specific pests and pathogens and estimate the monetary value associated with these potential threats.

Planting

Recruitment of new trees into urban forests can result from both natural seed-based regeneration and intentional planting, although the relative proportions of naturally occurring versus intentionally planted trees can vary widely among cities. (Nowak 2012). The majority of new trees added to San Diego's urban forest are the result of intentional planting rather than natural recruitment; Urban FIA data suggest that 75.0 percent of trees in San Diego were planted rather than naturally occurring. San Diego's urban forest 5-year plan estimates that the city's streets can accommodate four times the number of trees that currently line them and outlines general areas and land use categories in which supplemental planting may increase urban forest cover or replace trees that have been lost (City of San Diego 2017). Meeting the city's goal of 15 percent canopy cover by 2020 and 35 percent canopy cover by 2035 will require the availability of high quality stock from certified nurseries, sufficient water resources to invest in the irrigation of newly-planted trees, and knowledge of the tree species likely to thrive in the future (City of San Diego 2015, 2017). It will also require the participation of private landowners, as the majority of the city's trees occur on private and residential lands. Urban FIA can help meet some of these requirements by identifying the number and estimated monetary value of trees that are likely to be affected by a variety of agents of damage or change. This information can help managers to identify which trees may be more or less susceptible to current and future environmental constraints. In addition, continued monitoring of the urban forest will offer information on rates of growth and mortality among the city's trees through time.

Population Growth

The population of California is projected to grow by 3.9 million people in the 20 years following this inventory (2017-2037), with the population of San Diego County expected to see an increase of over 300,000 people during this time (California Department of Finance, Demographic Research Unit 2020). This population increase is expected to affect San Diego's urban forest. Changes in land use and land cover associated with the increased housing and infrastructure needs of a growing population may alter tree cover and composition and affect the benefits provided by the urban forest (Kreuter et al. 2001, Nowak et al. 2004, Steenberg et al. 2017, 2018, 2019). Managing urban forest composition to a desirable outcome is critical in urban environments where numerous external forces affect forest structure and benefits. Urban FIA can support management efforts by tracking changes in the urban forest through time via plot remeasurement and determining how observed changes are correlated with changes in population, land use, and other attributes of the city.

Current Tree Size Distribution and Potential Species Composition Changes

The current size distribution of tree species helps shape the future composition of the urban forest. Small, young trees that survive will grow to become larger, older trees, while those trees that are currently large and old will eventually decline and die. An inverse J-shaped distribution curve of tree size classes with more young trees than older trees is thought to indicate the long-term sustainability of tree cover, as sufficient numbers of young trees are present to compensate for the mortality of older trees. The size distribution in San Diego's urban forest is represented by such an inverse J-shaped curve, with most trees falling into the 1.0-3.0 inch diameter class and the fewest falling into the 23.1-25.0 inch diameter class. This shape indicates that San Diego's urban forest is forecasted to be self-sustaining. However, the interactions of several drivers which have not been analyzed in this report, including rates of growth, mortality, natural regeneration, and planting, also influence the diameter class curve, so the driving forces underlying this pattern and the extent of their predicted future stability are unknown.

The species composition of San Diego's urban forest may change in the future depending upon the current size distribution of individual species. Species whose size composition is skewed towards more small, young trees may come to dominate the future classes of intermediate- and large-diameter trees, while those species in which large adult trees are currently more common may decline in abundance through time. For example, pygmy date palm trees tend to be planted at a minimum of 3.0 inches in diameter, so this species is uncommon in the smallest diameter classes reported here (Broschat et al. 2014) (Fig. 8). Pygmy date palms currently in the 5.0-7.0 inch diameter range may survive and grow into larger diameter classes, but without continued planting of smaller-diameter trees to replace them, these trees may become a less common component of San Diego's urban forest over time. Chinese banyan, arroyo willow, Japanese cheesewood, and Aleppo pine dominate the small tree class, indicating that the prevalence of these species in intermediate to large diameter classes may increase in the future if enough survive, but continued natural regeneration or planting of these species may be similarly required. Actions such as pest management, targeted regeneration or planting of certain species, and restoration of habitat suitable for those species whose populations are expected to decline may aid in maintaining the current composition of the city's urban forest.

Native Versus Introduced Trees in San Diego

The City of San Diego occurs in what is naturally a Mediterranean ecosystem. Such ecosystems tend to be dominated by shrubs rather than trees. As such, few of the tree species encountered in San Diego's urban forest are native to the area. Rather, the vast majority are introduced via planting as previously described. Of the 69 species recorded by Urban FIA crews in the city (Appendix 2), six are native to San Diego and surrounding counties and another is native to California according to the USDA Plants database (https://plants.usda.gov) (Table 32). These species represent an estimated 798,000 individual trees, or roughly 16 percent of the trees in the city. Although these species are native to the area or the state, tree planting will likely be required to sustain these populations. Favoring native over introduced species when selecting which trees to plant in the city may be beneficial if those trees are better adapted to survive or thrive under local climatic conditions.

Table 32.—California native tree species recorded in the Urban Forest Inventory and Analysis (FIA) inventory, San Diego, 2017

Scientific name	Common name	San Diego native?	Number	Percent of all trees
Fraxinus velutina	velvet ash	Yes	4,300	0.1
Liquidambar styraciflua	sweetgum	No	12,000	0.2
Parkinsonia aculeata	Jerusalem thorn	Yes	5,900	0.1
Pinus torreyana	Torrey pine	Yes	12,000	0.2
Platanus racemosa	California sycamore	Yes	112,000	2.3
Quercus agrifolia	California live oak	Yes	54,000	1.1
Salix lasiolepis	arroyo willow	Yes	598,000	12.1
Total			**798,000**	**16.1**

Due to rounding, not all values will add up exactly.

Insect and Disease Impacts

Chief among the potential threats to San Diego's urban forest are the Kuroshio and polyphagous shot hole borers (*Euwallacea* spp.) and the associated fungal pathogens that cause the disease known as Fusarium dieback (*Fusarium* spp.), collectively known as the Invasive Shot Hole Borer-Fusarium Dieback Complex (ISHB-FD). Polyphagous shot hole borers are primarily distributed north of San Diego but have been recorded in San Diego County, while Kuroshio shot hole borers are concentrated in the southernmost region of California, including San Diego County (UC-ANR 2019, USDA Forest Service 2019). Both species of shot hole borers act as vectors for *Fusarium* spp., depositing the pathogenic fungus in the vascular system of the tree when they burrow in to deposit their eggs. Together, the fungus and the beetles destroy the tree's cambium and vascular tissue, yielding symptoms ranging from branch dieback to tree death (Lawler and Renner 2007, Eskalen et al. 2013). Over 200 host tree species for ISHB-FD have been identified; 65 of these are known to be reproductive hosts that support beetle reproduction and fungal growth, of which 15 are likely to experience mortality following infection (Eskalen et al. 2013, 2018; UC-ANR 2020). Two of these reproductive hosts (California live oak and California sycamore) are of particular concern due to their iconic status and cultural importance in the region. In San Diego, reproductive hosts threatened with severe damage or mortality as a result of ISHB-FD include arroyo willow, California sycamore, and Jerusalem thorn (Eskalen et al. 2013, 2018; UC-ANR 2020). Reproductive hosts threatened with less-severe damage such as branch dieback include Bangalow palm, black poui, California live oak, carrotwood, saltcedar, sentry palm, southern magnolia, sweetgum, Sydney golden wattle, and whiteflower kurrajong. Non-reproductive host trees susceptible to the ISHB-FD complex include bauhinia, pink flame tree, camphor tree, sweet orange, redbox, Chinese juniper, olive, peach, and tipa. Taken together, roughly 1.46 million trees and saplings throughout the sampling area are estimated to be susceptible to damage or mortality via the ISHB-FD disease complex; the total compensatory value of these trees exceeds $1.1 billion.

San Diego's pine trees face several threats from beetles that damage or destroy vascular tissue. Bark beetles found in San Diego, including the red turpentine beetle (*Dendroctonus valens*) and the redhaired pine bark beetle (*Hylurgus ligniperda*) (USDA Forest Service 2019), deposit their eggs under the bark of infested trees, where their larvae burrow into the surrounding cambium and vascular tissue (Seybold et al. 2008). These beetles are not expected to kill their hosts, but they may render them susceptible to decline due to other stressors (Seybold et al. 2008). Remeasurement of plots through time will allow for further evaluation of the extent to which declines in susceptible host species occur. Within San Diego, Urban FIA data suggest that nearly half a million Canary Island pine, Japanese black pine, and Aleppo pine, among other pine species, may be at risk of bark beetle attack. The combined compensatory value of these trees is estimated at over $1 billion.

San Diego's pines are also threatened by engraver beetles. Pine engravers deposit eggs in the phloem of pine trees; their larvae create characteristic feeding galleries as they consume the tree's vascular tissue (Kegley et al. 1997, Schultz and Bedard 1987). Infestations of these beetles may result in top-kill of affected trees or mortality in young or stressed trees (Kegley et al. 1997, Schultz and Bedard 1987). The pine engraver beetle (*Ips pini*) has been recorded just beyond the boundary of San Diego County (USDA Forest Service 2019) and may threaten several species of pine trees in San Diego's urban forest if its distribution expands into San Diego County. The California fivespined ips engraver beetle (*Ips paraconfusus*) also threatens San Diego's pine trees, including its population of Torrey pine. Torrey pine is America's rarest pine species and only occurs naturally in two counties: San Diego and Santa Barbara. Urban FIA estimates San Diego's population of Torrey pines is approximately 12,000 individuals, which represent an estimated compensatory value exceeding $96 million. These trees are faced with a significant risk of damage or death caused by the California fivespined ips. Widespread mortality attributed to this engraver beetle occurred in the 1980s in the Torrey Pines State Natural Reserve northwest of downtown San Diego, a pattern which re-emerged with increasing drought stress in the area beginning in 2001 (Torrey Pines State Natural Reserve 2019).

California live oak is the most threatened tree species within San Diego's urban forest (Table 31). In addition to its susceptibility to the ISHB-FD complex, this species is a host for the goldspotted oak borer (*Agrilus auroguttatus*) and is at risk of attack by the California oakworm (*Phryganidia californica*) and the oomycete that causes sudden oak death (*Phytophthora ramorum*), which have both been recorded within 750 miles of San Diego County (USDA Forest Service 2019). Goldspotted oak borer is an exotic insect pest that is thought to be responsible for the death of roughly 45 percent of oak trees in San Diego County through its destruction of plant vascular tissues and cambium (Coleman et al. 2017). Efforts to prevent the spread of goldspotted oak borer to other areas of the state involve covering or screening and seasoning wood cut from infested trees for at least 2 years or grinding or removing all bark from firewood that has not been seasoned for 2 years prior to transport (Coleman et al. 2017, Flint et al. 2013). California oakworm is a species of moth which feeds on the leaves of oaks as a caterpillar but is unlikely to kill its host tree unless attacks are severe and paired with additional stressors (Swain et al. 2009). Nonetheless, defoliation of oaks may lessen the benefits provided by these trees in San Diego.

The sudden oak death pathogen *P. ramorum* has been responsible for the deaths of over 1 million trees in California and Oregon alone (Parke and Rizzo 2011). *P. ramorum* causes cankers and tree mortality in California live oak, which may devastate the population of this species in San Diego if the infestation spreads southward into San Diego County. San Diego's urban forest contains about 54,000 California live oak trees. The mortality of these trees due to attacks by the goldspotted oak borer and sudden oak death would be associated with the loss of roughly $25 million of compensatory value in San Diego.

Another large hardwood species, California sycamore, is one of the most threatened species in San Diego's urban forest. Like California live oak, California sycamore is susceptible to attack by the ISHB-FD complex. In addition, the fungal pathogen sycamore anthracnose (*Apiognomonia veneta*) may endanger San Diego's estimated 112,000 California sycamore trees. Sycamore anthracnose results in leaf necrosis and defoliation and can kill twigs, shoots, buds, and fruits, and can occasionally lead to the development of stem cankers (Crump 2009). This disease may lead to a loss in the roughly $115 million of compensatory value associated with California sycamore trees in San Diego.

An important disease that has not been officially recorded in San Diego County is ficus canker, a type of "bot canker" that may be caused by the asexual state of the generalist pathogen *Botryosphaeria dothidea* (Mayorquin et al. 2012). Chinese banyan trees are highly susceptible to this disease (Marsberg et al. 2017, Mayorquin et al. 2012, Sahagún 2017). Ficus canker has devastated Chinese banyan trees in urban Los Angeles, California, and is already estimated to have been responsible for the death of more than 25 percent of Chinese banyan trees in the Los Angeles area (Barnes and Scauzillo 2017). Chinese banyan (*Ficus microcarpa*) is the most common tree in Urban FIA's inventory of San Diego's urban forest. If ficus canker spreads southward to San Diego, its impact on ficus trees could be enormous. The pathogen *B. dothidea* is known to infect a wide variety of hosts (Marsberg et al. 2017) and may have much stronger impacts on the trees comprising San Diego's urban forest. As the potential hosts of *B. dothidea* are not well-described, estimates of its potential impacts on San Diego's urban trees (1.2 million trees, $842 million in compensatory value) could be extremely conservative.

Climatic and Fire Impacts

Threats posed to trees by insects and diseases are expected to be compounded by prolonged extreme drought and heat conditions recently experienced in California, which weaken the ability of trees to defend against pests and pathogens. According to the National Drought Mitigation Center (2021), the entirety of San Diego County experienced severe to extreme drought from February 2014 to January 2017 and from May to December 2018, with portions of the County remaining under moderate to severe drought in the intervening 16 months. California also experienced temperatures that were "much above average" in 2017, with record-breaking summer temperatures in July and August of that year (NOAA 2018). Taken together, it is reasonable to expect that the trees of San Diego's urban forest may be at elevated risk of both heat and drought stress, which may in turn make them increasingly susceptible to attack by pests and pathogens. In addition to rendering trees in San Diego's urban forest more susceptible to attack, heat and drought stress are expected to result in more severe consequences stemming from these attacks than would be expected in unstressed trees.

Hot and dry conditions coupled with large fuel loads in California forests have also increased the risk of wildfire throughout the state, including at the wildland-urban interface. A sizeable proportion of San Diego's urban area is designated as a very high fire hazard severity zone (CAL FIRE 2020). This designation is based on several measures, including fuel availability and slope, with fires expected to move more swiftly through highly vegetated, steeply sloped areas such as the narrow canyons common throughout the city, including in areas along Interstate 8 and near Balboa Park, which borders downtown San Diego. Wildfire represents a significant threat to the myriad environmental, economic, and public health and safety benefits conferred by San Diego's urban forest detailed in this report and may also threaten nearby structures. Predicting the areas of greatest risk and the potential losses of urban trees to wildfires in different parts of the city may help urban foresters to prioritize areas in which to focus wildfire prevention efforts. Doing so is also expected to decrease the risk of tree mortality posed by insects and pathogens, as fire can weaken surviving trees and render them more susceptible to attack.

CONCLUSIONS

Sunset over San Diego's urban forest in Embarcadero Marina Park North. Courtesy photo by Brian Widener, City of San Diego, CA.

San Diego's urban forest contributes to the city's environmental, economic, and societal well-being. Throughout the city, an estimated 4.9 million trees, representing 69 species, provide an estimated tree canopy cover of 7.1 percent. This canopy provides a wide range of important environmental benefits including air pollution removal, reduced carbon emissions, carbon storage and sequestration, reduced energy use for buildings, stormwater capture, and many others.

There are several forces that may impact San Diego's forest structure, health, and the environmental benefits provided to the city's residents in the future. These include insect and disease infestations, aging and loss of larger trees, the expansion of invasive species, changes in the management and use of the forest, and growth of the human population.

This analysis provides a baseline for future monitoring. While data from this report capture attributes of the current urban forest resource and associated ecosystem services and values, future monitoring will identify how the forest is changing over time. The plots measured in San Diego will be remeasured annually on a 5-year cycle as part of the continuing urban FIA program. Future analyses of the city's forest can be used to determine the role that natural and human forces play in shaping forest structure and composition.

For now, managers can use the data in this report to inform long-term management plans and policies to sustain a healthy urban tree population and ecosystem services for future generations. Planning and management of the urban forest resource can help sustain vital ecosystem services and values for current and future generations in San Diego. In the future, change analyses can be used to evaluate the success of urban forest management programs.

REFERENCES

Abdollahi, K.K.; Ning, Z.H.; Appeaning, A., eds. 2000. **Global climate change and the urban forest.** Baton Rouge, LA: GCRCC and Franklin Press. 77 p.

Baer, K.C.; Nowak, D.J.; Brandeis, T.J.; Dooley, K.; Hellman, K. [et al]. 2024. **Additional sampling and estimation details for urban forest inventor and analysis reports (version 1).** Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 12 p. https://research.fs.usda.gov/nrs/understory/additional-sampling-and-estimation-details-urban-forest-inventory-and-analysis (accessed October 1, 2024).

Barnes, M.; Scauzillo, S. 2017. **South Bay ficus trees at risk of contracting fungal disease.** Long Beach Daily Breeze. June 27. https://www.dailybreeze.com/2017/06/27/south-bay-ficus-trees-at-risk-of-contracting-fungal-disease/ (accessed March 2021).

Bechtold, W.A.; Scott, C.T. 2005. **The forest inventory and analysis plot design.** In: Bechtold, W.A.; Patterson, P.L., eds. The enhanced Forest Inventory and Analysis Program - National sampling design and estimation procedures. General Technical Report SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 27-42.

Bounoua, L.; Nigro, J.; Thome, K.; Zang, P.; Fathi, N.; Lachir, A. 2018. **A method for mapping future urbanization in the United States.** Urban Science. 2(2): 40. https://doi.org/10.3390/urbansci2020040.

Broschat, T.K.; Klein, R.W.; Hilbert, D.R. 2014. ***Phoenix roebelenii:* pygmy date palm.** UF/IFAS Extension Service Report ENH-600. Gainesville, FL: University of Florida, Department of Environmental Horticulture. 4 p. Available at https://edis.ifas.ufl.edu/pdf/ST/ST44100.pdf (accessed August 2022).

Calfapietra, C.; Fares, S.; Manes, F.; Morani, A.; Loreto, F. 2013. **Role of biogenic volatile organic compounds (BVOC) emitted by urban trees on ozone concentration in cities: a review.** Environmental Pollution. 183: 71-80. https://doi.org/10.1016/j.envpol.2013.03.012.

CAL FIRE. 2020. **California fire hazard severity zone map.** California Department of Forestry and Fire Protection. https://gis.data.ca.gov/datasets/789d5286736248f69c4515c04f58f414 (accessed March 2021).

California Department of Finance, Demographic Research Unit. 2020. **Report P-2A: total population projections, California counties, 2010-2060** [baseline 2019 population projections; vintage 2019 release]. Sacramento, CA. https://dof.ca.gov/forecasting/demographics/projections/ (accessed August 2022).

California Forest Pest Council [CFPC]. 2018. 2018 **California forest pest conditions.** San Luis Obispo, CA. 32 p. https://www.caforestpestcouncil.org/_files/ugd/80da86_37b881003d5343f1a68713210b521022.pdf (accessed August 2022).

City of San Diego. 2015. **City of San Diego climate action plan.** San Diego, CA. 67 p. https://www.sandiego.gov/sites/default/files/final_july_2016_cap.pdf (accessed March 2021).

City of San Diego. 2017. **City of San Diego urban forestry program five year plan.** San Diego, CA. 31 p. https://www.sandiego.gov/sites/default/files/final_adopted_urban_forestry_program_five_year_plan.pdf (accessed March 2021).

City of San Diego. 2020. **Urban tree canopy assessment** [StoryMap]. https://sandiego.maps.arcgis.com/apps/MapSeries/index.html?appid=22676b84005b4365aa44af1b217d4201 (accessed March 2021).

Coleman, T.W.; Jones, M.I.; Smith, S.L.; Venette, R.C.; Flint, M.L.; Seybold, S.J. 2017. **Goldspotted oak borer.** Forest Insect & Disease Leaflet 183. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 16 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3833276.pdf (accessed August 2022).

Council of Tree and Landscape Appraisers. 2000. **Guide for plant appraisal. 9th ed.** Champaign, IL: International Society of Arboriculture. 143 p.

Crump, A. 2009. **Anthracnose.** Pest Notes Publication 7420. Davis, CA: University of California, Department of Agriculture and Natural Resources, Statewide Integrated Pest Management Program. 4 p. https://ucanr.edu/sites/HumboldtDelNorte/files/206742.pdf (accessed August 2022).

Davis, M.A. 2009. **Invasion Biology.** Oxford, UK: Oxford University Press. 288 p.

Dooley, K. 2019. **Woodlands.** In: Oswalt, S.; Smith, W.B.; Miles, P.D.; Pugh, S.A. **Forest resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA assessment.** Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office: 13-16. https://doi.org/10.2737/WO-GTR-97.

Environmental Systems Research Institute [Esri]. 2017. **Light gray canvas basemap** [1:468,900] [world basemap]. https://basemaps.arcgis.com/arcgis/rest/services/World_Basemap_v2/VectorTileServer (accessed October 2022).

Environmental Systems Research Institute [Esri]. 2021a. **ArcGIS Pro.** Release 2.9.3. Redlands, CA.

Environmental Systems Research Institute [Esri]. 2021b. **ArcMap.** Release 10.8.2. Redlands, CA.

Eskalen, A.; Kabashima, J.; Dimson, M.; Lynch, S. 2018. **Invasive shot-hole borer and Fusarium dieback field guide: identifying polyphagous and Kuroshio shot-hole borer in California.** ANR Publication 8590. Davis, CA: University of California, Agriculture and Natural Resources, Communications Services. 39 p. https://anrcatalog.ucanr.edu/pdf/8590.pdf (accessed August 2022).

Eskalen, A.; Stouthamer, R.; Lynch, S.C.; Rugman-Jones, P.F.; Twizeyimana, M.; Gonzalez, A.; Thibault, T. 2013. **Host range of Fusarium dieback and its ambrosia beetle (Coleoptera: Scoltinae) vector in southern California.** Plant Disease. 97(7): 938-951. https://doi.org/10.1094/PDIS-11-12-1026-RE.

Fehsenfeld, F.; Calvert, J.; Goldan, P.; Guenther, A.B.; Hewitt, C.N.; Lamb, B.; Liu, S.; Trainer, M.; Westberg, H.; Zimmerman P. 1992. **Emissions of volatile organic compounds from vegetation and the implications for atmospheric chemistry.** Global Biogeochemical Cycles. 6(4): 389-430. https://doi.org/10.1029/92GB02125.

Flint, M.L.; Jones, M.I.; Coleman, T.W.; Seybold, S.J. 2013. **Goldspotted oak borer.** Pest Notes Publication 74163. Davis, CA: University of California, Department of Agriculture and Natural Resources, Statewide Integrated Pest Management Program. 7 p. http://ipm.ucanr.edu/PDF/PESTNOTES/pngoldspottedoakborer.pdf (accessed March 2021).

Heisler, G.M. 1986. **Energy savings with trees.** Journal of Arboriculture. 12(5): 113–125. https://doi.org/10.48044/jauf.1986.026.

Hirabayashi, S. 2013. **i-Tree Eco precipitation interception model descriptions.** Washington, DC: U.S. Department of Agriculture, Forest Service; Kent, OH: Davey Tree Expert Co.; and other cooperators. 21 p. https://www.itreetools.org/eco/resources/iTree_Eco_Precipitation_Interception_Model_Descriptions.pdf (accessed March 2021).

Hodel, D.R.; Marika, M.A.; Ohara, L.M. 2016. **The South American palm weevil: a new threat to palms in California and the Southwest.** PalmArbor. 2016-3: 1-27. https://ucanr.edu/sites/HodelPalmsTrees/files/247345.pdf (accessed August 2022).

Homer, C.G.; Dewitz J.; Yang L.; Jin S.; Danielson P.; Xian G.; Coulston J.; Herold N.; Wickham J.; Megown K. 2015. **Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information.** Photogrammetric Engineering and Remote Sensing. 81(5): 345-354.

Hong, B.D.; Slatick, E.R. 1994. **Carbon dioxide emission factors for coal.** Energy Information Administration DOE/EIA-0121(94/Q1) quarterly coal report, January-April 1994. Washington, DC: Energy Information Administration: 1-8. http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html (accessed March 2021).

Interagency Working Group on Social Cost of Carbon, United States Government. 2013. **Technical support document: technical update of the social cost of carbon for regulatory impact analysis under Executive Order 12866.** https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (accessed March 2021).

Intergovernmental Panel on Climate Change. 2014. **Climate Change 2014 synthesis report.** World Meteorological Organization and United Nations Environment Programme. 138 p. https://www.ipcc.ch/site/assets/uploads/2018/03/WGIIIAR5_SPM_TS_Volume-3.pdf (accessed March 2021).

Karlik, J.F.; Pittenger, D.R. 2012. **Urban trees and ozone formation: a consideration for large-scale plantings.** ANR Publication 8484. Davis, CA: University of California, Department of Agriculture and Natural Resources. 9 p. https://doi.org/10.3733/ucanr.8484.

Kegley, S.J.; Livingston, R.L.; Gibson, K.E. 1997. **Pine engraver, *Ips pini* (Say), in the western United States.** Forest Insect & Disease Leaflet 122. Missoula, MT: U.S. Department of Agriculture, Forest Service. 5 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043668.pdf (accessed August 2022).

Kreuter, U.P.; Harris, H.G.; Matlock, M.D.; Lacey, R.E. 2001. **Change in ecosystem service values in the San Antonio area, Texas.** Ecological Economics. 39(3): 333-346. https://doi.org/10.1016/S0921-8009(01)00250-6.

Lawler, R.; Renner, A., comp. 2007. **Kuroshio and polyphagous shot hole borer in southern California wildlands: associated host identification guide.** Sacramento, CA: California Department of Fish and Wildlife. 48 p. https://ucanr.edu/sites/pshb/files/319244.pdf (accessed March 2021).

Manes, F.; Incerti, G.; Salvatori, E.; Vitale, M.; Ricotta, C.; Costanza, R. 2012. **Urban ecosystem services: tree diversity and stability of tropospheric ozone removal.** Ecological Applications. 22(1): 349-360. https://doi.org/10.1890/11-0561.1.

Marsberg, A.; Kemler, M.; Jami, F.; Nagel, J.H.; Postma-Smidt, A. [et al.]. 2017. ***Botryosphaeria dothidea:* a latent pathogen of global importance to woody plant health.** Molecular Plant Pathology. 18(4): 477-488. https://doi.org/10.1111/mpp.12495.

Mayorquin J.S.; Eskalen A.; Downer A.J.; Hodel D.R.; Liu A. 2012. **First report of multiple species of the Botryosphaeriaceae causing bot canker disease of Indian laurel leaf fig in California.** Plant Disease. 96(3): 459. https://doi.org/10.1094/PDIS-08-11-0714.

McPherson, E.G.; Simpson, J.R. 1999. **Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters.** Gen. Tech. Rep. PSW-GTR-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p. https://doi.org/10.2737/PSW-GTR-171.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Xiao, Q. 2005. **Municipal forest benefits and costs in five US cities.** Journal of Forestry. 103(8): 411-416. https://doi.org/10.1093/jof/103.8.411.

Multi-Resolution Land Characteristics Consortium [MRLC]. 2018. **National Land Cover Database 2011 (NLCD 2011).** https://data.nal.usda.gov/dataset/national-land-cover-database-2011-nlcd-2011 (accessed October 2022).

National Drought Mitigation Center. 2021. **U.S. drought monitor, San Diego County, CA.** [U.S. time series map]. Lincoln, NE. https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx (accessed August 2022).

National Oceanic and Atmospheric Association [NOAA]. 2018. **Annual 2017 National climate report.** Available at https://www.ncdc.noaa.gov/sotc/national/201713 (accessed March 2021).

Nowak, D.J. 2012. **Contrasting natural regeneration and tree planting in fourteen North American cities.** Urban Forestry and Urban Greening. 11(4): 374-382. https://doi.org/10.1016/j.ufug.2012.02.005.

Nowak, D.J. 2024. **Understanding i-Tree: 2023 summary of programs and methods.** General Technical Report NRS-200-2023. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 103 p. [plus 14 appendixes]. https://doi.org/10.2737/NRS-GTR-200-2023.

Nowak, D.J.; Aevermann, T. 2019. **Tree compensation rates: compensating for the loss of current and future tree values.** Urban Forestry & Urban Greening. 41: 93-103. https://doi.org/10.1016/j.ufug.2019.03.014.

Nowak, D.J.; Appleton, N.; Ellis, E.; Greenfield, E. 2017. **Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States.** Urban Forestry and Urban Greening. 21: 158–165. https://doi.org/10.1016/j.ufug.2016.12.004.

Nowak, D.J.; Civerolo, K.L.; Rao, S.T.; Sistla, S.; Luley, C.J.; Crane, D.E. 2000. **A modeling study of the impact of urban trees on ozone.** Atmospheric Environment. 34(10):1601-1613. https://doi.org/10.1016/S1352-2310(99)00394-5.

Nowak, D.J.; Crane, D.E.; Dwyer, J.F. 2002a. **Compensatory value of urban trees in the United States.** Journal of Arboriculture. 28(4): 194-199. https://doi.org/10.48044/jauf.2002.028.

Nowak, D.J.; Crane, D.E.; Stevens, J.C. 2006. **Air pollution removal by urban trees and shrubs in the United States.** Urban Forestry and Urban Greening. 4(3-4): 115-123. https://doi.org/10.1016/j.ufug.2006.01.007.

Nowak, D.J.; Crane, D.E.; Stevens, J.C.; Hoehn, R.E.; Walton, J.T; Bond, J. 2008. **A ground-based method of assessing urban forest structure and ecosystem services.** Arboriculture and Urban Forestry. 34(6): 347-358. https://doi.org/10.48044/jauf.2008.048.

Nowak, D.J.; Greenfield, E.J. 2018. **U.S. urban forest statistics, values, and projections. Journal of Forestry 116(2):164–177.** https://doi.org/10.1093/jofore/fvx004.

Nowak, D.J.; Greenfield, E.J.; Ash, R. 2019. **Annual biomass loss and potential value of urban tree waste in the United States.** Urban Forestry and Urban Greening. 46: 126469. https://doi.org/10.1016/j.ufug.2019.126469.

Nowak, D.J.; Hirabayashi, S.; Bodine, A.; Greenfield; E.J. 2014. **Tree and forest effects on air quality and human health in the United States.** Environmental Pollution. 193: 119-129. https://doi.org/10.1016/j.envpol.2014.05.028.

Nowak, D.J.; Kuroda, M.; Crane, D.E. 2004. **Tree mortality rates and tree population projection in Baltimore, Maryland, USA.** Urban Forestry and Urban Greening. 2(3): 139-147. https://doi.org/10.1078/1618-8667-00030.

Nowak, D.J.; Stevens, J.C.; Sisinni, S.M.; Luley, C.J. 2002b. **Effects of urban tree management and species selection on atmospheric carbon dioxide.** Journal of Arboriculture. 28(3): 113-122. https://doi.org/10.48044/jauf.2002.017.

Parke, J.L.; Rizzo, D.M. 2011. ***Phytophthora ramorum.*** Forest Phytophthoras. 1(1). https://doi.org/10.5399/osu/fp.1.1.1821.

Pimentel, D.; Lach, L.; Zuniga, R.; Morrison, D. 2000. **Environmental and economic costs of nonindigenous species in the United States.** BioScience. 50(1): 53–65. https://doi.org/10.1641/0006-3568(2000)050[0053:EAECON]2.3.CO;2

Pope, C.A., III; Burnett, R.T.; Thun, M.J.; Calle, E.E.; Krewski, D.; Ito, K.; Thurston, G.D. 2002. **Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution.** Journal of the American Medical Association. 287(9): 1132-1141. https://doi.org/10.1001/jama.287.9.1132.

R Core Development Team. 2022. **R: a language and environment for statistical computing.** Vienna, Austria: R Foundation for Statistical Computing. R-project.org.

Sahagún, L. 2017. **Insects and disease are ravaging the Southland's urban trees. Who's going to stop them?** The Los Angeles Times. May 5. https://www.latimes.com/local/california/la-me-trees-change-20170427-story.html (accessed April 2019).

San Diego County Water Authority. **2019. 2019 annual report: water sources and uses, fiscal year 2018-2019.** https://www.sdcwa.org/annualreport/2019/diversification-and-efficiency/water-sources-and-uses.php (accessed March 2021).

Schultz, D.E.; Bedard, W.D. 1987. **California fivespined ips.** Forest Insect & Disease Leaflet 102. Berkeley, CA: U.S. Department of Agriculture, Forest Service. 8 p. https://www.fs.usda.gov/foresthealth/docs/fidls/FIDL-102-CaliforniaFiveSpinedIps.pdf (accessed August 2022).

Seybold, S.J.; Paine, T.D.; Dreistadt, S.H. 2008. **Bark beetles.** Pest Notes Publication 7421. Davis, CA: University of California, Department of Agriculture and Natural Resources, Statewide Integrated Pest Management Program. 7 p. https://cecentralsierra.ucanr.edu/files/230149.pdf (accessed August 2022).

Simberloff, D. 2013. **Invasive species: what everyone needs to know.** New York, NY: Oxford University Press.

Shannon, C.E. 1948. **A mathematical theory of communication.** Bell System Technical Journal. 27(3): 379-423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x.

Spellerberg, I.F.; Fedor, P.J. 2003. **A tribute to Claude Shannon (1916-2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon-Wiener' Index.** Global Ecology and Biogeography. 12: 177-179. https://doi.org/10.1046/j.1466-822X.2003.00015.x.

Steenberg, J.W.N.; Millward, A.A.; Nowak, D.J.; Robinson, P.J. 2017. **A conceptual framework of urban forest ecosystem vulnerability.** Environmental Reviews. 25(1): 115-126. https://doi.org/10.1139/er-2016-0022.

Steenberg, J.W.N.; Millward, A.A.; Nowak, D.J.; Robinson, P.J.; Smith, S.M. 2019. **A social-ecological analysis of urban tree vulnerability for publicly owned trees in a residential neighborhood.** Arboriculture & Urban Forestry. 45(1): 10-25. https://doi.org/10.48044/jauf.2019.002.

Steenberg, J.W.N.; Robinson, P.J.; Millward, A.A. 2018. **The influence of building renovation and rental housing on urban trees.** Journal of Environmental Planning and Management 61(3): 553-567. https://doi.org/10.1080/09640568.2017.1326883.

Steinman, J. 2000. **Tracking the health of trees over time on forest health monitoring plots.** In: Hansen, M.; Burk, T., eds. Integrating tools for natural resources inventories in the 21st century. Gen. Tech. Rep. NC-212. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station: 334-339. https://doi.org/10.2737/NC-GTR-212.

Swain, S.; Tjosvold; S.A.; Dreistadt, S.H. 2009. **California oakworm.** Pest Notes Publication 7422. Davis, CA: University of California, Department of Agriculture and Natural Resources, Statewide Integrated Pest Management Program. 6 p. https://ipm.ucanr.edu/PDF/PESTNOTES/pncaliforniaoakworm.pdf (accessed August 2022).

Torrey Pines State Natural Reserve. 2019. **Beetles.** https://torreypine.org/nature-center/insects-spiders/beetles/ (accessed March 2021).

U.S. Census Bureau. 2020a. **Characteristics of new housing.** Department of Commerce. https://www.census.gov/construction/chars/highlights.html (accessed March 2021).

U.S. Census Bureau. 2020b. **City and town population totals: 2010-2019.** https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-cities-and-towns.html (accessed March 2021).

U.S. Department of Agriculture, Animal and Plant Health Inspection Service [USDA APHIS]. 2017. **Federal noxious weed list.** Washington, DC. https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/weedlist.pdf (accessed August 2022).

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2016a. **Forest Inventory and Analysis strategic plan.** FS-1079. Washington, DC: U.S. Department of Agriculture, Forest Service. 49 p. https://research.fs.usda.gov/sites/default/files/2023-01/fia_strategic_plan_fs-1079.pdf (accessed August 2022).

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2016b. **Forest Inventory and Analysis glossary.** https://www.nrs.fs.usda.gov/fia/data-tools/state-reports/glossary/default.asp (accessed September 2022).

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2017. **Field instructions for the urban inventory of San Diego, California: 2017.** U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis Resource Monitoring and Assessment Team. https://usfs-public.app.box.com/s/z3dtmflaa1xrtt215sx1mnld03y5onh2/file/1173239532256 (accessed March 2021).

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2018. **Forest pest conditions in California, 2018.** Vallejo, CA: U.S. Department of Agriculture, Forest Service, Forest Health Protection. 32 p. https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046704 (accessed March 2021).

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2019. **2018 National insect & disease risk maps/data.** Fort Collins, CO: U.S. Department of Agriculture Forest Service, Forest Health Technology Enterprise Team. Available at https://www.fs.usda.gov/science-technology/data-tools-products/fhp-mapping-reporting/national-insect-disease-risk-and-hazard-mapping (accessed August 2022).

U.S. Energy Information Administration [U.S. EIA]. 2012a. **Average retail price of electricity to ultimate customers by end-use sector. Table 5.6.A.** Washington, DC: U.S. Department of Energy, Energy Information Administration. Available at http://www.eia.gov/electricity/monthly/index.php (accessed September 2022).

U.S. Energy Information Administration [U.S. EIA]. 2012b. **Residential sector energy price estimates, 2012. Table E3.** In: State energy price and expenditure estimates: 1970-2012. Washington, DC: U.S. Department of Energy, Energy Information Administration. https://www.eia.gov/state/seds/archive/seper2012.pdf (accessed September 2022).

U.S. Energy Information Administration [U.S. EIA]. 2014a. **CE5.2 Household wood consumption.** Washington, DC: U.S. Department of Energy, Energy Information Administration. https://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption (accessed September 2022).

U.S. Energy Information Administration [U.S. EIA]. 2014b. **Natural gas prices.** Washington, DC: Energy Information Administration, U.S. Department of Energy. http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm (accessed March 2021).

U.S. Energy Information Administration [U.S. EIA]. 2014c. **Residential heating oil weekly oil and propane prices (October—March).** Washington, DC: U.S. Department of Energy, Energy Information Administration. https://www.eia.gov/dnav/pet/pet_pri_wfr_dcus_nus_w.htm (accessed March 2021).

U.S. Environmental Protection Agency [U.S. EPA]. 2012. **Environmental Benefits Mapping and Analysis Program (BenMAP).** http://www.epa.gov/benmap/ (accessed March 2021).

U.S. Environmental Protection Agency [U.S. EPA]. 2020. **Greenhouse gas equivalencies calculator-calculations and references.** https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references (accessed March 2021).

University of California, Department of Agriculture and Natural Resources [UC-ANR]. 2019. **Invasive shot hole borer/fusarium die-back distribution map.** http://ucanr.maps.arcgis.com/apps/Viewer/index.html?appid=3446e311c5bd434eabae98937f085c80 (accessed March 2021).

University of California, Department of Agriculture and Natural Resources [UC-ANR]. 2020. **Invasive shot hole borer reproductive hosts.** https://ucanr.edu/sites/pshb/pest-overview/ishb-reproductive-hosts/ (accessed March 2021).

University of California Riverside, Center for Invasive Species Research [UCR-CISR]. 2019. **Asian citrus psyllid.** https://cisr.ucr.edu/invasive-species/asian-citrus-psyllid (accessed March 2021).

Wickham H. 2016. **ggplot2: elegant graphics for data analysis.** New York, NY: Springer-Verlag.

Wickham H.; François R.; Henry L.; Müller K. 2022. **dplyr: a grammar of data manipulation.** R package version 1.1.4. https://dplyr.tidyverse.org (accessed October 2022).

Widener, B. 2020. **Personal communication.** City forester, Transportation & Storm Water Department, 2781 Caminito Chollas, MS 44, San Diego, CA 92123.

GLOSSARY OF TERMS

Diameter: For timber species, diameter is measured at breast height (d.b.h.), which is usually measured at 4.5 feet (1.37 m) above the ground line on the uphill side of the tree. For woodland species, if the tree has multiple stems, the diameter of each stem is measured and combined to establish total diameter for the tree. Woodland diameters are measured at the ground line or at the stem(s) root collar (d.r.c.), whichever is higher. Timber and woodland tree species are listed in Table 34 in Appendix 2. Woodland species are identified with a superscript "c" following the common name in Table 34 in Appendix 2 (USDA Forest Service 2017).

Forest/forest land/forested area: Land that has at least 10 percent crown cover by live trees or land formerly having such tree cover and is not currently developed for a nonforest use. The minimum area for classification as forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must be at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas shall be classified as forest if less than120 feet in width or 1.0 acre in size. Forest land is divided into timberland, reserved forest land, and other forest land (such as woodland) (USDA Forest Service 2016b).

Invasive species: A nonnative species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112, 1999). A list of potential invasive species included in this inventory is presented in Table 39 in Appendix 6.

Rights-of-way: Developed lands including improved and/or maintained roads, railways, power or gas line clearings, and maintained canals (USDA Forest Service 2017).

Rotten or cull: Missing or rotten main stem or large branch volume caused by agents including cankers, punky knots, hollow sounding stems, or embedded metal in the wood (USDA Forest Service 2016b, 2017).

Shannon-Wiener diversity index: An index of species diversity (also known as the Shannon diversity index) which takes into account both species richness (total number of species in a community) and species evenness (relative abundances among species in a community). Shannon diversity (H') is calculated as follows:

$$H' = -\sum_{i=1}^{S} p_i \ln (p_i)$$

where: S = the total number of species in the community (species richness) and pi = proportion of the total assemblage of individuals represented by individuals of species i (Shannon 1948, Spellerberg and Fedor 2003).

Woodland: A subset of FIA-designated forest land that is dominated by woodland species (Dooley 2019).

Woodland species: FIA classifies all tree species into either woodland or timber categories. Woodland species are typically small, slow-growing trees characterized by a multi-stemmed growth form; timber species generally grow from a single central stem (USDA Forest Service 2017). This difference in typical form induced some differences in data collection and calculation, such as how diameters are determined (see diameter definition). Woodland species are identified with a superscript "c" following the common name in Table 34 in Appendix 2.

APPENDIX 1 - LAND COVER DESCRIPTION

Table 33.—National Land Cover Database (NLCD) land cover descriptions

NLCD land cover class	NLCD code	Land cover description
Open water	11	Areas of open water generally with less than 25 percent of vegetation or soil.
Perennial ice/snow	12	Areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed-open space	21	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed-low intensity	22	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.
Developed-medium intensity	23	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.
Developed-high intensity	24	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.
Barren land (rock/sand/clay)	31	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Deciduous forest	41	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen forest	42	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed forest	43	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Dwarf scrub	51	Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
Shrub/Scrub	52	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous	71	Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Sedge/Herbaceous	72	Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
Lichens	73	Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.

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Table 33 (continued).

NLCD land cover class	NLCD code	Land cover description
Moss	74	Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Pasture/Hay	81	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
Cultivated crops	82	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	90	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetlands	95	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Source: Homer et al. 2015

APPENDIX 2 – TREE SPECIES COMPOSITION

Table 34.—List of all live tree species and their characteristics, San Diego, 2017

Genus	Species	Common name	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total SE (number)	Average diamter (in.)
Acacia	*longifolia*	Sydney golden wattle	0	29,000	0	29,000	0.6	21,000	6.5
Afrocarpus	*gracilior*	East African yellowwood	0	7,100	0	7,100	0.1	6,400	7.9
Afrocarpus	*falcatus*	yellowwood	0	31,000	4,300	35,000	0.7	18,000	8.4
Annona	*cherimola*	Annona cheri-mola	129,000	5,900	0	135,000	2.7	98,000	2.8
Araucaria	*columnaris*	New Caledonia pine	0	7,100	0	7,100	0.1	6,400	5.4
Araucaria	*heterophylla*	Norfolk Island pine	0	0	5,900	5,900	0.1	5,900	17.7
Archontophoenix	*cunninghamiana*	Bangalow palm	0	35,000	0	35,000	0.7	22,000	7.7
Bauhinia	*x blakeana*	bauhinia	0	5,900	0	5,900	0.1	5,900	6.2
Brachychiton	*populneum*	whiteflower kurrajong	73,000	36,000	0	110,000	2.2	98,000	5.3
Brachychiton	*discolor*	pink flame tree	0	0	5,900	5,900	0.1	5,900	12.5
Callistemon	*viminalis*	weeping bottle-brush	0	14,000	0	14,000	0.3	13,000	8.2
Cassia	*leptophylla*	gold medallion tree	0	4,500	0	4,500	0.1	5,200	6.5
Chamaerops	*humilis*	European fan palm	0	5,900	0	5,900	0.1	5,900	10
Cinnamomum	*camphora*	camphortree	0	19,000	7,100	26,000	0.5	20,000	8.7
Citrus	*x sinensis*	sweet orange	0	5,900	0	5,900	0.1	5,900	5.4
Corymbia	*citriodora*	Corymbia citri-odora	89,000	7,100	0	96,000	1.9	87,000	4.3
Cupaniopsis	*anacardioides*	carrotwood	73,000	10,000	0	84,000	1.7	74,000	1.7
Cupressus	*sempervirens*	Italian cypress	55,000	40,000	5,900	101,000	2	69,000	5.7
Eriobotrya	*japonica*	loquat	0	4,500	0	4,500	0.1	5,200	5.3
Eriobotrya	*deflexa*	bronze loquat	0	12,000	0	12,000	0.2	8,300	5.8
Eriobotrya	spp.	loquat	73,000	0	0	73,000	1.5	74,000	4.5
Eucalyptus	*sideroxylon*	red ironbark	0	19,000	21,000	40,000	0.8	31,000	10.3
Eucalyptus	*cladocalyx*	sugargum	0	7,100	19,000	26,000	0.5	15,000	24.7
Eucalyptus	*polyanthemos*	redbox	0	26,000	0	26,000	0.5	17,000	5.8
Eucalyptus	*globulus*	Tasmanian bluegum	89,000	35,000	23,000	147,000	3.0	126,000	6.5
Eucalyptus	*camaldulensis*	river redgum	0	4,300	4,300	8,700	0.2	10,000	10

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Table 34 (continued).

Genus	Species	Common name	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total SE (number)	Average diamter (in.)
Eucalyptus	*rudis*	Western Australian floodedgum	0	8,700	4,300	13,000	0.3	15,000	11
Eucalyptus	*leucoxylon*	white ironbark	0	0	5,900	5,900	0.1	5,900	12.1
Feijoa	*sellowiana*	feijoa	0	12,000	0	12,000	0.2	12,000	6
Ficus	*microcarpa*	Chinese banyan	800,000	42,000	5,900	848,000	17.2	502,000	2.2
Ficus	*auriculata*	Roxburgh fig	0	5,900	0	5,900	0.1	5,900	7.4
Fraxinus	*velutina*	velvet ash	0	4,300	0	4,300	0.1	5,000	8.3
Harpephyllum	*caffrum*	South African wild plum	0	5,900	0	5,900	0.1	5,900	10.8
Howeia	*forsteriana*	sentrypalm	0	18,000	0	18,000	0.4	18,000	5.6
Jacaranda	*mimosifolia*	black poui	0	18,000	5,900	23,000	0.5	17,000	7.7
Juniperus	*chinensis*	Chinese juniper	55,000	27,000	5,900	88,000	1.8	65,000	4.4
Lagerstroemia	*indica*	crapemyrtle[c]	73,000	4,500	0	78,000	1.6	74,000	3.9
Ligustrum	*japonicum*	Japanese privet[c]	0	12,000	0	12,000	0.2	12,000	7.4
Liquidambar	*styraciflua*	sweetgum	0	12,000	0	12,000	0.2	12,000	9.7
Lophostemon	*confertus*	vinegartree	0	32,000	5,900	38,000	0.8	17,000	8.3
Magnolia	*grandiflora*	southern magnolia	73,000	7,100	0	80,000	1.6	74,000	4.7
Melaleuca	*quinquenervia*	melaleuca[b]	0	15,000	60,000	75,000	1.5	46,000	12.8
Myoporum	*laetum*	ngaio tree	0	57,000	7,100	64,000	1.3	58,000	8.2
Olea	*europaea*	olive	0	23,000	12,000	35,000	0.7	35,000	10.8
Parkinsonia	*aculeata*	Jerusalem thorn	0	5,900	0	5,900	0.1	5,900	5.9
Phoenix	*roebelenii*	pygmy date palm	0	185,000	10,000	195,000	4.0	88,000	7.7
Phoenix	*dactylifera*	date palm	0	0	28,000	28,000	0.6	24,000	17.3
Pinus	*canariensis*	Canary Island pine	0	12,000	37,000	49,000	1.0	24,000	16.7
Pinus	*halepensis*	Aleppo pine	267,000	50,000	26,000	343,000	6.9	301,000	4.4
Pinus	*torreyana*	Torrey pine	0	0	12,000	12,000	0.2	12,000	17.6
Pinus	*thunbergii*	Japanese black pine	0	78,000	7,100	85,000	1.7	77,000	7.6
Pinus	spp.	pine spp.	0	4,300	0	4,300	0.1	5,000	7.8
Pittosporum	*tobira*	Japanese cheesewood	440,000	26,000	0	466,000	9.4	443,000	2.6
Platanus	*racemosa*	California sycamore	73,000	38,000	0	112,000	2.3	82,000	4.7
Prunus	spp.	cherry and plum spp.	0	5,900	0	5,900	0.1	5,900	7.8
Prunus	*armeniaca*	apricot	0	5,900	0	5,900	0.1	5,900	5.5
Prunus	*persica*	peach	73,000	0	0	73,000	1.5	74,000	2.9

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Table 34 (continued).

Genus	Species	Common name	1-4.9 in. diameter trees (number)	5-10.9 in. diameter trees (number)	11+ in. diameter trees (number)	Total (number)	Total (percent)	Total SE (number)	Average diamter (in.)
Psidium	*guajava*	guava	73,000	0	0	73,000	1.5	74,000	2.1
Pyrus	*calleryana*	Callery pear	0	54,000	0	54,000	1.1	28,000	7.3
Quercus	*agrifolia*	California live oak	54,000	0	0	54,000	1.1	62,000	3.3
Salix	*lasiolepis*	arroyo willow	464,000	114,000	21,000	598,000	12.1	465,000	3.5
Salix	*x sepulcralis*	weeping willow	0	5,900	0	5,900	0.1	5,900	6.8
Schinus	*molle*	Peruvian pepper-tree[b]	0	31,000	0	31,000	0.6	24,000	8.1
Schinus	*terebinthifolius*	Brazilian pepper-tree[b]	55,000	9,000	0	64,000	1.3	64,000	1.8
Syagrus	*romanzoffiana*	queen palm	0	62,000	47,000	109,000	2.2	38,000	10.6
Syzygium	*paniculatum*	brush cherry	0	5,900	0	5,900	0.1	5,900	5
Tamarix	*ramosissima*	saltcedar[b]	0	0	7,100	7,100	0.1	6,400	11.7
Tipuana	*tipu*	tipa	0	20,000	4,300	24,000	0.5	21,000	10.1
Washingtonia	*robusta*	Washington fan palm	0	5,900	61,000	67,000	1.4	32,000	14.4
Total			3,080,000	1,390,000	469,000	4,950,000	100	982,000	5.1

Due to rounding, not all values will add up exactly.

[a] Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species. Median and average diameter measurements are estimated for live trees only.

[b] Invasive species.

[c] Woodland species.

APPENDIX 3 – TREE CHARACTERISTICS WITHIN NLCD LAND COVER CLASSES AND FIA LAND USE

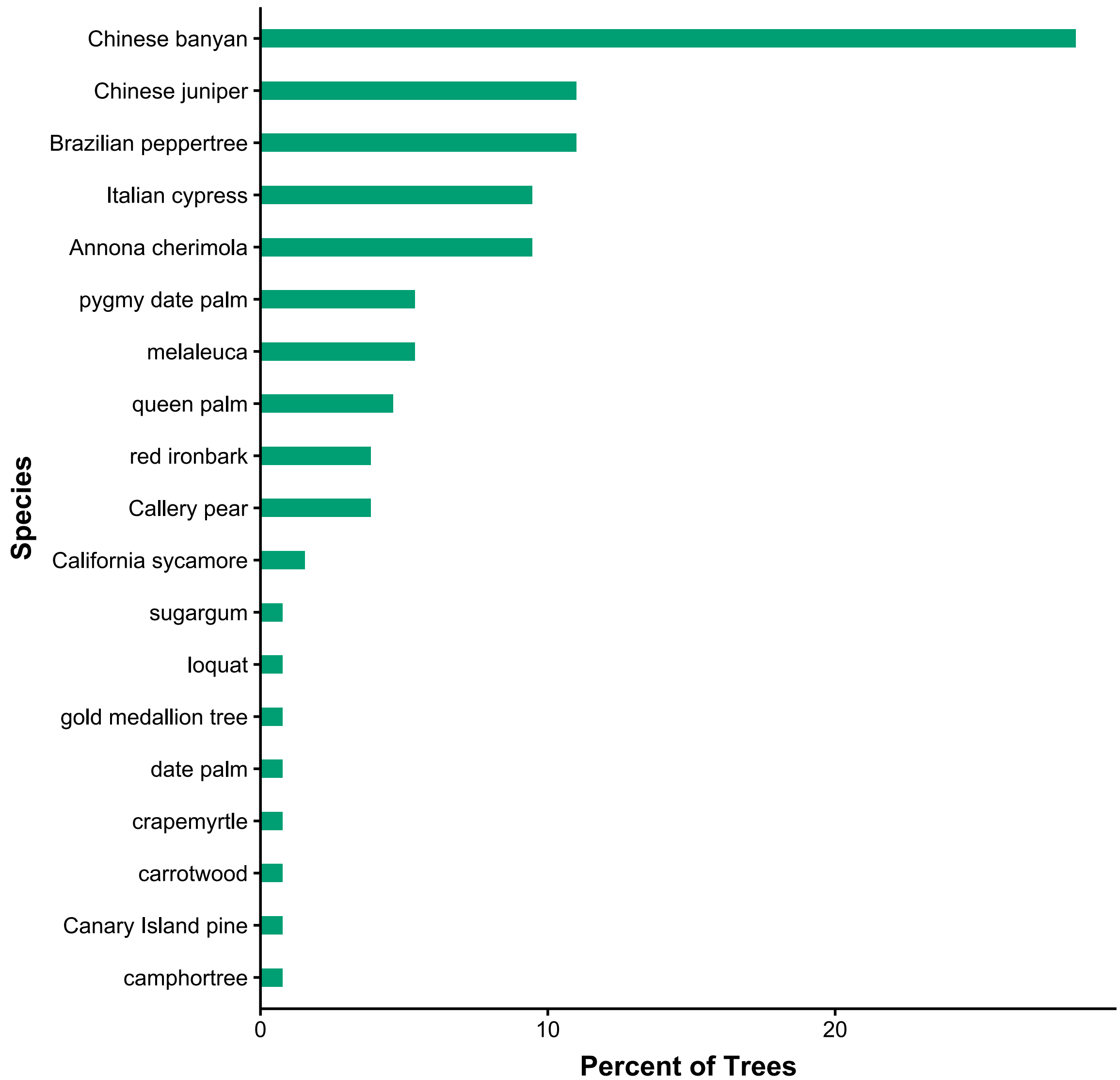

Figure 27.— Percentage of total tree population in Developed-high National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

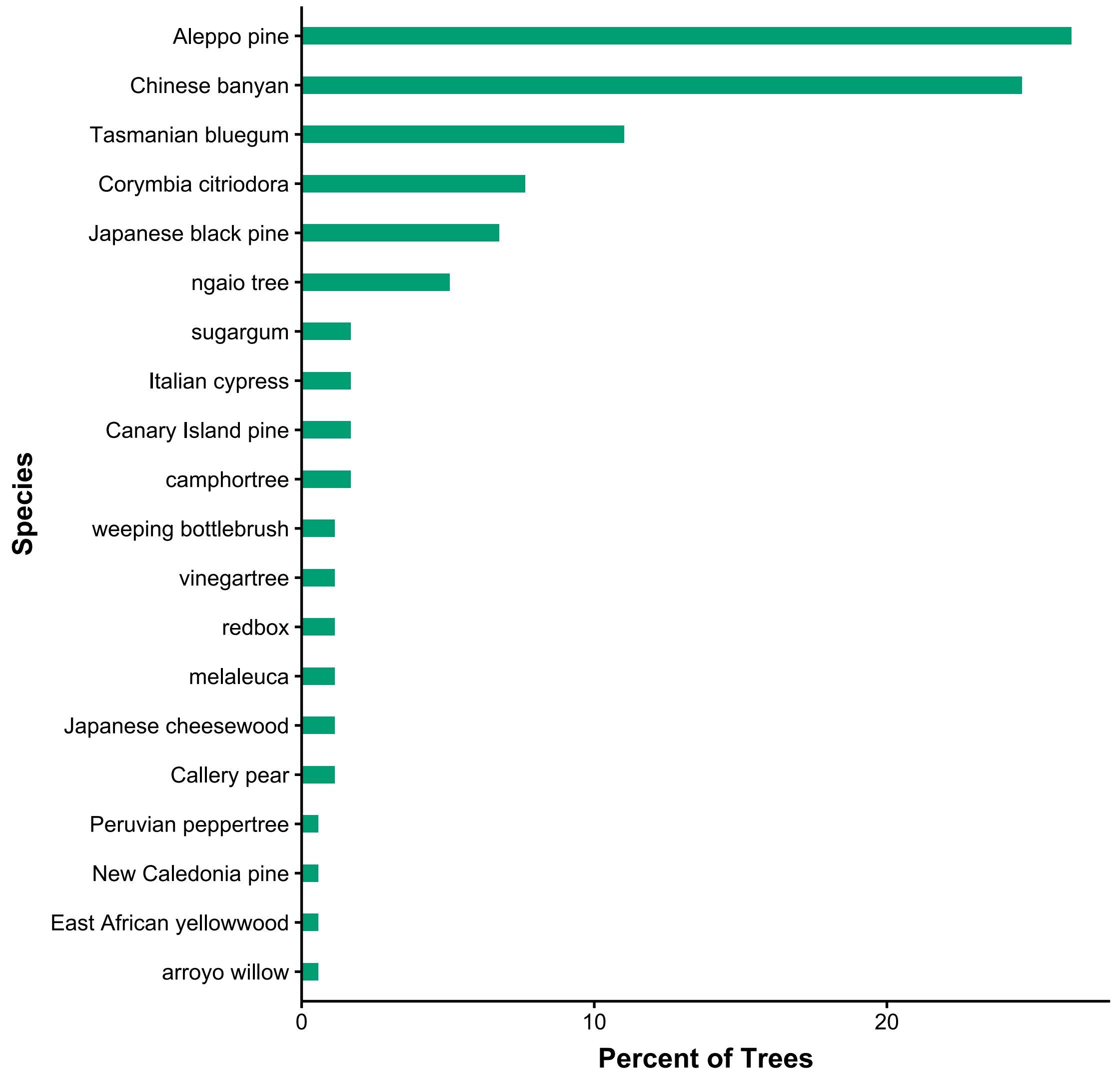

Figure 28.— Percentage of total tree population in Developed-low National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

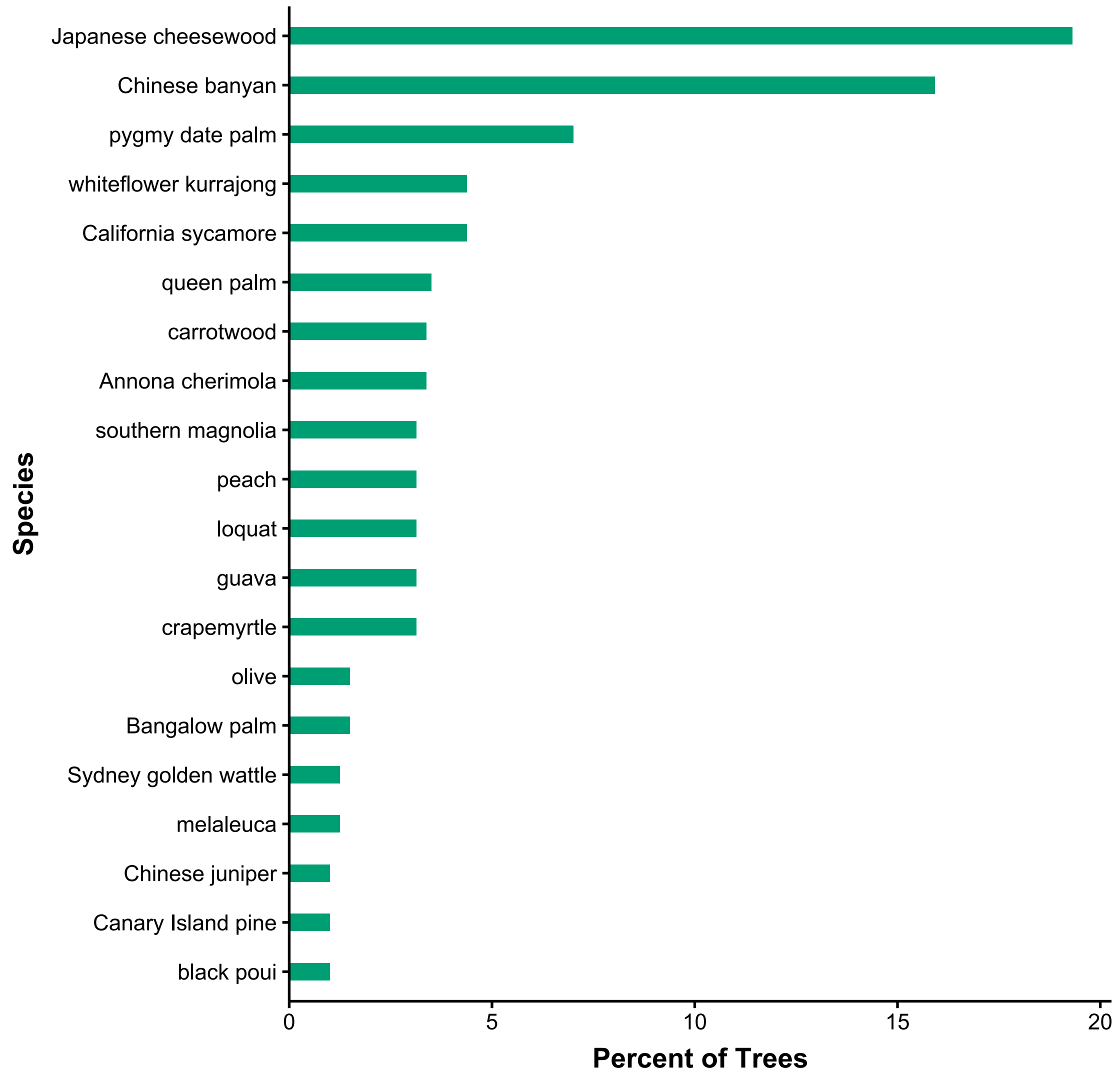

Figure 29.— Percentage of total tree population in Developed-medium National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

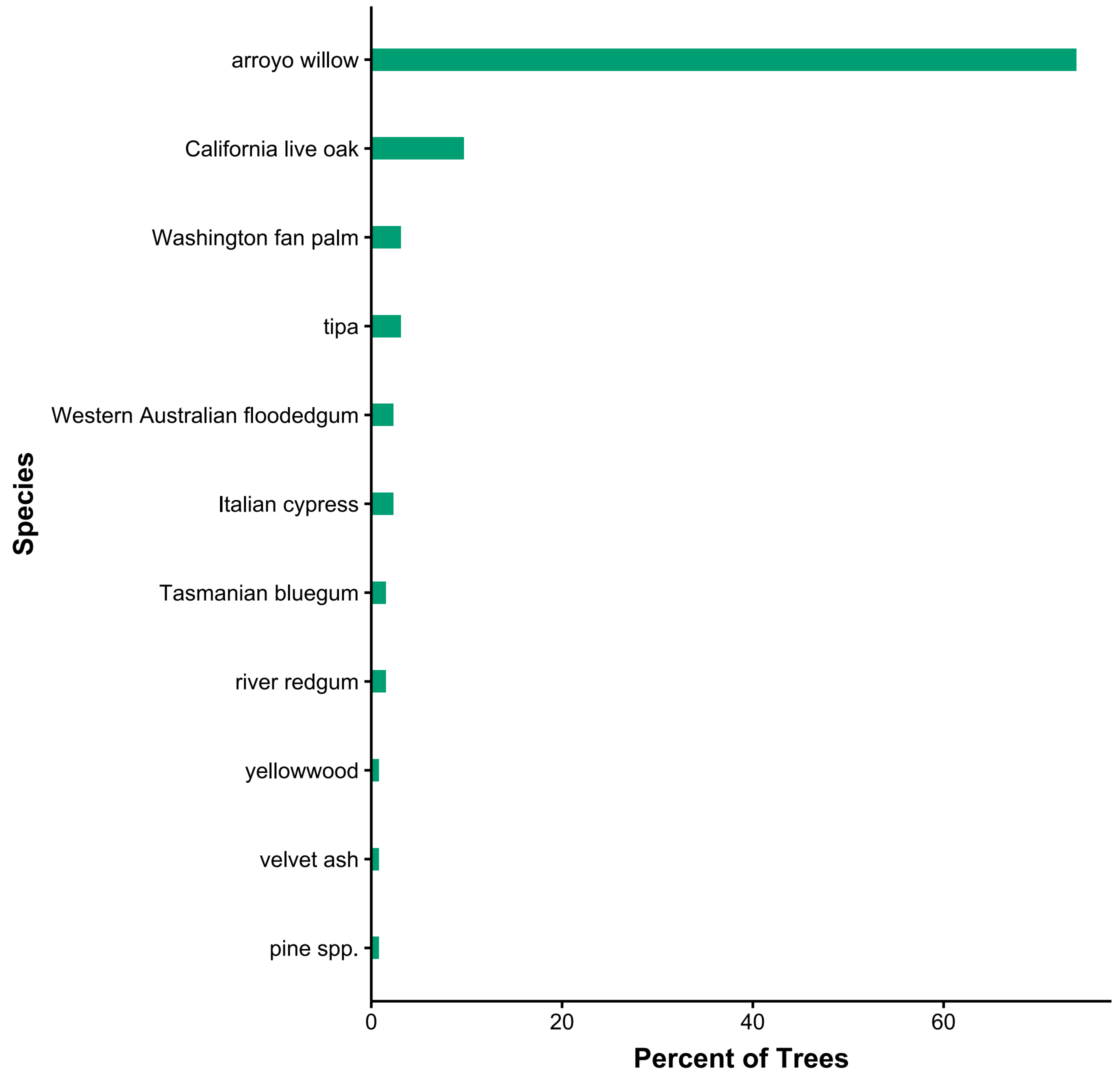

Figure 30.— Percentage of total tree population in Developed-open National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

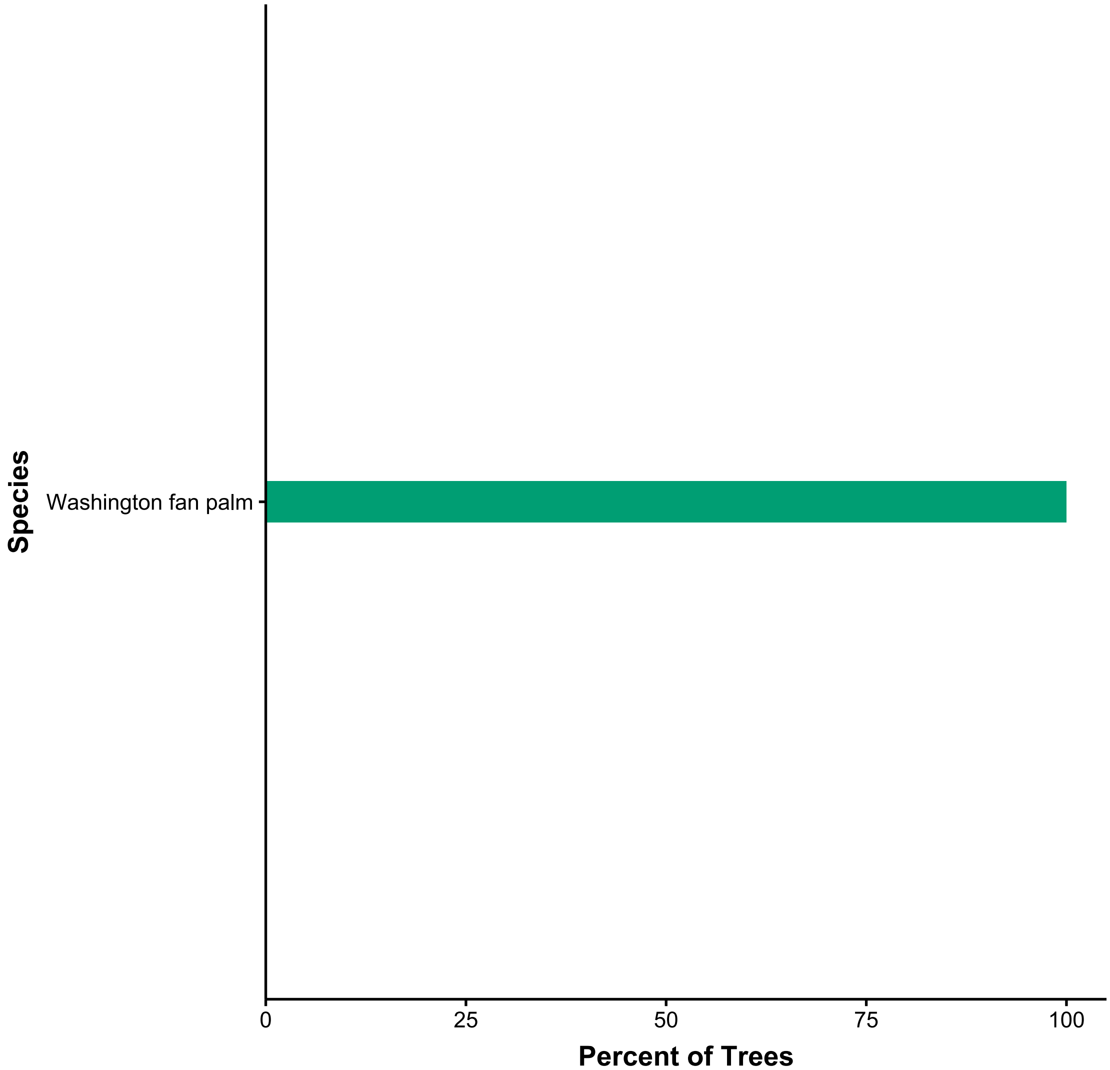

Figure 31.— Percentage of trees in Forest/Shrub National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

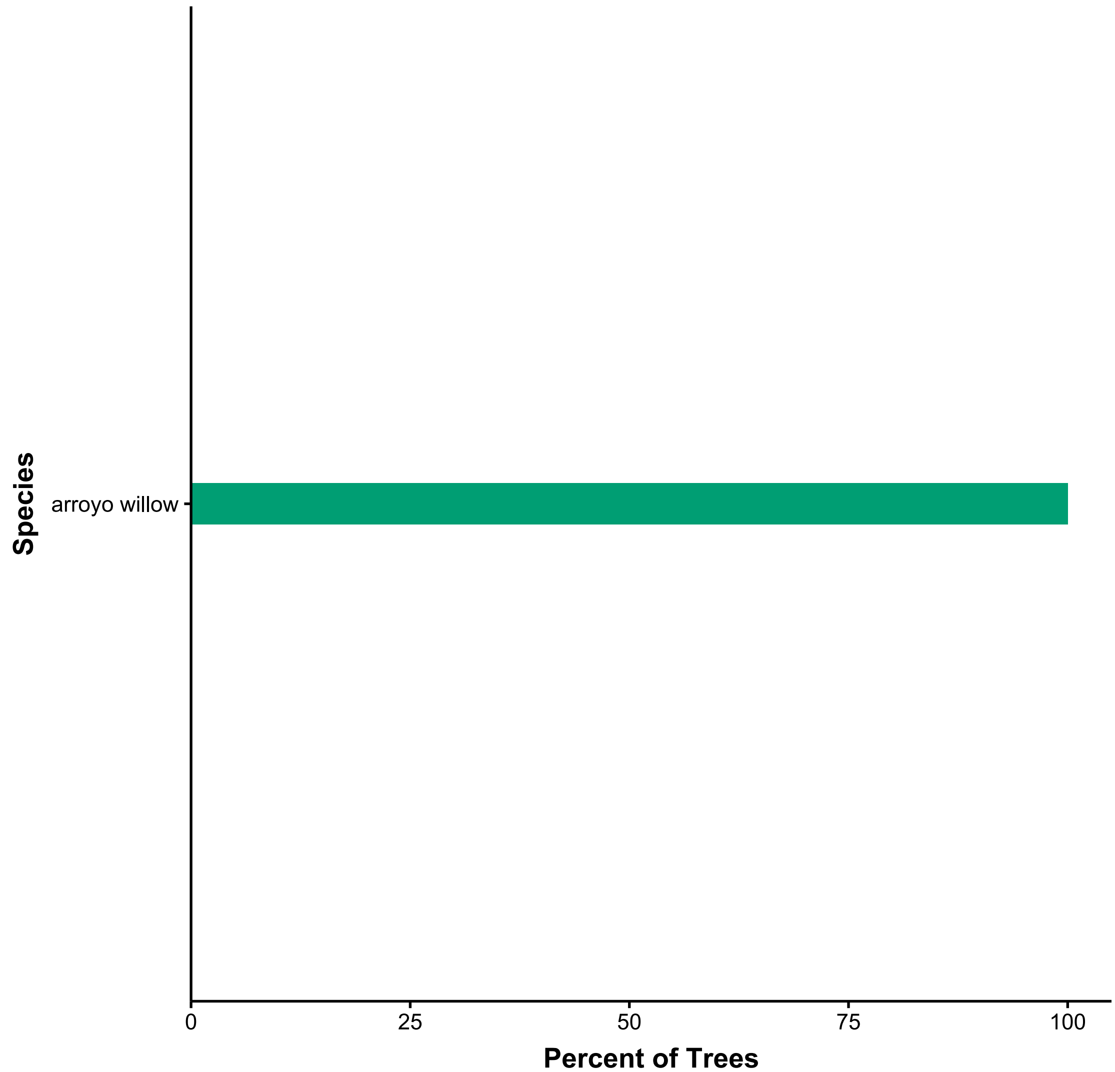

Figure 32.— Percentage of total tree population in Grass/Crop National Land Cover Database (NLCD) land cover class for up to 20 of the most common species by number, San Diego, 2017.

Table 35.—Estimates of total number of trees, basal area (square feet per acre), and average diameter by aggregated National Land Cover Database (NLCD) land cover class for San Diego, 2017

Land cover and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Developed-high			
Annona cherimola	55,346	0	1.6
Brazilian peppertree[c]	64,336	0.1	1.8
California sycamore	8,990	0.1	6.8
Callery pear	22,475	0.2	6.1
camphortree	4,495	0	5
Canary Island pine	4,495	0.4	17.8
carrotwood	4,495	0	5.2
Chinese banyan	166,038	0.1	1.2
Chinese juniper	64,336	0.1	2.4
crapemyrtle[d]	4,495	0.1	6.8
date palm	4,495	0.4	19
gold medallion tree	4,495	0	6.5
Italian cypress	55,346	0.2	4.1
loquat	4,495	0	5.3
melaleuca[c]	31,465	1.7	13.4
pygmy date palm	31,465	0.6	8.5
queen palm	26,970	0.9	11.2
red ironbark	22,475	0.7	10.2
sugargum	4,495	0.2	11.6
Developed-medium			
Aleppo pine	11,715	0.6	25.8
Annona cherimola	79,214	0.1	3.7
apricot	5,857	0	5.5
Bangalow palm	35,144	0.2	7.7
bauhinia	5,857	0	6.2
black poui	23,429	0.1	7.7
bronze loquat	11,715	0	5.8
brush cherry	5,857	0	5.0
California sycamore	102,643	0.2	4.5
Callery pear	17,572	0.1	9.0
Canary Island pine	23,429	0.4	13.4
carrotwood	79,214	0	1.5
cherry and plum spp.	5,857	0	7.8
Chinese banyan	372,640	0.3	2
Chinese juniper	23,429	0.2	9.9

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Table 35 (continued).

Land cover and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
crapemyrtle[d]	73,356	0.1	3.7
date palm	23,429	0.5	17.0
European fan palm	5,857	0	10.0
feijoa	11,715	0	6.0
guava	73,356	0	2.1
Italian cypress	11,715	0.1	10.0
Japanese cheesewood	451,853	0.3	2.5
Japanese privet[d]	11,715	0.1	7.4
Jerusalem thorn	5,857	0	5.9
loquat	73,356	0.1	4.5
melaleuca[c]	29,286	0.4	12.5
Norfolk Island pine	5,857	0.1	17.7
olive	35,144	0.3	10.8
peach	73,356	0	2.9
Peruvian peppertree[c]	23,429	0.1	7.7
pink flame tree	5,857	0.1	12.5
pygmy date palm	164,004	0.8	7.6
queen palm	82,002	0.7	10.4
red ironbark	17,572	0.2	10.6
redbox	11,715	0	5.9
Roxburgh fig	5,857	0	7.4
sentrypalm	17,572	0	5.6
South African wild plum	5,857	0.1	10.8
southern magnolia	73,356	0.1	4.4
sweet orange	5,857	0	5.4
sweetgum	11,715	0.1	9.7
Sydney golden wattle	29,286	0.1	6.5
Torrey pine	11,715	0.3	17.6
vinegartree	23,429	0.2	9.0
Washington fan palm	23,429	0.4	14
weeping willow	5,857	0	6.8
white ironbark	5,857	0.1	12.1
whiteflower kurrajong	102,643	0.2	4.9
yellowwood	23,429	0.1	8.2

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Table 35 (continued).

Land cover and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Developed-low			
Aleppo pine	330,909	1.5	3.6
arroyo willow	7,078	0	5.1
Callery pear	14,156	0.1	7.0
camphortree	21,235	0.4	9.5
Canary Island pine	21,235	1.7	20.1
Chinese banyan	309,674	0.7	3.0
Corymbia citriodora	96,147	0.4	4.3
East African yellowwood	7,078	0.1	7.9
Italian cypress	21,235	0.1	5.7
Japanese black pine	84,939	1.0	7.6
Japanese cheesewood	14,156	0.2	7.2
melaleuca[c]	14,156	0.4	12.4
New Caledonia pine	7,078	0	5.4
ngaio tree	63,704	1.0	8.2
Peruvian peppertree[c]	7,078	0.1	9.7
redbox	14,156	0.1	5.8
saltcedar	7,078	0.2	11.7
southern magnolia	7,078	0.1	7.8
sugargum	21,235	3.9	27.5
Tasmanian bluegum	138,616	0.9	4.8
tipa	7,078	0.1	7.5
vinegartree	14,156	0.1	7.0
weeping bottlebrush	14,156	0.2	8.2
whiteflower kurrajong	7,078	0.1	10.3
yellowwood	7,078	0.1	6.9
Developed-open			
arroyo willow	412,087	2.3	3.8
California live oak	54,182	0.2	3.3
Italian cypress	13,049	0.2	8.6
pine spp.	4,350	0.1	7.8
river redgum	8,699	0.2	10.0
Tasmanian bluegum	8,699	2.7	34.1
tipa	17,399	0.6	11.2
velvet ash	4,350	0.1	8.3
Washington fan palm	17,399	0.7	12.7

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Table 35 (continued).

Land cover and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Western Australian floodedgum	13,049	0.4	11.0
yellowwood	4,350	0.2	12.5
Grass/Herb/Crop			
arroyo willow	179,200	2.2	2.8
Forest/Shrub			
Washington fan palm	25,953	2.1	16.1

Due to rounding, not all values will add up exactly.

[a] Basal area is the cross-sectional area of the tree stems measured at the diameter.

[b] Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species.

[c] Woodland species.

Table 36.—Estimates of total number of trees, basal area, and average diameter by Forest Inventory and Analysis (FIA) land use for San Diego, 2017

FIA land use and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Forest land			
arroyo willow	209,648	10.7	3.2
river redgum	8,699	2.5	10.0
velvet ash	4,350	0.8	8.3
Washington fan palm	4,350	2.7	15.0
Western Australian floodedgum	13,049	4.6	11.0
Rangeland/Chaparral			
arroyo willow	388,718	1.3	3.7
California live oak	54,182	0.1	3.3
pine spp.	4,350	0	7.8
saltcedar	7,078	0.2	11.7
sugargum	14,156	3.1	36.8
Washington fan palm	25,953	1.1	16.1
Commercial/Industrial			
black poui	11,715	0.1	6.0
Brazilian peppertree[c]	55,346	0	1.1
bronze loquat	5,857	0	5.5
California sycamore	99,918	0.4	4.6
Callery pear	42,489	0.3	6.5
Canary Island pine	22,067	0.8	14.4
carrotwood	5,857	0	6.3
Chinese juniper	11,715	0.1	8.3
date palm	23,429	1.1	17.0
Italian cypress	11,715	0.2	10.0
melaleuca[c]	45,622	1.4	13.1
pygmy date palm	8,990	0.1	7.6
queen palm	8,990	0.2	10.6
red ironbark	40,047	0.8	10.3
sentrypalm	17,572	0.1	5.6
sugargum	4,495	0.1	11.6
Torrey pine	11,715	0.6	17.6
vinegartree	5,857	0	5.5
Washington fan palm	5,857	0.1	10.5
white ironbark	5,857	0.1	12.1
whiteflower kurrajong	102,643	0.4	4.9

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Table 36 (continued).

FIA land use and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Multi-family residential			
Aleppo pine	5,857	3.8	30.2
camphortree	21,235	1.6	9.5
Canary Island pine	14,156	3.5	18.7
Chinese banyan	166,038	0.2	1.2
Chinese juniper	4,495	0.1	5.4
date palm	4,495	1.2	19.0
Japanese cheesewood	440,139	2.0	2.4
queen palm	4,495	0.5	12.7
tipa	17,399	1.6	11.2
Washington fan palm	13,049	1.3	11.9
whiteflower kurrajong	7,078	0.5	10.3
yellowwood	7,078	0.2	6.9
Residential			
Aleppo pine	336,766	1.4	3.9
Annona cherimola	134,560	0.2	2.8
apricot	5,857	0	5.5
Bangalow palm	35,144	0.3	7.7
bauhinia	5,857	0	6.2
black poui	11,715	0.2	9.5
Brazilian peppertree[c]	8,990	0.1	6.4
bronze loquat	5,857	0	6.0
brush cherry	5,857	0	5.0
Callery pear	11,715	0.2	10.2
camphortree	4,495	0	5
Canary Island pine	7,078	0.5	22.8
carrotwood	77,851	0	1.3
cherry and plum spp.	5,857	0	7.8
Chinese banyan	682,314	1.0	2.5
Chinese juniper	71,556	0.3	3.7
Corymbia citriodora	96,147	0.3	4.3
crapemyrtle[d]	4,495	0	6.8
East African yellowwood	7,078	0.1	7.9
European fan palm	5,857	0.1	10.0
feijoa	11,715	0.1	6.0
guava	73,356	0	2.1

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Table 36 (continued).

FIA land use and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
Italian cypress	89,630	0.4	5.1
Japanese black pine	84,939	0.7	7.6
Japanese cheesewood	25,871	0.2	6.7
Japanese privet[d]	11,715	0.1	7.4
Jerusalem thorn	5,857	0	5.9
loquat	77,851	0.2	4.5
melaleuca[c]	29,286	0.7	12.5
New Caledonia pine	7,078	0	5.4
ngaio tree	63,704	0.7	8.2
Norfolk Island pine	5,857	0.3	17.7
peach	73,356	0.1	2.9
Peruvian peppertree[c]	30,507	0.3	8.1
pink flame tree	5,857	0.1	12.5
pygmy date palm	186,479	1.6	7.7
queen palm	61,706	1.1	11.1
redbox	11,715	0.1	5.9
Roxburgh fig	5,857	0	7.4
southern magnolia	80,435	0.3	4.7
sugargum	7,078	0.1	9.0
sweet orange	5,857	0	5.4
Sydney golden wattle	11,715	0.1	6.4
tipa	7,078	0.1	7.5
vinegartree	25,871	0.3	8.5
weeping bottlebrush	14,156	0.1	8.2
weeping willow	5,857	0	6.8
yellowwood	11,715	0.1	7.2
Recreation/Cemetery			
Canary Island pine	5,857	0.5	13.1
redbox	7,078	0.1	5.5
Tasmanian bluegum	147,315	6.7	6.5
yellowwood	11,715	0.4	9.1
Rights-of-way			
California sycamore	11,715	0.1	5.7
crapemyrtle[d]	73,356	0.2	3.7
gold medallion tree	4,495	0	6.5
olive	35,144	0.7	10.8

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Table 36 (continued).

FIA land use and common name	Trees (number)	Basal area[a] (sq ft per ac)	Average diameter[b] (inches)
queen palm	33,781	0.5	9.4
redbox	7,078	0	6.1
South African wild plum	5,857	0.1	10.8
sweetgum	11,715	0.2	9.7
Sydney golden wattle	17,572	0.1	6.6
vinegartree	5,857	0.1	10.1
Washington fan palm	17,572	0.7	15.1
yellowwood	4,350	0.1	12.5

Due to rounding, not all values will add up exactly.

[a] Basal area is the cross-sectional area of the tree stems measured at the diameter.

[b] Diameter measurements were taken at breast height (d.b.h.) or root collar (d.r.c.) for woodland species.

[c] Invasive species.

[d] Woodland species.

APPENDIX 4 – SPECIES COMPOSITION IN MAINTAINED AREAS

Table 37.—Species composition in maintained areas, San Diego, 2017

Common name	Trees (number)
Chinese banyan	539,000
Japanese cheesewood	466,000
pygmy date palm	195,000
Annona cherimola	135,000
California sycamore	112,000
queen palm	109,000
whiteflower kurrajong	104,000
Italian cypress	101,000
Chinese juniper	88,000
Japanese black pine	85,000
carrotwood	84,000
southern magnolia	80,000
loquat	78,000
crapemyrtle	78,000
melaleuca	75,000
guava	73,000
peach	73,000
Callery pear	54,000
Canary Island pine	49,000
vinegartree	38,000
Washington fan palm	36,000
olive	35,000
Bangalow palm	35,000
yellowwood	35,000
camphortree	26,000
black poui	23,000
Peruvian peppertree	23,000
red ironbark	22,000
date palm	22,000
redbox	19,000
sentrypalm	18,000
tipa	17,000
weeping bottlebrush	14,000
Japanese privet	12,000
sweetgum	12,000
feijoa	12,000
Aleppo pine	12,000
bronze loquat	12,000
Sydney golden wattle	12,000
Brazilian peppertree	9,000
Tasmanian bluegum	8,700
saltcedar	7,100
ngaio tree	7,100
New Caledonia pine	7,100
apricot	5,900
Jerusalem thorn	5,900
Roxburgh fig	5,900
pink flame tree	5,900
cherry and plum spp.	5,900
Norfolk Island pine	5,900
white ironbark	5,900
European fan palm	5,900
South African wild plum	5,900
sweet orange	5,900
weeping willow	5,900
bauhinia	5,900
brush cherry	5,900
gold medallion tree	4,500
sugargum	4,500

APPENDIX 5 – DAMAGE, MAINTENANCE AND SITE ISSUES BY SPECIES

Table 38.—Percent of live trees identified with damage, maintenance and site issues, San Diego, 2017

Species	Sample (n)	Root/stem girdling (percent)	Trunk/bark inclusion (percent)	Topping /prunning (percent)	Root conflict (percent)	Crown conflict (percent)	Improper planting (percent)
Aleppo pine	14	0.0	0.0	0.0	0.0	1.7	0.0
Annona cherimola	3	0.0	0.0	45.5	0.0	0.0	0.0
arroyo willow	41	0.0	8.3	0.0	0.0	0.0	0.0
bauhinia	1	0.0	0.0	0.0	0.0	100.0	0.0
black poui	4	0.0	0.0	0.0	50.0	0.0	0.0
brush cherry	1	0.0	0.0	100.0	0.0	0.0	0.0
California sycamore	8	0.0	5.2	18.5	0.0	0.0	0.0
Callery pear	10	0.0	10.8	10.8	0.0	0.0	0.0
Canary Island pine	8	0.0	0.0	0.0	26.3	0.0	0.0
carrotwood	3	0.0	0.0	5.4	0.0	0.0	0.0
cherry and plum spp.	1	0.0	0.0	100.0	0.0	0.0	0.0
Chinese banyan	18	43.2	0.7	19.6	0.7	2.5	43.2
Chinese juniper	7	0.0	0.0	5.1	18.5	11.8	0.0
Corymbia citriodora	2	0.0	0.0	0.0	0.0	100.0	0.0
melaleuca	14	0.0	0.0	0.0	30.0	0.0	0.0
olive	6	0.0	0.0	33.3	0.0	0.0	0.0
Peruvian peppertree	5	0.0	0.0	0.0	0.0	23.2	0.0
pink flame tree	1	0.0	100.0	0.0	0.0	0.0	0.0
queen palm	20	0.0	0.0	0.0	0.0	5.4	0.0
red ironbark	8	0.0	14.6	0.0	0.0	0.0	0.0
South African wild plum	1	100.0	0.0	0.0	0.0	100.0	0.0
southern magnolia	2	0.0	0.0	0.0	0.0	0.0	91.2
sugargum	4	0.0	0.0	0.0	0.0	27.5	0.0
sweetgum	2	0.0	0.0	0.0	100.0	50.0	0.0
Sydney golden wattle	5	0.0	0.0	20.0	0.0	0.0	0.0
tipa	5	35.5	17.8	0.0	0.0	0.0	0.0
vinegartree	6	0.0	0.0	0.0	15.6	15.6	0.0
weeping bottlebrush	2	0.0	0.0	50.0	0.0	0.0	0.0
Western Australian floodedgum	3	0.0	33.3	0.0	0.0	0.0	0.0

This table includes only the live tree population in San Diego.

APPENDIX 6 – LIST OF INVASIVE PLANT SPECIES

Table 39.—List of invasive plant species inventoried in San Diego, 2017.

Scientific name	Common name
Ailanthus altissima	tree of heaven
Albizia julibrissin	silktree
Carduus nutans	nodding plumeless thistle[a]
Centaurea diffusa	diffuse knapweed[a]
Centaurea solstitialis	yellow star-thistle
Centaurea stoebe ssp. *micranthos*	spotted knapweed
Chondrilla juncea	rush skeletonweed
Cirsium arvense	Canada thistle
Euphorbia esula	leafy spurge
Euphorbia oblongata	eggleaf spurge
Genista monspessulana	French broom
Hypericum perforatum	common St. Johnswort
Koelreuteria spp.	goldenrain tree
Melaleuca quinquenervia	melaleuca
Melia azedarach	Chinaberrytree
Paulownia tomentosa	princesstree
Schinus molle	Peruvian peppertree
Schinus terebinthifolius	Brazilian peppertree
Taeniatherum caput-medusae	medusahead[a]
Tamarix spp.	tamarisk
Triadica sebifera	Chinese tallow
Ulmus pumila	Siberian elm

[a] While these species were tallied during the San Diego inventory, these species were excluded in the report because they were believed to have been misidentified in the field.

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