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San Antonio's Urban Forest, 2018

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The Mission Espada National Historical Park in San Antonio, TX.



Rural land still figures prominently in the extraterritorial jurisdiction of San Antonio, TX.

FOREWORD

The U.S. Department of Agriculture, Forest Service, Southern Research Station's Forest Inventory and Analysis (FIA) research work unit and cooperating State forestry agencies conduct annual forest inventories of resources in the 13 Southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the Commonwealth of Puerto Rico, and the U.S. Virgin Islands. To provide more frequent and nationally consistent information on America's forest resources, all research stations and their respective FIA work units conduct annual surveys with a common sample design. These surveys are mandated by law through the Agricultural Research, Extension, and Education Reform Act (1998) (Farm Bill) and updated in Title VIII of the 2014 Farm Bill. For more information, please visit <https://www.fs.usda.gov/research/programs/fia>.

The Urban FIA Program builds upon FIA's Nationwide Forest Inventory (NFI) to assess the status and trends of trees and forests in urban settings, including the services they provide, their health, and future risk from insects and diseases. The Urban FIA Program fuses methods and infrastructure of the NFI with the expertise provided by i-Tree, a state-of-the-art, peer-reviewed software suite that provides seamless analysis of the NFI and Urban FIA along with tools for assessing the benefits of urban trees.

More detailed information about the Urban FIA Program can be found at <https://www.fs.usda.gov/research/programs/urbanfia>.

The data collected by the Urban FIA Program are explained in detail in the *Urban FIA Field Guide* (USDA Forest Service 2023c), *Urban FIADB User Guide* (USDA Forest Service 2024b) and the data themselves can be downloaded from the Urban DataMart (USDA Forest Service 2023b). Additional visualizations of Urban FIA results and the opportunity to interactively explore the urban forests of inventoried cities, including San Antonio, can be found on the My City's Trees website (Texas A&M Forest Service and USDA Forest Service 2024a) for an introduction and the My City's Trees Application (Texas A&M Forest Service and USDA Forest Service 2024b) for the tool itself.

Additional information about any aspect of Southern Research Station FIA surveys may be obtained from:

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A view of downtown San Antonio, TX.

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EXECUTIVE SUMMARY

The city and extraterritorial jurisdiction (ETJ) of San Antonio were sampled from 2017 through 2018 to assess the magnitude, composition, and value of its urban forest resource. The sample area (representing the city and ETJ, a total of 694,668 acres), was estimated to contain 137.8 million live trees, 73.9 percent of which were <5.0 inches in diameter (table 1).

The most abundant tree species of at least 1 inch in diameter in the combined city and ETJ sample area were Ashe juniper (*Juniperus*

ashei), Texas persimmon (*Diospyros texana*), mescal bean (*Sophora secundiflora*), sugarberry (*Celtis laevigata*), and honey mesquite (*Prosopis glandulosa*). Of these species, all were among the five most common species in the smallest diameter class (<5.0 inches). The most abundant large-diameter (11.0+ inches) tree species were Ashe juniper, live oak (*Quercus virginiana*), honey mesquite, sugarberry, and cedar elm (*Ulmus crassifolia*). The species with the greatest importance value—based on the number of trees and leaf area—were Ashe juniper and Texas persimmon.

Table 1—Summary of urban forest estimates, San Antonio, 2018

		City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Number of trees (millions)	Live saplings (1.0 to 4.9 inches in diameter)	33.9	67.9	101.8
	Live trees (≥5.0 inches in diameter)	12.2	23.9	36.0
	Total live trees	46.0	91.7	137.8
	Standing dead saplings (1.0 to 4.9 inches in diameter)	1.8	4.0	5.8
	Standing dead trees (≥5.0 inches in diameter)	0.7	1.8	2.5
Most abundant species by	Number of live trees	Sugarberry	Ashe juniper	Ashe juniper
	Leaf area	Sugarberry	Ashe juniper	Ashe juniper
Ecosystem services	Pollution removal	2,591 tons/year (\$24.4 million/year)	3,974 tons/year (\$37.5 million/year)	6,565 tons/year (\$61.9 million/year)
	Reduction in acute respiratory symptoms	3,074 cases/year (\$266,761/year)	4,715 cases/year (\$409,168/year)	7,790 cases/year (\$675,928/year)
	VOC emissions	5,115 tons/year	7,846 tons/year	12,962 tons/year
	Avoided runoff	151 million cubic feet/year (\$10.1 million/year)	231 million cubic feet/year (\$15.4 million/year)	382 million cubic feet/year (\$25.5 million/year)
	Carbon storage	1.4 million tons (\$241.9 million)	2.1 million tons (\$352.4 million)	3.5 million tons (\$594.4 million)
	Carbon sequestration	119,556 tons/year (\$20.4 million/year)	200,503 tons/year (\$34.2 million/year)	320,059 tons/year (\$54.5 million/year)
	Net aboveground volume	83.6 million cubic feet	122.7 million cubic feet	206.4 million cubic feet
	Reduced residential building energy use	180,648.6 GJ/year (\$17.5 million/year)	139,987.2 GJ/year (\$4.9 million/year)	320,635.8 GJ/year (\$22.4 million/year)
	Reduced residential carbon emissions	24,928 tons/year (\$4.3 million/year)	7,192 tons/year (\$1.2 million/year)	32,120 tons/year (\$5.5 million/year)
Compensatory value		\$15.9 billion	\$17.3 billion	\$33.1 billion

VOC = volatile organic carbon; GJ = gigajoule (one billion [1,099] joules).

The majority of trees were found on forest land (86.5 percent, 119.3 million trees) even though forests occupied only 30.0 percent of the combined city and ETJ. Overall, 9.7 percent of trees were classified as growing in maintained areas, which are regularly impacted by mowing, weeding, cutting, brush clearing, herbicide applications, and more. Trees on public land totaled 35.2 million and accounted for 25.5 percent of the total live tree population.

Urban forest ecosystem services were evaluated in terms of air pollution removal, carbon sequestration, stormwater runoff reduction, residential building energy use, and carbon emissions avoidance. The compensatory value of the urban forest (roughly equivalent to the replacement value of all trees in the urban forest) was estimated at \$33.1 billion, with the urban forest producing over \$170.5 million in annual benefits (table 1).

Black willow (*Salix nigra*) was the tree species with the greatest incidence of dieback, occurring on an average of 23.1 percent of the trees of that species. Mescal bean was the species most affected by rot, averaging 17.9 percent of trees. The species with the most urban tree damages was Callery pear (*Pyrus calleryana*), with 54.5 percent of trees with at least one damage type. The most common urban tree damages affecting all tree species in the combined city and ETJ were bark inclusion (2.3 percent of trees) and topping or improper pruning (1.6 percent of trees).

Several insects and diseases threaten the urban forest of San Antonio and its ETJ. The greatest threats, based on the percentage of trees that are potential hosts, are from polyphagous shot hole borer (*Euwallacea fornicatus*) (17.9 percent of trees in the San Antonio urban forest population at risk), which has fortunately not yet been observed in Bexar County; spotted lanternfly (*Lycorma delicatula*) (16.8 percent of trees at risk); and forest tent caterpillar (*Malacosoma disstria*) (12.9 percent of trees at risk). Oak wilt (*Bretziella fagacearum*), though only potentially affecting 5.3 percent of San Antonio's trees, is of concern because it could

impact the large, charismatic live oaks (*Quercus virginiana*) as well as other oak species.

Invasive plant species also threaten to alter forest composition. Invasive plants were found on 31.8 percent of the sampled plots; Chinaberry tree (*Melia azedarach*) was estimated to cover the largest area (3,205 acres) of any invasive plant species in the combined city and ETJ.

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

BACKGROUND

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, Forest Service's Forest Inventory and Analysis (FIA) Program has provided information on the amount, status, and character of forest land across the country. The 2014 U.S. Farm Bill (Agricultural Act of 2014) 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.

In this bulletin, urban forest describes all trees in the San Antonio, TX sample area, which consists of the city (2010 U.S. Census Bureau boundary of the city of San Antonio) and its ETJ (defined as unincorporated land within 5 miles of the city of San Antonio's boundaries that is not located in another city's municipal boundary or ETJ) across public and private ownerships. This includes

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 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 partnership leverages the strengths of the i-Tree program in terms of urban data processing and FIA in terms of the quality, consistency, and comprehensiveness of collected data in the combined national urban forest inventory effort.

This report covers the first full inventory of San Antonio under the Urban FIA Program. The survey is annualized, meaning that a portion of the plots are visited each year during a 10-year cycle. To get information sooner, an accelerated data collection program was set in place for this first inventory cycle: measuring all of the plots over only 2 years. As a result, San Antonio was the fourth city to complete a full inventory cycle under the Urban FIA Program. In addition to accelerating plot collection, San Antonio also opted to include the ETJ data in analysis and reporting. This additional area plays an important role in planning and decision making for the city; therefore, much of the data in this bulletin is presented for the city, the ETJ, and the combined sample area of both.

These data and analyses can be useful for managers and policymakers. In 2019 city officials and interested experts developed a strategic plan for climate action and adaptation (City of San Antonio 2019a). The strategic plan proposes ambitious goals for the city and its residents and having information and data about the urban forest will be an important tool to aid in decision making relative to achieving these objectives. Goals include reducing greenhouse gas emissions and achieving carbon neutrality by 2050; managing climatic changes such as hotter temperatures, increasing periods of drought, and more severe storms; preserving native species; protecting water; managing increased air pollution; reducing building energy consumption;

and promoting biodiversity. Data contained in this bulletin can help inform managers and policymakers on these topics.

Related to the action and adaptation plan, the city developed a vulnerability and risk assessment (City of San Antonio 2019c). Twelve priority risks—three high and nine medium—were identified. Trees and forests can be linked to at least nine of these priorities, including all three of the high priorities. Therefore, having a summary of tree and forest statistics for the area can assist with decision making relative to this risk assessment. Bolstering the notion of data utility is the assessment's explicit aim to “promote, restore, and protect green infrastructure and ecosystems” as one of seven key action areas presented in the report (City of San Antonio 2019c).

To evaluate the extent, composition, and benefits of San Antonio's urban forest, the collected data were analyzed using FIA methodology and i-Tree Eco modeling software. This bulletin summarizes the findings of these analyses. Results include information on forest structure, ecosystem services, and associated monetary values. Structure describes various physical attributes of the urban forest, including tree species composition and diversity, number of trees, tree density, tree health, leaf area, and biomass. Ecosystem services discussed in this report were evaluated based on forest structure in conjunction with local environmental variables and include



San Antonio's urban green spaces provide valued recreational opportunities for all who live there or visit.

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 bulletin, information from this analysis is accessible via My City's Trees (Texas A&M Forest Service and USDA Forest Service 2024b), 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 Data-Mart (USDA Forest Service 2024a).

METHODS

To evaluate the extent, composition, and benefits of San Antonio'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 National Urban FIA Plot Field Guide, Version 9.3* (USDA Forest Service 2023c), *Additional sampling and estimation details for urban forest inventory and analysis reports (version 1)* (Baer et al. 2024), and i-Tree Eco modeling software (Nowak 2020).

This inventory established survey plots across San Antonio and aims to revisit those plots every 10 years. Future reports can build on these data and consistently provide information on urban forest extent, diversity, health, and benefits. During the two field seasons of 2017 and 2018, San Antonio's 10-year measurement cycle was accelerated and completed. The sampling area was defined by the union of the 2010 U.S.

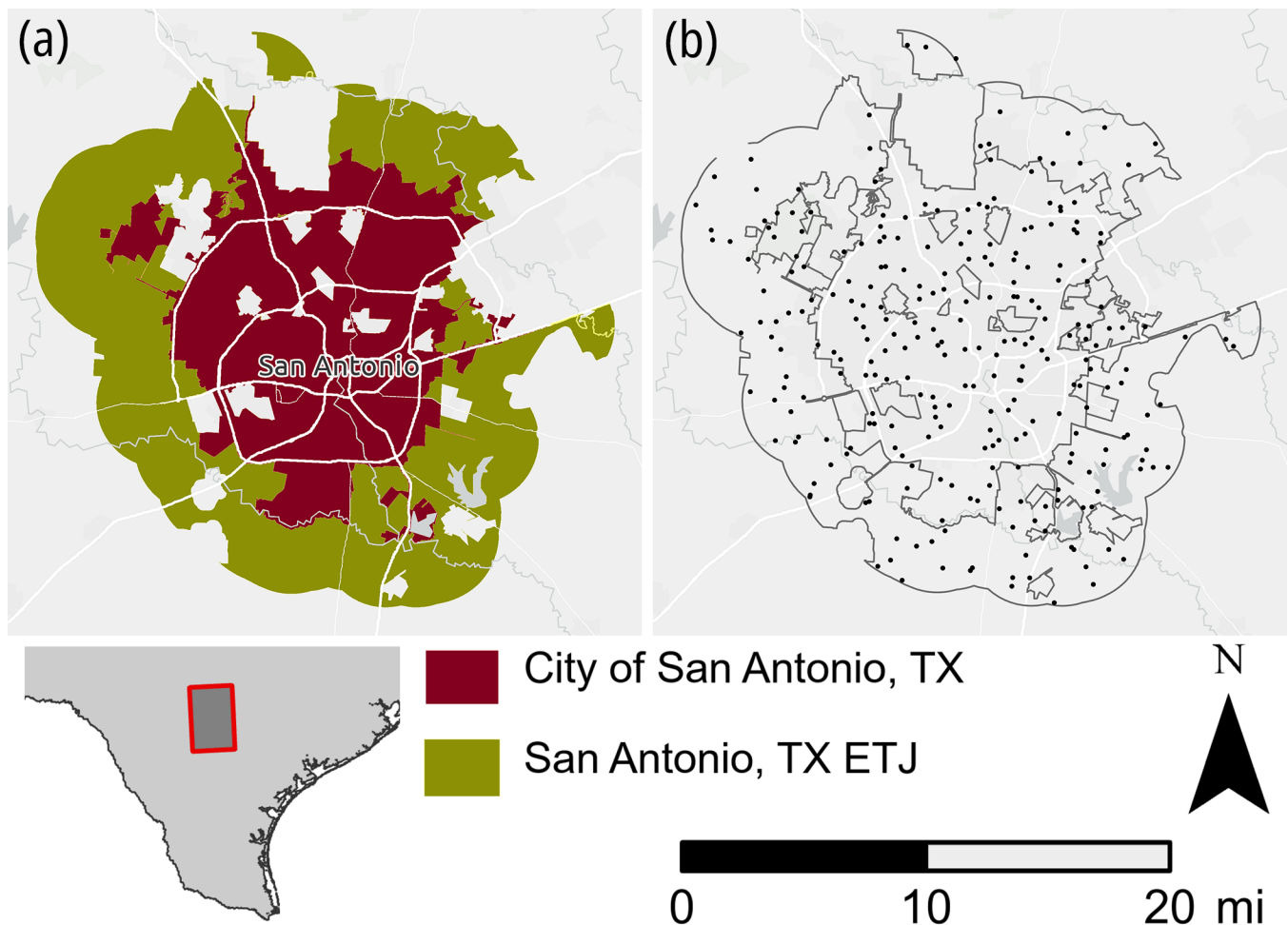


Figure 1—(a) Study area and (b) approximate plot locations for the Urban Forest Inventory and Analysis inventory of San Antonio, 2018. ETJ = extraterritorial jurisdiction.

Census Bureau designated places boundary for San Antonio (red area in fig. 1a) and the ETJ surrounding the city, defined by the city of San Antonio's 2016 ETJ boundary plus areas annexed between 2010 and 2016 (green area in fig. 1a). In total, the Urban FIA sample surveyed 267 plots (150 within the city of San Antonio and an additional 117 within the surrounding ETJ) across 694,668 acres (298,719 acres in the city and 395,948 acres in the ETJ) (fig. 1b).

New methods were implemented in the inventory of San Antonio's urban forest to allow for flexibility in the estimation of tree characteristics for forked trees. In this inventory, all stems of forked trees were 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. Refer to the *Additional sampling and estimation details for urban forest inventory and analysis reports (version 1)* (Baer et al. 2024) to this bulletin for more detailed information. Throughout this bulletin, except where explicitly noted, trees refer to woody plant species listed in the appendices of the *National Urban FIA Plot Field Guide, Version 9.3* (USDA Forest Service 2023c) with diameters of at least 1.0 inch, and results are given for live trees.

The collected data were analyzed using FIA methodology and i-Tree Eco modeling software outlined in the *Additional sampling and estimation details for urban forest inventory and analysis reports (version 1)* (Baer et al. 2024) to this bulletin. Additional analyses were conducted with R Statistical software version 4.2.1 (R Core Team 2022) and Microsoft Excel (Microsoft Corporation, Redmond, WA). Figures presented in this bulletin 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 were created with ArcGIS® Pro (Esri 2021).

AREA AND COVER CHARACTERISTICS

In 2010, Texas had 5,586,000 acres of urban land which covered 3.3 percent of the State area



The city of San Antonio and its extraterritorial jurisdiction encompass diverse land uses.

(Nowak and Greenfield 2018); this urban area is projected to increase to 7.8 percent of the State by 2060 (Nowak and Greenfield 2018). The city of San Antonio is Texas's second largest by population (1,327,407 residents with a population density of 2,879.8 per square mile in 2010) (U.S. Census Bureau 2020b).

FIA land use

Plots were classified in the field based on FIA land-use classes (table 2). There are often multiple land uses on a single plot. When this occurs, the area of each land-use class is mapped and a percentage of the total plot area is assigned. These categories provide a specific look at how the land is being used by the local population in San Antonio.

Forest land was the most prevalent land use in the combined city and ETJ, covering 30.1 percent of the area (containing 86.5 percent of the area's trees), followed by single-family residential (hereafter residential) (26.2 percent of the area), agriculture (15.8 percent), commercial/industrial (11.6 percent), and rights-of-way (7.3 percent) (table 3).

In the city, residential was the most prevalent land use, covering 34.1 percent of the area (containing 20.4 percent of the trees) (table 3), followed by commercial/industrial (22.3 percent of the area), forest (17.2 percent), rights-of-way (13.2 percent), and recreation/cemetery (5.3 percent).

Table 2—Description of Forest Inventory and Analysis (FIA) land-use classes and subclasses, San Antonio, 2018

FIA land-use class	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	None
Multifamily residential	None
Natural land	Beach, nonvegetated land, other, wetland
Rangeland/chaparral	None
Recreation/cemetery	Cemetery, golf course, park, recreation
Residential	None
Rights-of-way	Right-of-way, transportation, utility
Water	None

Table 3—Sample area and count of plots within Forest Inventory and Analysis (FIA) land-use classes, San Antonio, 2018

FIA land-use class	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
	<i>Acres</i>	<i>Percent</i>	<i>Plots</i>	<i>Acres</i>	<i>Percent</i>	<i>Plots</i>	<i>Acres</i>	<i>Percent</i>	<i>Plots</i>
Agriculture	11,959.9	4.0	5.6	97,823.9	24.7	33.1	109,783.7	15.8	38.7
Commercial/industrial	66,675.0	22.3	35.4	13,741.8	3.5	3.0	80,416.8	11.6	38.4
Forest	51,365.5	17.2	22.6	157,683.7	39.8	44.8	209,049.2	30.1	67.3
Multifamily residential	10,225.7	3.4	5.4	3,123.4	0.8	1.0	13,349.1	1.9	6.4
Rangeland/chaparral	—	—	—	15,617.0	3.9	5.2	15,617.0	2.2	5.2
Recreation/cemetery	15,759.9	5.3	7.4	—	—	—	15,759.9	2.3	7.4
Residential	101,877.7	34.1	51.8	80,200.6	20.3	21.0	182,078.3	26.2	72.8
Rights-of-way	39,446.7	13.2	21.0	11,431.1	2.9	2.6	50,877.8	7.3	23.6
Water	1,408.8	0.5	0.8	16,326.8	4.1	6.2	17,735.6	2.6	7.0
Total	298,719.2	100.0	150.0	395,948.3	100.0	117.0	694,667.5	100.0	267.0

— = no data.

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

The ETJ was predominantly forest, which covered 39.8 percent of the area (containing 93.3 percent of the trees) (table 3), followed by agriculture (24.7 percent of area), residential (20.3 percent), water (4.1 percent), and rangeland/chaparral (3.9 percent).

Tree, shrub, and ground cover

Tree cover in San Antonio's combined city and ETJ was estimated at 29.3 percent and shrub cover at 7.6 percent, based on field crew assessments (table

4). Tree cover in the city was estimated at 25.5 percent and shrub cover at 6.6 percent; tree cover in the ETJ was estimated at 32.1 percent and shrub cover at 8.3 percent. Tree cover estimates are based on field plot estimates and though precise (highly replicable), can have a relatively lower degree of accuracy due to the subjective nature of tree cover data collection in the field and effects of sample size. Generally, more accurate tree cover estimates can be derived from photointerpretation or high-resolution tree cover maps.

Table 4—Average percentage of tree, shrub, and impervious cover by Forest Inventory and Analysis (FIA) land-use class, San Antonio, 2018

FIA land-use class	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
	Tree	Shrub	Impervious	Tree	Shrub	Impervious	Tree	Shrub	Impervious
<i>percent</i>									
Agriculture	3.0	0.1	0.0	2.4	2.4	0.0	2.4	2.2	0.0
Commercial/industrial	10.6	1.0	32.2	1.3	0.3	33.3	9.0	0.9	32.4
Forest	63.4	21.5	2.1	62.2	17.5	1.9	62.4	18.5	1.9
Multifamily residential	8.8	5.1	26.8	20.0	5.0	60.0	11.4	5.1	34.6
Rangeland/chaparral	0.0	0.0	0.0	19.6	4.4	0.0	19.6	4.4	0.0
Recreation/cemetery	12.1	0.4	26.0	0.0	0.0	0.0	12.1	0.4	26.0
Residential	30.3	5.9	8.6	28.0	2.7	9.6	29.3	4.5	9.0
Rights-of-way	6.6	2.9	57.6	0.3	1.8	52.2	5.1	2.7	56.4
Water	1.9	3.7	3.1	0.1	0.1	5.1	0.3	0.4	4.9
Average	25.5	6.6	20.4	32.1	8.3	6.0	29.3	7.6	12.2

Overall, tree cover in the combined city and ETJ ranged from 1.0 to 99.0 percent on plots where tree cover was present (fig. 2a). Shrub cover on plots ranged from 1.0 to 90.0 percent on plots where shrub cover was present (fig. 2b). Average tree cover was highest on forest (62.4 percent), residential (29.3 percent), and rangeland/chaparral (19.6 percent) land (table 4). Average shrub cover was highest on forest (18.5 percent), multifamily residential (5.1 percent), residential (4.5 percent), and rangeland/chaparral (4.4 percent) land. Average impervious cover was highest on rights-of-way (56.4 percent), multifamily residential (34.6 percent), and commercial/industrial (32.4 percent) land (table 4).

In the city, tree cover averaged 25.5 percent. Average tree cover in the city was highest on forest (63.4 percent), residential (30.3 percent), and recreation/cemetery (12.1 percent) land (table 4). Average shrub cover was highest on forest (21.5 percent), residential (5.9 percent), and multifamily residential (5.1 percent) land. Average impervious cover was highest on rights-of-way (57.6 percent), commercial/industrial (32.2 percent), and multifamily residential (26.8 percent) land (table 4).

In the ETJ, tree cover averaged 32.1 percent and shrub cover 8.3 percent. Average tree cover in the ETJ was highest on forest (62.2 percent), residential (28.0 percent), and multifamily residential (20.0 percent) land (table 4). Average shrub cover was highest on forest (17.5 percent), multifamily residential (5.0 percent), and rangeland/chaparral (4.4 percent) land. Average impervious cover was highest on multifamily residential (60.0 percent), rights-of-way (52.2 percent), and commercial/industrial (33.3 percent) land (table 4).

Field crews categorized ground surface cover on each field plot according to five classes: (i) building, (ii) herbaceous (low vegetation), (iii) permeable (soil, leaf litter, mulch, gravel, etc.), (iv) impervious (nonbuilding), or (v) water. Permeable and herbaceous ground covers accounted for 78.3 percent of all ground covers in the sample area, and building and other impervious cover accounted for 19.5 percent. An additional 2.2 percent of the sample area was classified as water (figs. 3, 4). In the city, 54.0 percent of the ground was covered in permeable or herbaceous covers and 32.8 percent was buildings or impervious surfaces. In the ETJ those covers accounted for 70.3 percent and 26.9 percent, respectively.

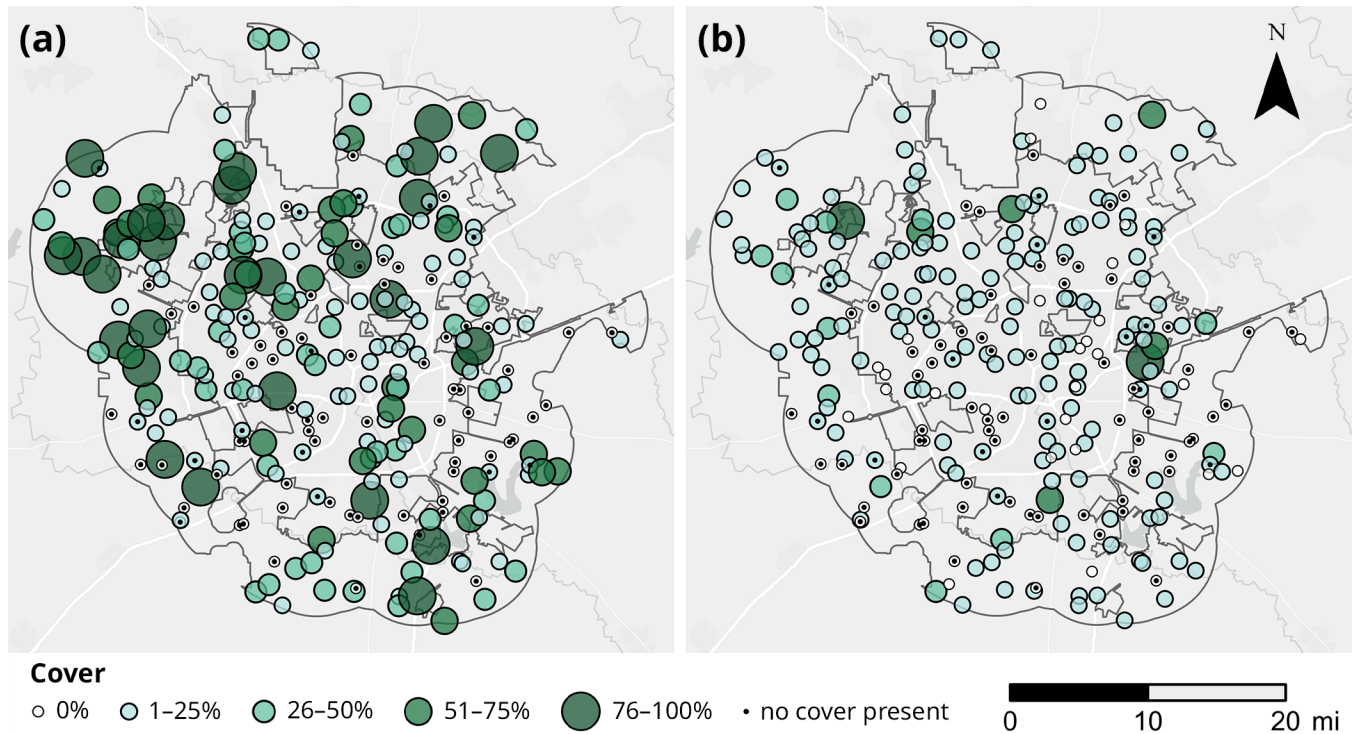


Figure 2—(a) Tree and (b) shrub cover estimates by plot, San Antonio, 2018.

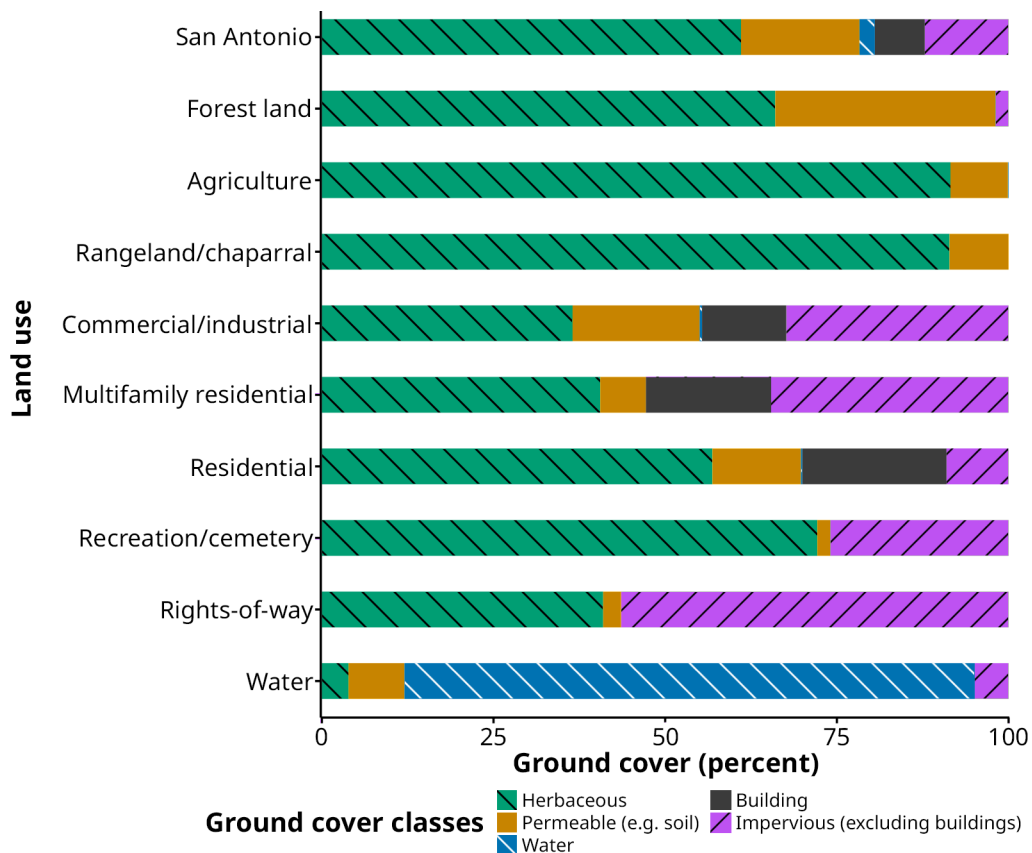


Figure 3—Percentage of ground cover for San Antonio (top bar = combined city and extraterritorial jurisdiction) and by each Forest Inventory and Analysis land-use class, 2018.

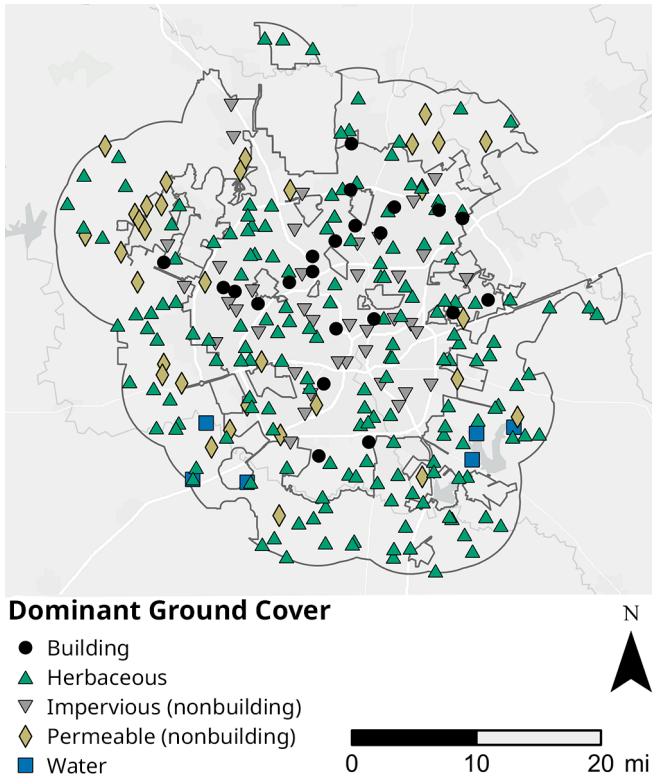


Figure 4—Dominant ground cover by plot, San Antonio, 2018.

Ownership

Plot ownership was divided into private, State and local government, Federal government, and unknown (water). The most dominant ownership in the combined city and ETJ was private (78.8 percent), followed by State and local (17.6 percent), unknown (water) (2.6 percent), and Federal (1.0 percent) (table 5).



Urban areas like San Antonio are covered in a variety of surfaces, both permeable and impervious, that affect urban ecosystem functions.

In the combined city and ETJ, there were a total of 102.6 million trees (74.5 percent of the live tree population) on private land, 35.1 million trees (25.5 percent) on State and local land, and 121,000 trees (0.1 percent) on Federal land (table 5). The sapling (1.0–4.9 inches in diameter) population was mostly found on private land (74.4 percent), followed by State and local land (25.6 percent), with none on Federal land (table 5).

The most dominant ownership in the city of San Antonio was also private (69.8 percent), followed by State and local (27.3 percent), Federal (2.4 percent), and unknown (water) (0.5 percent) (table 5). Percentage of tree cover in the combined city and ETJ was greatest on State and local land (27.7 percent), followed by private (25.4 percent), and Federal (10.1 percent) land (table 6). In the

Table 5—Distribution of percentage of live trees within diameter classes by ownership and sampling area, San Antonio, 2018

Ownership class	City					Extraterritorial jurisdiction (ETJ)					Combined city and ETJ				
	Tree diameter class (inches)					Tree diameter class (inches)					Tree diameter class (inches)				
	1.0–4.9	5.0–10.9	≥11.0	Total trees	Land area	1.0–4.9	5.0–10.9	≥11.0	Total trees	Land area	1.0–4.9	5.0–10.9	≥11.0	Total trees	Land area
<i>percent</i>															
Federal	0.0	1.0	1.0	0.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.1	1.0
State and Local	50.9	49.1	28.7	49.0	27.3	13.0	14.2	20.3	13.7	10.3	25.6	25.3	23.7	25.5	17.6
Private	49.1	50.0	70.2	50.8	69.8	87.0	85.8	79.7	86.3	85.6	74.4	74.4	75.9	74.5	78.8
Unknown (water)	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	2.6

Table 6—Average percentage of tree cover and land area by ownership and sampling area, San Antonio, 2018

Ownership class	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
	Number	Tree cover	Land area	Number	Tree cover	Land area	Number	Tree cover	Land area
		percent			percent			percent	
Federal	120,579	10.1	2.4	—	0.0	0.0	120,579	10.1	10.1
State and Local	22,550,974	27.7	27.3	12,528,933	43.0	10.3	35,079,907	32.8	27.7
Private	23,371,078	25.4	69.8	79,214,871	32.3	85.6	102,585,949	29.7	25.4
Unknown (water)	0	1.9	0.5	—	0.1	4.1	—	0.3	1.9

— = no data.

city, there were a total of 23.4 million trees (50.8 percent of the live tree population) on private land, 22.6 million trees (49.0 percent) on State and local land, and 120,000 trees (0.3 percent) on Federal land (table 5). The city's sapling population was mostly found on State and local land (50.9 percent), followed by private land (49.1 percent) (table 5). In the ETJ, the most dominant ownership was again private (85.6 percent), followed by State and local (10.3 percent), and unknown (water) (4.1 percent), with no Federal land ownership (table 5). Percentage of tree cover in the ETJ was greatest on State and local land (43.0 percent), followed by private (32.3 percent), and unknown (water) (0.1 percent) (table 6). In the ETJ, there were a total of 79.2 million trees (86.3 percent of the live tree population) on private land, 12.5 million trees (13.7 percent) on State and local land, and no trees on unknown (water) (table 5). The ETJ's sapling population was mostly found on private land (87.0 percent), followed by State

and local land (13.0 percent), with no saplings on unknown (water) (table 5).

FOREST STRUCTURE

Number of trees

San Antonio's urban forest had an estimated 137.8 million live trees (table 7). The number of trees varied by land-use class and diameter class. Most of the trees were located on forest land (86.5 percent, 119.3 million trees) (table 7). Overall, 73.9 percent of the combined city and ETJ's trees were saplings, 20.2 percent were medium trees (5.0–10.9 inches in diameter), and the remaining 6.0 percent were large trees (≥ 11.0 inches in diameter).

Viewed separately, the city of San Antonio had an estimated 46.0 million live trees. As with the combined city and ETJ, most of the trees in the city were located on forest land (73.1 percent, 33.7 million trees) (table 7). Overall, 73.6 percent of the city of San Antonio's trees were saplings (1.0–4.9 inches in diameter); the remaining 19.3 percent and 7.1 percent were medium trees (5.0–10.9 inches in diameter) and large trees (≥ 11.0 inches in diameter), respectively. The city held an estimated 2.5 million standing dead trees.

The ETJ had an estimated 91.7 million live trees. Most of the trees in the ETJ were located on forest land (93.3 percent, 85.6 million trees) (table 7). Overall, 74.0 percent of the ETJ's trees were saplings (1.0–4.9 inches in diameter) and 20.6 percent were medium trees (5.0–10.9 inches in diameter); the remaining 5.4 percent were large trees (≥ 11.0 inches in diameter).



Trees and gardens surrounding the city of San Antonio's Sunken Gardens Theater facility.

Table 7—Distribution of live trees by Forest Inventory and Analysis (FIA) land-use class and diameter class, San Antonio, 2018

FIA land-use class	City				Extraterritorial jurisdiction (ETJ)				Combined city and ETJ						
	Tree diameter class (inches)			Density (trees per acre)	Tree diameter class (inches)			Density (trees per acre)	Tree diameter class (inches)			Total number of trees	Density (trees per acre)		
	1.0-4.9	5.0-10.9	≥11.0		1.0-4.9	5.0-10.9	≥11.0		1.0-4.9	5.0-10.9	≥11.0				
Agriculture	0.0	9,960.1	0.0	9,960.1	0.8	2,101,597.8	252,000.9	37,593.6	2,391,192.3	24.4	2,101,597.8	261,960.9	37,593.6	2,401,152.4	21.9
Commercial/ industrial	684,556.3	462,638.6	325,836.5	1,473,031.3	22.1	0.0	0.0	27,566.3	27,566.3	2.0	684,556.3	462,638.6	353,402.7	1,500,597.6	18.7
Forest	26,486,335.8	5,895,425.1	1,280,471.2	33,662,232.1	655.3	65,436,002.9	16,389,699.9	3,764,442.6	85,590,145.4	542.8	91,922,338.7	22,285,125.0	5,044,913.8	119,252,377.5	570.5
Multifamily residential	0.0	50,832.2	82,506.3	133,338.6	13.0	0.0	0.0	18,796.8	18,796.8	6.0	0.0	50,832.2	101,303.1	152,135.4	11.4
Rangeland/ chaparral	0.0	0.0	0.0	0.0	–	0.0	56,390.4	93,984.1	150,374.5	9.6	0.0	56,390.4	93,984.1	150,374.5	9.6
Recreation/ cemetery	0.0	177,236.6	81,801.5	259,038.1	16.4	0.0	0.0	0.0	0.0	–	0.0	177,236.6	81,801.5	259,038.1	16.4
Residential	5,904,749.1	2,141,826.0	1,362,254.8	9,408,830.0	92.4	343,385.8	2,153,957.8	987,026.3	3,484,369.9	43.4	6,248,134.9	4,295,783.9	2,349,281.1	12,893,199.9	70.8
Rights-of-way	808,626.2	137,097.8	150,731.4	1,096,455.3	27.8	0.0	82,698.8	0.0	82,698.8	7.2	808,626.2	219,796.5	150,731.4	1,179,154.1	23.2
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	33,884,267.3	8,875,016.4	3,283,601.7	46,042,885.4	827.9	67,880,986.6	18,934,747.8	4,929,409.6	91,745,144.0	635.6	101,765,253.9	27,809,764.2	8,213,011.3	137,788,029.4	742.4

– = no data.

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



A natural forest area within the San Antonio extraterritorial jurisdiction.

The ETJ had an estimated 5.8 million trees that qualified as standing dead.

Species composition

Common and scientific names for all species observed in the Urban FIA inventory of San Antonio are reported in table A1. The 10 most

common tree species within the combined city and ETJ accounted for 92.1 percent of all recorded live trees and included Ashe juniper, Texas persimmon, mescal bean, sugarberry, honey mesquite, cedar elm, live oak, sweet acacia (*Acacia farnesiana*), bluewood (*Condalia hookeri*), and loquat (*Eriobotrya japonica*) (table 8, fig. 5). These top 10 most common species remained largely consistent but with some differences when considering the city and ETJ separately. For the city, crapemyrtle (*Lagerstroemia indica*) entered the top 10 and bluewood dropped out. For the ETJ, black hickory (*Carya texana*) and catclaw acacia (*Acacia greggii*) entered, and sweet acacia and loquat dropped out. In the city, the top 10 species by count accounted for 87.3 percent of all recorded live trees, though in the ETJ the top 10 accounted for 95.7 percent of the total.

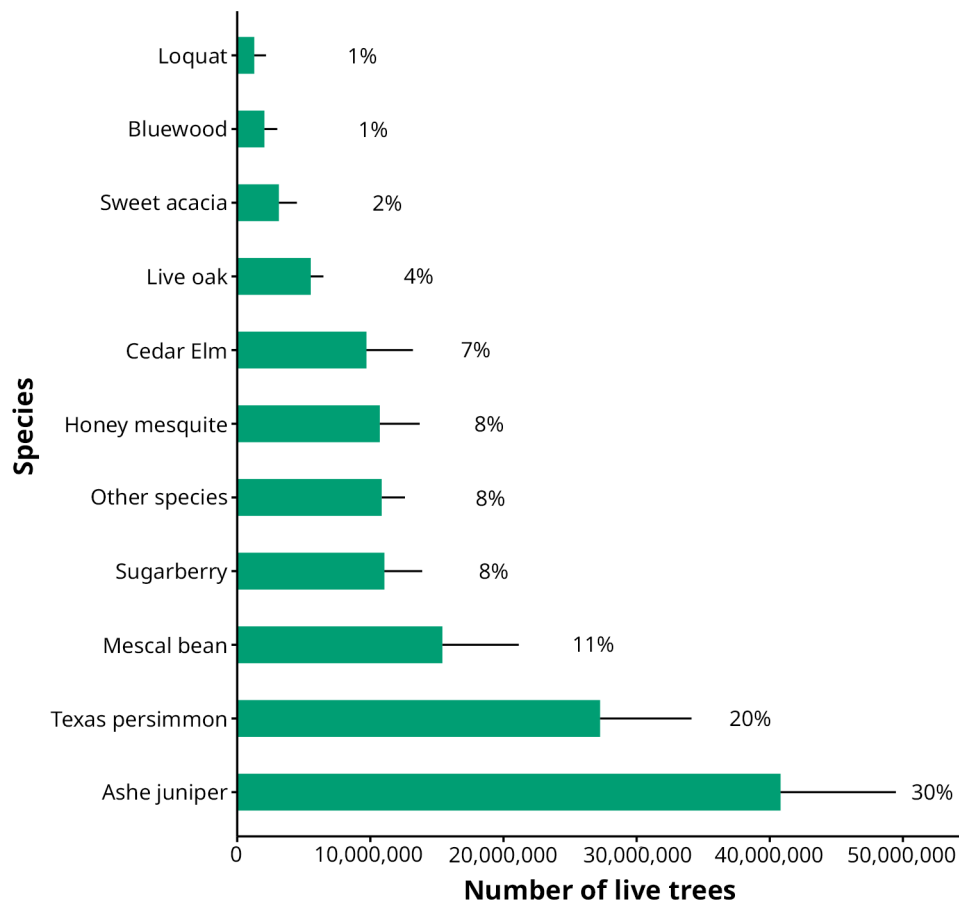


Figure 5—The 10 most common tree species by number of trees and percentage of the sample, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

SAN ANTONIO'S URBAN FOREST, 2018

Table 8—Urban forest species composition in San Antonio, 2018

Species common name	City		Extraterritorial jurisdiction (ETJ)		Combined city and ETJ	
	Total number of trees	Percent	Total number of trees	Percent	Total number of trees	Percent
Ashe juniper	6,433,368.1	14.0	34,379,453.0	37.5	40,812,821.1	29.6
Texas persimmon	7,376,265.0	16.0	19,879,859.6	21.7	27,256,124.5	19.8
Mescal bean	4,465,474.7	9.7	10,946,373.0	11.9	15,411,847.7	11.2
Sugarberry	7,954,126.6	17.3	3,101,275.9	3.4	11,055,402.5	8.0
Honey mesquite	3,158,248.8	6.9	7,552,731.9	8.2	10,710,980.7	7.8
Cedar elm	4,084,792.0	8.9	5,622,807.5	6.1	9,707,599.4	7.0
Live oak	1,822,718.9	4.0	3,702,278.8	4.0	5,524,997.8	4.0
Sweet acacia	2,710,775.6	5.9	419,865.0	0.5	3,130,640.6	2.3
Bluewood	914,739.2	2.0	1,128,416.2	1.2	2,043,155.4	1.5
Loquat	1,282,330.9	2.8	0.0	0.0	1,282,330.9	0.9
Crapemyrtle	924,447.8	2.0	55,132.5	0.1	979,580.3	0.7
Black hickory	0.0	0.0	919,163.9	1.0	919,163.9	0.7
Ailanthus	717,279.8	1.6	0.0	0.0	717,279.8	0.5
Japanese privet	678,841.2	1.5	0.0	0.0	678,841.2	0.5
Texas live oak	548,295.4	1.2	93,984.1	0.1	642,279.4	0.5
Catclaw acacia	0.0	0.0	566,211.7	0.6	566,211.7	0.4
Chittamwood, gum bumelia	186,733.9	0.4	305,111.0	0.3	491,844.9	0.4
Texas sophora	173,100.3	0.4	305,111.0	0.3	478,211.3	0.3
Chinaberry	343,218.3	0.7	115,832.0	0.1	459,050.3	0.3
Jerusalem thorn	184,882.9	0.4	265,880.0	0.3	450,762.9	0.3
Eastern baccharis	440,316.2	1.0	0.0	0.0	440,316.2	0.3
Bastard oak	0.0	0.0	427,579.1	0.5	427,579.1	0.3
Havard oak	0.0	0.0	403,085.5	0.4	403,085.5	0.3
Black walnut	0.0	0.0	348,401.4	0.4	348,401.4	0.3
Velvet ash	259,977.6	0.6	27,566.3	0.0	287,543.9	0.2
Black willow	0.0	0.0	252,291.4	0.3	252,291.4	0.2
Pecan	217,454.5	0.5	27,566.3	0.0	245,020.7	0.2
Goldenrain tree	196,665.4	0.4	0.0	0.0	196,665.4	0.1
Mexican buckeye	173,100.3	0.4	0.0	0.0	173,100.3	0.1
Lacey oak	0.0	0.0	171,455.4	0.2	171,455.4	0.1
Texas red oak	0.0	0.0	171,455.4	0.2	171,455.4	0.1
Citrus species	146,772.1	0.3	0.0	0.0	146,772.1	0.1
Callery pear	129,607.9	0.3	0.0	0.0	129,607.9	0.1
Texas walnut	0.0	0.0	97,974.5	0.1	97,974.5	0.1
Blackjack oak	0.0	0.0	95,204.5	0.1	95,204.5	0.1
Buckley oak	47,158.7	0.1	24,493.6	0.0	71,652.3	0.1

SAN ANTONIO'S URBAN FOREST, 2018

Table 8—Urban forest species composition in San Antonio, 2018 (continued)

Species common name	City		Extraterritorial jurisdiction (ETJ)		Combined city and ETJ	
	Total number of trees	Percent	Total number of trees	Percent	Total number of trees	Percent
Shumard oak	71,542.9	0.2	0.0	0.0	71,542.9	0.1
Chinese tallowtree	45,336.2	0.1	24,493.6	0.0	69,829.9	0.1
Post oak	0.0	0.0	57,000.7	0.1	57,000.7	0.0
Netleaf hackberry	0.0	0.0	48,987.3	0.1	48,987.3	0.0
Bur oak	43,485.2	0.1	0.0	0.0	43,485.2	0.0
Peach	0.0	0.0	42,688.5	0.0	42,688.5	0.0
Helecho gigante	0.0	0.0	38,814.1	0.0	38,814.1	0.0
White mulberry	9,960.1	0.0	27,566.3	0.0	37,526.3	0.0
Oriental arborvitae	33,525.1	0.1	0.0	0.0	33,525.1	0.0
Washington fan palm	29,880.2	0.1	0.0	0.0	29,880.2	0.0
Osage-orange	29,880.2	0.1	0.0	0.0	29,880.2	0.0
Queen sago	0.0	0.0	27,566.3	0.0	27,566.3	0.0
Other palms	0.0	0.0	27,566.3	0.0	27,566.3	0.0
Southern magnolia	25,416.1	0.1	0.0	0.0	25,416.1	0.0
Western soapberry	25,416.1	0.1	0.0	0.0	25,416.1	0.0
Black cherry	0.0	0.0	24,493.6	0.0	24,493.6	0.0
Mexican white oak	23,593.6	0.1	0.0	0.0	23,593.6	0.0
Chinese pistache	21,742.6	0.0	0.0	0.0	21,742.6	0.0
Anacua knockaway	19,920.1	0.0	0.0	0.0	19,920.1	0.0
Glossy privet	0.0	0.0	19,407.0	0.0	19,407.0	0.0
Green ash	13,633.6	0.0	0.0	0.0	13,633.6	0.0
Durand oak	13,633.6	0.0	0.0	0.0	13,633.6	0.0
Chinese elm	11,782.5	0.0	0.0	0.0	11,782.5	0.0
Apple species	11,782.5	0.0	0.0	0.0	11,782.5	0.0
Chinese parasoltree	11,782.5	0.0	0.0	0.0	11,782.5	0.0
Chinese privet	9,960.1	0.0	0.0	0.0	9,960.1	0.0
Red mulberry	9,960.1	0.0	0.0	0.0	9,960.1	0.0
Hackberry	9,960.1	0.0	0.0	0.0	9,960.1	0.0
Italian cypress	0.0	0.0	0.0	0.0	0.0	0.0
Total	46,042,885.4	100.0	91,745,144.0	100.0	137,788,029.4	100.0

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

The relative abundance of trees by species and diameter class are presented in table 9 and figures 6 and 7. In the combined city and ETJ, small-diameter trees (saplings) were generally the most abundant of the three tree size classes for the

10 most common tree species (live oak being the exception), together comprising 75.7 percent of the total trees of the 10 most common species, though large-diameter trees comprised only 5.3 percent (table 9, fig. 6).



Ashe juniper (*Juniperus ashei*), seen along this urban path, was the most abundant tree species in San Antonio, TX.

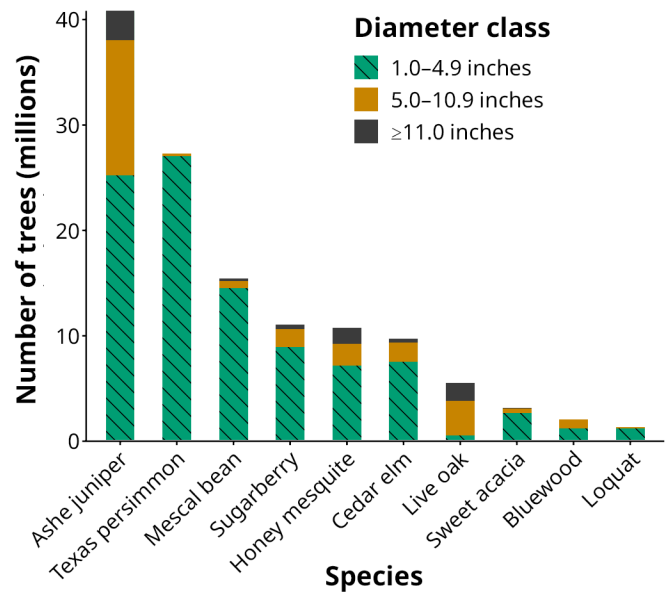


Figure 6—Number of trees by diameter class for the 10 most common tree species, San Antonio, 2018.

Table 9—Number of live trees by size class for the 10 most common tree species in San Antonio, 2018

Species common name	City				Extraterritorial Jurisdiction (ETJ)				Combined City and ETJ			
	Tree diameter class (inches)			Total number of trees	Tree diameter class (inches)			Total number of trees	Tree diameter class (inches)			Total number of trees
	1.0–4.9	5.0–10.9	≥11.0		1.0–4.9	5.0–10.9	≥11.0		1.0–4.9	5.0–10.9	≥11.0	
Ashe juniper	3,063,149.7	2,616,224.2	753,994.1	6,433,368.1	22,177,327.1	10,195,712.6	2,006,413.4	34,379,453.0	25,240,476.8	12,811,936.8	2,760,407.5	40,812,821.1
Texas persimmon	7,362,368.9	13,896.1	0.0	7,376,265.0	19,660,356.3	219,503.3	0.0	19,879,859.6	27,022,725.1	233,399.4	0.0	27,256,124.5
Mescal bean	4,105,377.9	360,096.8	0.0	4,465,474.7	10,411,270.6	535,102.4	0.0	10,946,373.0	14,516,648.5	895,199.2	0.0	15,411,847.7
Sugarberry	6,513,513.5	1,161,959.3	278,653.7	7,954,126.6	2,430,131.6	538,956.4	132,187.9	3,101,275.9	8,943,645.1	1,700,915.7	410,841.7	11,055,402.5
Honey mesquite	1,902,142.6	693,755.4	562,350.8	3,158,248.8	5,278,805.2	1,369,565.1	904,361.7	7,552,731.9	7,180,947.7	2,063,320.5	1,466,712.5	10,710,980.7
Cedar elm	3,249,419.5	705,153.8	130,218.6	4,084,792.0	4,287,100.7	1,097,910.3	237,796.5	5,622,807.5	7,536,520.2	1,803,064.1	368,015.1	9,707,599.4
Live oak	173,100.3	951,122.2	698,496.3	1,822,718.9	343,385.8	2,356,889.7	1,002,003.3	3,702,278.8	516,486.2	3,308,012.0	1,700,499.6	5,524,997.8
Sweet acacia	2,419,482.3	263,501.1	27,792.2	2,710,775.6	235,409.0	184,456.0	0.0	419,865.0	2,654,891.3	447,957.0	27,792.2	3,130,640.6
Bluewood	692,401.4	222,337.8	0.0	914,739.2	540,520.0	568,489.2	19,407.0	1,128,416.2	1,232,921.4	790,826.9	19,407.0	2,043,155.4
Loquat	1,197,973.5	84,357.4	0.0	1,282,330.9	0.0	0.0	0.0	0.0	1,197,973.5	84,357.4	0.0	1,282,330.9
Total	30,678,929.6	7,072,404.1	2,451,505.9	40,202,839.7	65,364,306.3	17,066,585.0	4,302,169.8	86,733,061.0	96,043,235.9	24,138,989.1	6,753,675.6	126,935,900.7

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

These percentages were very similar when examining the city (76.3 and 6.1 percent, respectively) and ETJ (75.4 and 5.0 percent, respectively) separately. When broken down into 2-inch diameter classes, the top five species maintained an abundance distribution dominated by sapling size classes (1.0–3.0 and 3.1–4.9) in the combined city and ETJ (fig. 7).

The preceding table and figures (table 9, figs. 6, 7) highlight the most prominent species for all trees ≥ 1.0 inch in diameter. Because smaller diameter trees were generally more abundant per unit area, the overall species composition may be more reflective of the smaller diameter species when examining 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. In the combined city and ETJ, the five most common species in terms of stem numbers in the smallest diameter size classes (<5.0 inches in diameter) were Texas persimmon, Ashe juniper, mescal bean, sugarberry, and cedar elm, which together represented 81.8 percent of all live trees <5.0 inches in diameter (table 10). Ashe juniper, live oak, honey mesquite, cedar elm, and sugarberry were the most common species in intermediate diameter size classes, representing 78.0 percent of all live trees between 5.0 and 10.9 inches in diameter. Dominant species in the largest diameter class, often the most recognizable component of the urban forest canopy, were Ashe juniper, live oak, honey mesquite, sugarberry, and cedar elm, comprising 81.7 percent of all live trees at least 11.0 inches in diameter.

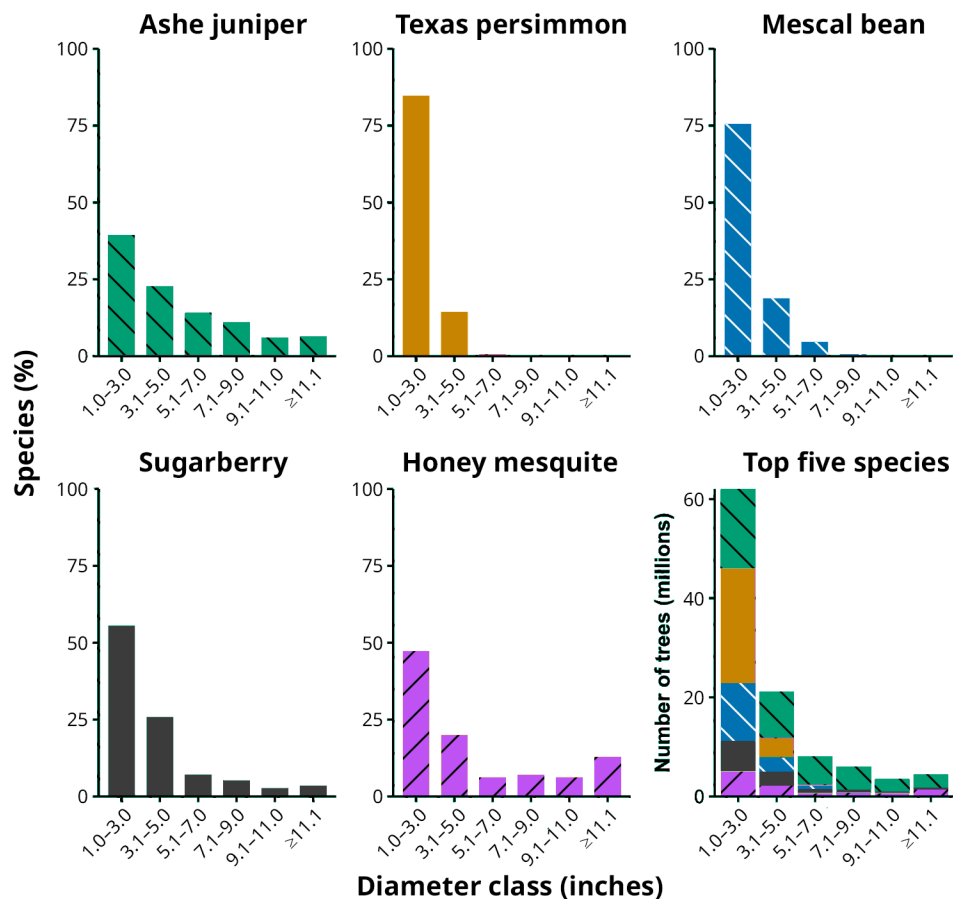


Figure 7—Percentage of species population by diameter class for the five most common tree species, San Antonio, 2018.

SAN ANTONIO'S URBAN FOREST, 2018

Table 10—Top five tree species by number of trees within each diameter class, San Antonio, 2018

		Common name	Total number of trees
City	1.0–4.9-inch diameter class	Texas persimmon	7,362,368.9
		Sugarberry	6,513,513.5
		Mescal bean	4,105,377.9
		Cedar elm	3,249,419.5
		Ashe juniper	3,063,149.7
		Total	24,293,829.5
	5.0–10.9-inch diameter class	Ashe juniper	2,616,224.2
		Sugarberry	1,161,959.3
		Live oak	951,122.2
		Cedar elm	705,153.8
		Honey mesquite	693,755.4
		Total	6,128,215.0
	≥11.0-inch diameter class	Ashe juniper	753,994.1
		Live oak	698,496.3
		Honey mesquite	562,350.8
		Sugarberry	278,653.7
		Pecan	152,198.1
		Total	2,445,693.1
Extraterritorial jurisdiction (ETJ)	1.0–4.9-inch diameter class	Ashe juniper	22,177,327.1
		Texas persimmon	19,660,356.3
		Mescal bean	10,411,270.6
		Honey mesquite	5,278,805.2
		Cedar elm	4,287,100.7
		Total	61,814,859.8
	5.0–10.9-inch diameter class	Ashe juniper	10,195,712.6
		Live oak	2,356,889.7
		Honey mesquite	1,369,565.1
		Cedar elm	1,097,910.3
		Black hickory	619,804.5
		Total	15,639,882.3
	≥11.0-inch diameter class	Ashe juniper	2,006,413.4
		Live oak	1,002,003.3
		Honey mesquite	904,361.7
		Cedar elm	237,796.5
		Black willow	213,477.3
		Total	4,364,052.2

Table 10—Top five tree species by number of trees within each diameter class, San Antonio, 2018 (continued)

		Common name	Total number of trees
Combined city and ETJ	1.0–4.9-inch diameter class	Texas persimmon	27,022,725.1
		Ashe juniper	25,240,476.8
		Mescal bean	14,516,648.5
		Sugarberry	8,943,645.1
		Cedar elm	7,536,520.2
		Total	83,260,015.8
	5.0–10.9-inch diameter class	Ashe juniper	12,811,936.8
		Live oak	3,308,012.0
		Honey mesquite	2,063,320.5
		Cedar elm	1,803,064.1
		Sugarberry	1,700,915.7
		Total	21,687,249.2
	≥11.0-inch diameter class	Ashe juniper	2,760,407.5
		Live oak	1,700,499.6
		Honey mesquite	1,466,712.5
		Sugarberry	410,841.7
		Cedar elm	368,015.1
		Total	6,706,476.4

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

In the city, things were slightly less skewed toward the top species. The five most common species in terms of tree counts in the smallest diameter size classes (<5.0 inches in diameter) were Texas persimmon, sugarberry, mescal bean, cedar elm, and Ashe juniper. Together these five species represented 71.7 percent of all live trees <5.0 inches in diameter (table 10). Ashe juniper, sugarberry, live oak, cedar elm, and honey mesquite were the most common species in intermediate diameter size classes, comprising 69.1 percent of all live trees between 5.0 and 10.9 inches in diameter. Dominant species in the largest diameter class were Ashe juniper, live oak, honey mesquite, sugarberry, and pecan (*Carya illinoensis*), representing 74.5 percent of live trees at least 11.0 inches in diameter.

Top species were especially dominant in the ETJ, with 91.1 percent of all live trees <5.0 inches in diameter being represented by the top five species

of Ashe juniper, Texas persimmon, mescal bean, honey mesquite, and cedar elm (table 10). In the intermediate diameter size classes, between 5.0 and 10.9 inches in diameter, 82.6 percent of trees were from the top five species: Ashe juniper, live oak, honey mesquite, cedar elm, and black hickory. Dominant species in the largest diameter class were Ashe juniper, live oak, honey mesquite, cedar elm, and black willow, together representing 88.5 percent of live trees at least 11.0 inches in diameter.

In the combined city and ETJ, tree species composition on private land was dominated by Ashe juniper (32.0 percent), Texas persimmon (16.8 percent), and mescal bean (10.2 percent) (table 11). These same species were most common on public land, but in different percentages: Texas persimmon (28.6 percent), Ashe juniper (22.6 percent), and mescal bean (14.1 percent) (table 12). A total of 59 tree species were recorded on private land, with a [Shannon-Weiner diversity index](#) value of 2.3. Crews recorded 23 species

Table 11—Species composition on private land in San Antonio, 2018

Common name	City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Percent			
Ashe juniper	5.12	39.97	32.03
Texas persimmon	10.76	18.52	16.75
Mescal bean	0.53	13.05	10.20
Sugarberry	26.41	3.89	9.02
Honey mesquite	8.79	8.49	8.56
Cedar elm	8.32	5.60	6.22
Live oak	4.32	4.25	4.26
Bluewood	3.38	1.40	1.85
Sweet acacia	6.24	0.46	1.77
Loquat	5.44	0.00	1.24
Crapemyrtle	3.58	0.00	0.82
Ailanthus	3.07	0.00	0.70
Japanese privet	2.90	0.00	0.66
Catclaw acacia	0.00	0.71	0.55

Table 11—Species composition on private land in San Antonio, 2018 (continued)

Common name	City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Percent			
Chittamwood, gum bumelia	0.80	0.39	0.48
Texas sophora	0.74	0.39	0.47
Jerusalem thorn	0.79	0.34	0.44
Eastern baccharis	1.88	0.00	0.43
Havard oak	0.00	0.51	0.39
Black walnut	0.00	0.44	0.34
Velvet ash	1.11	0.03	0.28
Black hickory	0.00	0.32	0.24
Pecan	0.93	0.03	0.24
Chinaberry	0.93	0.02	0.23
Goldenrain tree	0.84	0.00	0.19
Lacey oak	0.00	0.22	0.17
Texas red oak	0.00	0.22	0.17
Citrus species	0.63	0.00	0.14
Callery pear	0.55	0.00	0.13
Texas walnut	0.00	0.12	0.10
Blackjack oak	0.00	0.12	0.09
Texas live oak	0.00	0.12	0.09
Buckley oak	0.20	0.03	0.07
Shumard oak	0.31	0.00	0.07
Post oak	0.00	0.07	0.06
Netleaf hackberry	0.00	0.06	0.05
Chinese tallowtree	0.19	0.00	0.04
Peach	0.00	0.05	0.04
Helecho gigante	0.00	0.05	0.04
Oriental arborvitae	0.14	0.00	0.03
Osage-orange	0.13	0.00	0.03
Queen sago	0.00	0.03	0.03
White mulberry	0.00	0.03	0.03
Southern magnolia	0.11	0.00	0.02
Black cherry	0.00	0.03	0.02
Mexican white oak	0.10	0.00	0.02

Table 11—Species composition on private land in San Antonio, 2018 (continued)

Common name	City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Percent			
Bur oak	0.10	0.00	0.02
Chinese pistache	0.09	0.00	0.02
Anacua knockaway	0.09	0.00	0.02
Glossy privet	0.00	0.02	0.02
Green ash	0.06	0.00	0.01
Durand oak	0.06	0.00	0.01
Western soapberry	0.06	0.00	0.01
Chinese parasol tree	0.05	0.00	0.01
Chinese elm	0.05	0.00	0.01
Apple species	0.05	0.00	0.01
Hackberry	0.04	0.00	0.01
Red mulberry	0.04	0.00	0.01
Chinese privet	0.04	0.00	0.01

of trees on public land, with a Shannon-Weiner diversity index value of 2.1. The top three genera found on both private and public land were *Juniperus*, *Diospyros*, and *Sophora* (fig. 8). Species composition by characteristics and FIA land-use classes is detailed in tables A1 and A2, respectively.

Private land in the city had a slightly different dominant species mix of sugarberry (26.4 percent), Texas persimmon (10.8 percent), honey mesquite (8.8 percent), and cedar elm (8.3 percent). A total of 42 tree species were recorded on private land in the city, with a Shannon-Weiner diversity index value of 2.7. Public land in the city were similar to what was present in the combined city and ETJ: Ashe juniper (23.1 percent), Texas persimmon (21.4 percent), and mescal bean (19.1 percent). On public land in the city of San Antonio, a total of 18 species were recorded, and they had a Shannon-Weiner diversity index value of 2.1.

In the ETJ, dominant tree species on private land were Ashe juniper (40.0 percent), Texas

Table 12—Species composition on public land in San Antonio, 2018

Common name	City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Percent			
Texas persimmon	21.44	41.59	28.61
Ashe juniper	23.10	21.67	22.59
Mescal bean	19.15	4.87	14.07
Cedar elm	9.44	9.45	9.44
Honey mesquite	4.87	6.58	5.48
Sugarberry	7.86	0.15	5.12
Sweet acacia	5.53	0.45	3.72
Live oak	3.59	2.69	3.27
Black hickory	0.00	5.34	1.90
Texas live oak	2.42	0.00	1.56
Bastard oak	0.00	3.41	1.21
Black willow	0.00	2.01	0.72
Chinaberry	0.55	0.77	0.63
Mexican buckeye	0.76	0.00	0.49
Bluewood	0.55	0.15	0.41
Crapemyrtle	0.38	0.44	0.40
Washington fan palm	0.13	0.00	0.08
Other palms	0.00	0.22	0.08
Chinese tallowtree	0.00	0.20	0.07
Bur oak	0.09	0.00	0.06
Western soapberry	0.05	0.00	0.03
Loquat	0.04	0.00	0.03
White mulberry	0.04	0.00	0.03

persimmon (18.5 percent), and mescal bean (13.0 percent). There were 33 species recorded on private land in the ETJ, and they had a Shannon-Weiner diversity index value of 1.9. Public ETJ land had 16 tree species recorded, and a Shannon-Weiner diversity index value of 1.8. The most common species in the ETJ were Texas persimmon (41.6 percent), Ashe juniper (21.7 percent), and cedar elm (9.5 percent).

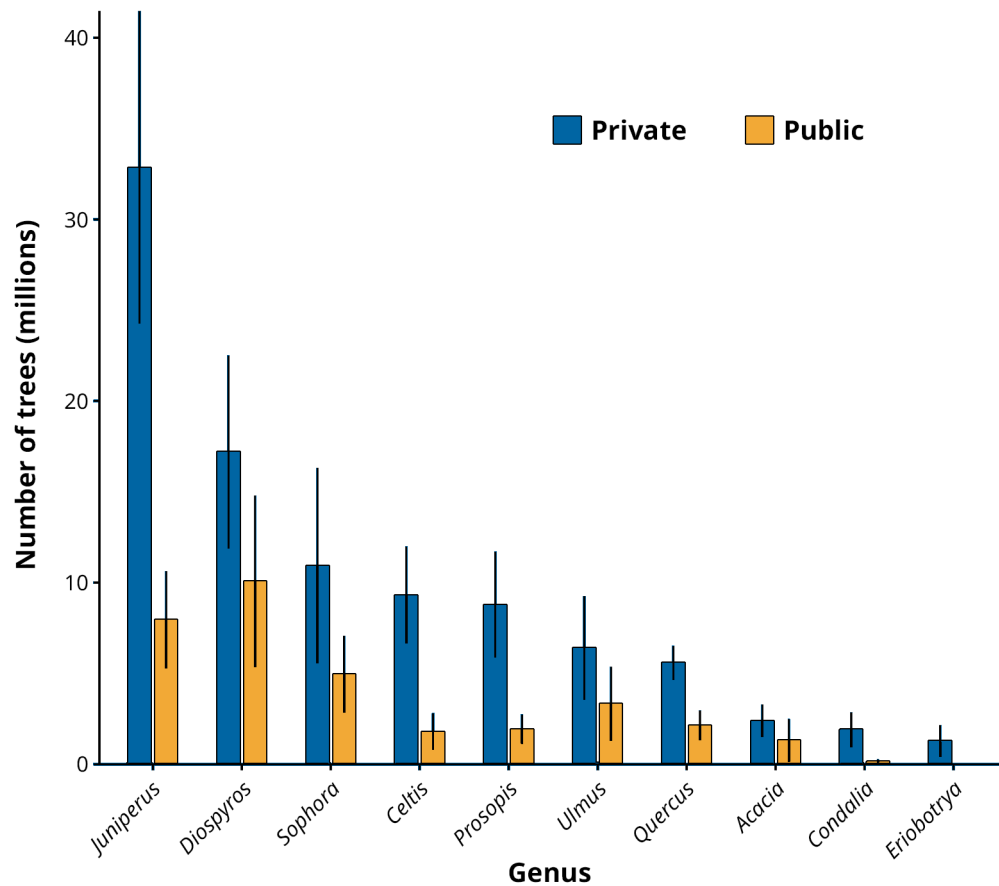


Figure 8—Number of trees by genus within ownership classes for the 10 most common genera, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

Maintained trees

In the combined city and ETJ of San Antonio, 9.7 percent of trees were classified as growing in maintained areas. Maintained areas are those which are regularly impacted by mowing, weeding, cutting, brush clearing, herbicide applications, and more. Examples of maintained areas include, but are not limited to, lawns, shrub and flower beds, rights-of-way, and manicured parks. However, a tree found in a maintained area has not necessarily received care. In the combined city and ETJ, the most common tree species in maintained areas were sugarberry (35.9 percent of the top 10 tree species), live oak (17.0 percent of the top 10), and loquat (11.0 percent of the top 10) (table 13).

As expected, in the city of San Antonio many more trees, 23.6 percent, were found in maintained areas. The most common species in maintained areas were sugarberry (42.7 percent of the top 10 tree species), loquat (13.6 percent of the top 10), crapemyrtle (9.8 percent of the top 10), and live oak (9.8 percent of the top 10).

Conversely, the ETJ only had 2.8 percent of trees recorded as growing in maintained areas. In the ETJ, the most common species found in maintained areas were live oak (47.4 percent of the top 10 tree species), Ashe juniper (20.9 percent of the top 10), and honey mesquite (19.7 percent of the top 10) (table 13). The complete listing of species composition in maintained areas of San Antonio is in table A3.

Table 13—Top 10 tree species in maintained areas by number of trees, San Antonio, 2018

Common name	City		Extraterritorial jurisdiction (ETJ)		Combined city and ETJ	
	Total number of trees	Percent	Total number of trees	Percent	Total number of trees	Percent
Sugarberry	4,014,370.9	42.7	157,886.0	7.1	4,172,256.9	35.9
Live oak	917,614.4	9.8	1,053,007.4	47.4	1,970,621.8	17.0
Loquat	1,282,330.9	13.6	0.0	0.0	1,282,330.9	11.0
Crapemyrtle	924,447.8	9.8	55,132.5	2.5	979,580.3	8.4
Honey mesquite	354,662.2	3.8	437,098.6	19.7	791,760.8	6.8
Ailanthus	717,279.8	7.6	0.0	0.0	717,279.8	6.2
Japanese privet	597,039.7	6.4	0.0	0.0	597,039.7	5.1
Ashe juniper	113,447.0	1.2	463,365.0	20.9	576,812.0	5.0
Velvet ash	259,977.6	2.8	27,566.3	1.2	287,543.9	2.5
Pecan	217,454.5	2.3	27,566.3	1.2	245,020.7	2.1
Totals	9,398,624.7	100.0	2,221,622.1	100.0	11,620,246.8	100.0

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



Sycamore trees growing in a San Antonio urban park.

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. The percentage of total leaf area in the combined city and ETJ's urban forest was greatest for trees 1.0–5.0 inches in diameter (18.0 percent), followed by 9.1–11.0 inches in diameter (13.7 percent), and 7.1–9.0 inches in diameter (13.4 percent) (fig. 9). In San Antonio, leaf area was greatest on forest land (64.5 percent of total leaf area), followed by residential (25.5 percent), and commercial/industrial land (4.3 percent) (fig. 10).

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. Because 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 LAI on land with live trees ranged from 7.7 in rights-of-way to 3.3 on rangeland/chapparral (fig. 10).

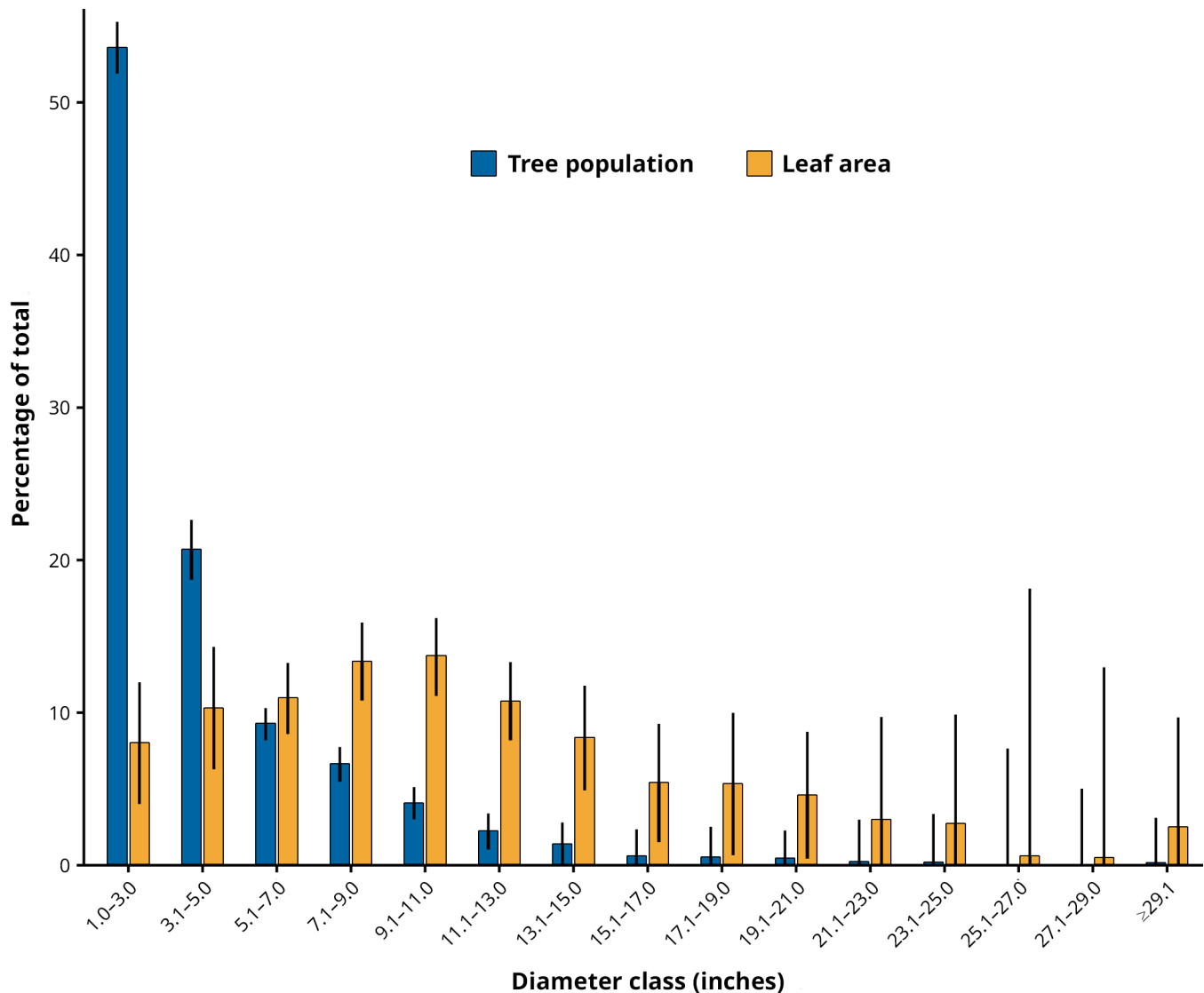


Figure 9—Percentage of tree population and leaf area by 2-inch diameter class, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

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 Antonio's combined city and ETJ with the greatest IVs were Ashe juniper (53.8), Texas persimmon (23.4), and live oak (21.0) (table 14). In the city, sugarberry took over as the species with highest IV (36.5), followed by Ashe juniper (25.3), and live oak (20.4), whereas in the ETJ Ashe juniper had an even more striking IV of 70.7, followed Texas persimmon (26.3), and live oak (21.4) (table 14).

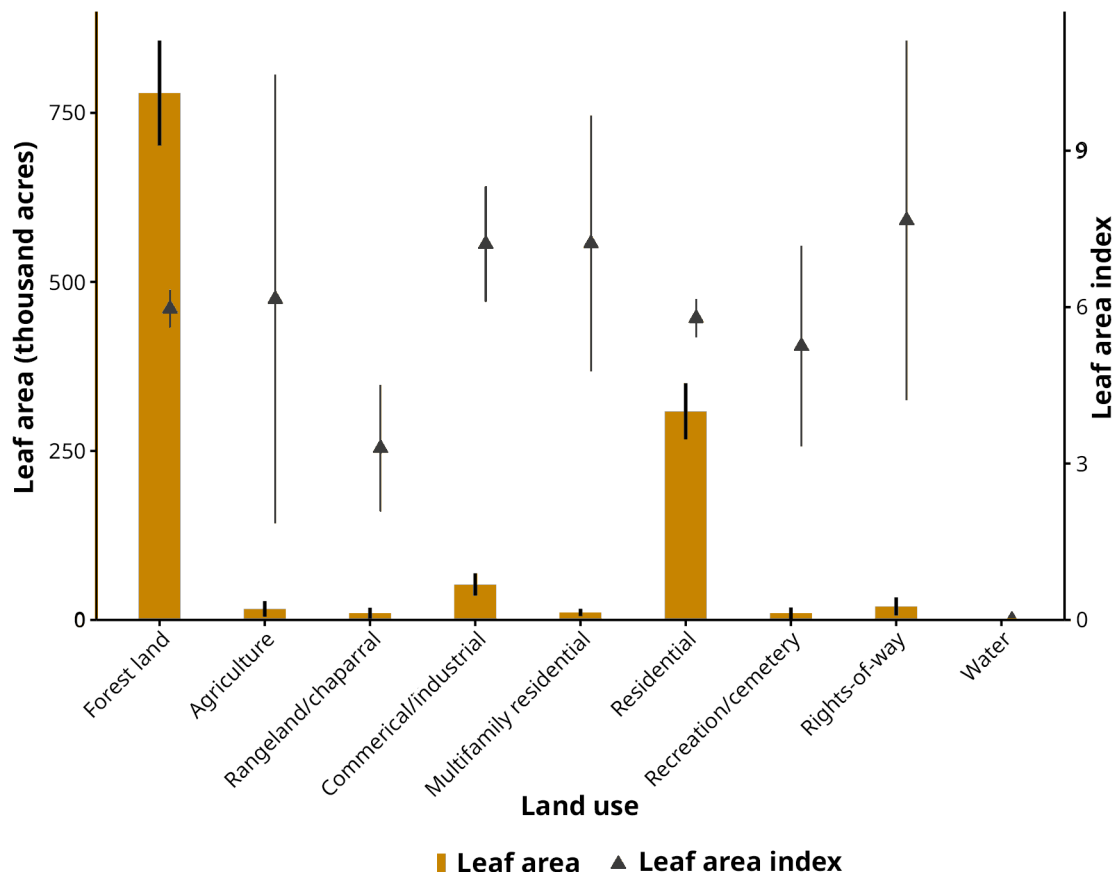


Figure 10—Leaf area and leaf area index by Forest Inventory and Analysis land-use class, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

VOLUME AND BIOMASS

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 bulletin is presented in the *Additional sampling and estimation details for urban forest inventory and analysis reports (version 1)* (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 postdisaster recovery, including debris removal and cost (i.e., cubic volume). 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 previously discarded wood into traditional wood products such as lumber, handcrafted furniture, nature-based landscape supplies, and biofuel (e.g., Nowak and Aevermann 2019).

In the combined city and ETJ of San Antonio, live trees at least 5.0 inches in diameter were estimated to contain 206.4 million cubic feet of net volume and over 1.7 million net board feet of sawtimber volume (tables 15, 16). To put this value in perspective, the median size of American homes constructed in 2019 was 2,301 square feet (U.S. 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.

Table 14—Importance values of the 10 most common tree species, San Antonio, 2018

	Common name	Percentage of the population	Percentage of the total leaf area	Importance value
City	Sugarberry	17.3	19.3	36.5
	Ashe juniper	14.0	11.3	25.3
	Live oak	4.0	16.4	20.4
	Texas persimmon	16.0	2.1	18.2
	Cedar elm	8.9	8.5	17.4
	Honey mesquite	6.9	9.3	16.1
	Mescal bean	9.7	1.0	10.7
	Sweet acacia	5.9	2.6	8.5
	Pecan	0.5	4.6	5.1
	Crapemyrtle	2.0	2.9	4.9
Extraterritorial jurisdiction (ETJ)	Ashe juniper	37.5	33.3	70.7
	Texas persimmon	21.7	4.6	26.3
	Live oak	4.0	17.3	21.4
	Honey mesquite	8.2	10.2	18.4
	Cedar elm	6.1	9.4	15.6
	Mescal bean	11.9	2.0	13.9
	Sugarberry	3.4	6.5	9.9
	Black hickory	1.0	3.2	4.2
	Black willow	0.3	2.1	2.4
	Bluewood	1.2	0.8	2.1
Combined city and ETJ	Ashe juniper	29.6	24.1	53.8
	Texas persimmon	19.8	3.6	23.4
	Live oak	4.0	17.0	21.0
	Sugarberry	8.0	11.8	20.9
	Honey mesquite	7.8	9.8	17.6
	Cedar elm	7.0	9.0	16.1
	Mescal bean	11.2	1.6	12.8
	Sweet acacia	2.3	1.5	3.8
	Black hickory	0.7	1.9	2.6
	Bluewood	1.5	1.0	2.4

Importance value = population (%) + leaf area (%).

SAN ANTONIO'S URBAN FOREST, 2018

Table 15—Net volume for tree species with greatest net volume, San Antonio, 2018

	Common name	Volume (cubic feet)	Percent
City	Live oak	16,987,267.3	20.3
	Ashe juniper	15,145,700.3	18.1
	Honey mesquite	12,422,681.1	14.9
	Sugarberry	8,014,444.3	9.6
	Pecan	6,820,272.3	8.2
	Cedar elm	4,635,720.1	5.5
	Velvet ash	4,371,772.7	5.2
	Crapemyrtle	2,277,964.0	2.7
	Chinaberry	2,146,306.4	2.6
	Japanese privet	1,317,219.2	1.6
	Other species	9,498,927.7	11.4
	Total	83,638,275.2	100.0
Extraterritorial jurisdiction (ETJ)	Ashe juniper	50,179,214.0	40.9
	Live oak	23,070,638.9	18.8
	Honey mesquite	20,721,718.1	16.9
	Cedar elm	8,297,105.0	6.8
	Black willow	4,456,570.4	3.6
	Black hickory	2,561,316.2	2.1
	Sugarberry	2,547,961.9	2.1
	Blackjack oak	1,779,452.0	1.4
	Lacey oak	1,506,253.9	1.2
	Post oak	1,293,726.4	1.1
	Other species	6,327,071.4	5.2
	Total	122,741,028.1	100.0
Combined city and ETJ	Ashe juniper	65,324,914.2	31.7
	Live oak	40,057,906.2	19.4
	Honey mesquite	33,144,399.1	16.1
	Cedar elm	12,932,825.0	6.3
	Sugarberry	10,562,406.2	5.1
	Pecan	6,976,390.2	3.4
	Velvet ash	4,584,470.4	2.2
	Black willow	4,456,570.4	2.2
	Black hickory	2,561,316.2	1.2
	Chinaberry	2,547,137.7	1.2
	Other species	23,230,967.6	11.3
	Total	206,379,303.3	100.0

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

Table 16—Net sawtimber volume for tree species with greatest net volume, San Antonio, 2018

	Common name	Volume (board feet)	Percent
City	Cedar elm	1,738,203.6	100.0
	Other species	0.0	0.0
	Total	1,738,203.6	100.0
Extraterritorial jurisdiction (ETJ)	Other species	0.0	0.0
	Total	0.0	0.0
Combined city and ETJ	Cedar elm	1,738,203.6	100.0
	Other species	0.0	0.0
	Total	1,738,203.6	100.0

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

Thus, the net sawtimber volume of the combined city and ETJ's urban forest is roughly equivalent to the amount of wood that would be needed to construct 117 median-sized homes. The tree species found in the San Antonio area, though, do not produce wood appropriate for construction. Ashe juniper, most commonly used for fencing, fuelwood, and smaller woodenware items, contributed the greatest net cubic-foot volume at 31.7 percent of the combined city and ETJ (table 15). Cedar elm, a species used for furniture, containers, fencing and veneer, contributed 100 percent of the total net board-foot sawtimber volume (table 16). By diameter class, the greatest net cubic-foot volume was provided by trees 9.1–11.0 inches in diameter (fig. 11).

Though sawtimber could potentially be derived from urban forests to provide economic value, the broader social-ecological value of this forest is derived from ecosystem services provided by healthy trees. Across the United States, 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 would reduce these local annual benefits. Utilizing urban wood waste, however, does not affect the healthy tree canopy and augments the value of the urban

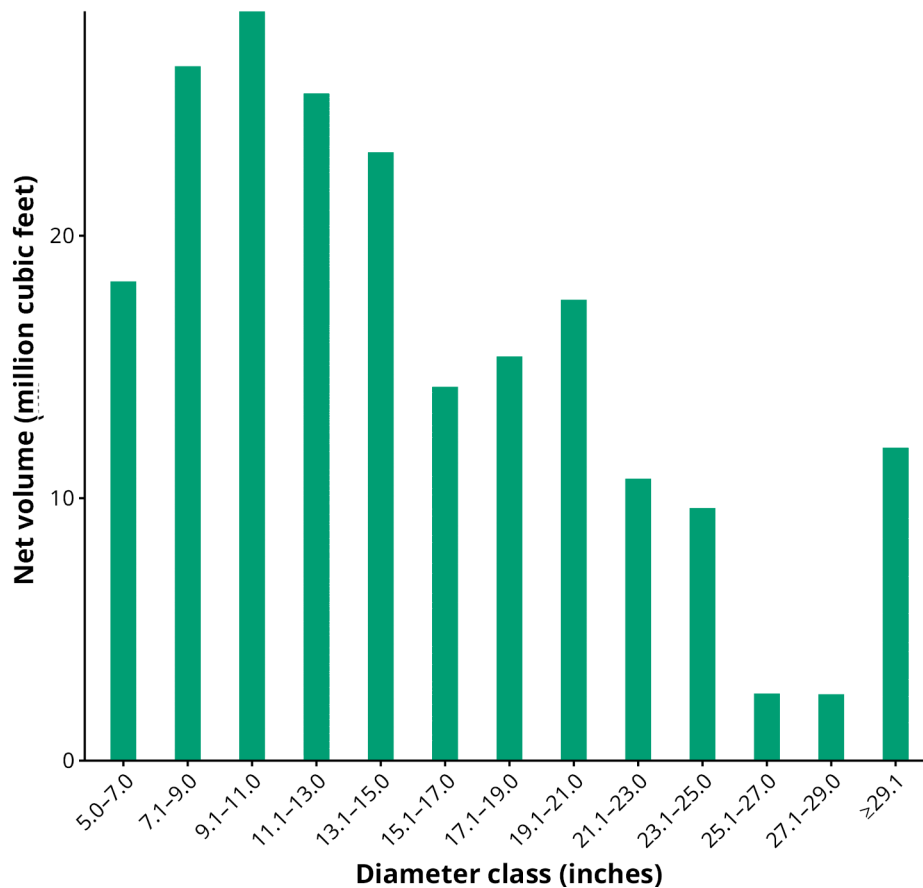


Figure 11—Net volume by tree diameter class, San Antonio, 2018.

forest. Urban wood waste could produce between \$89 million and \$786 million per year nationally depending upon the product derived (e.g., wood chips to lumber) (Nowak and Aevermann 2019).

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 the combined city and ETJ was estimated at 8.7 million green tons (table 17). The amount of biomass stored by live trees varied by species. The tree species with the greatest total aboveground biomass were live oak (25.8 percent), Ashe juniper (17.9 percent), and honey mesquite (12.1 percent) (table 17).



Texas persimmon (*Diospyros texana*) is a small, multistemmed tree commonly found in the San Antonio area. (Photo courtesy of Jonathan Motsinger, Texas A&M Forest Service)

Table 17—Aboveground biomass of tree species with the greatest biomass, San Antonio, 2018

	Common name	Biomass (green tons)	Percent
City	Live oak	934,678.8	25.6
	Sugarberry	415,261.4	11.4
	Honey mesquite	385,403.2	10.6
	Ashe juniper	319,058.2	8.7
	Pecan	300,058.2	8.2
	Cedar elm	259,411.7	7.1
	Velvet ash	162,705.8	4.5
	Chinaberry	102,578.3	2.8
	Sweet acacia	81,478.9	2.2
	Crapemyrtle	80,135.5	2.2
	Other species	608,060.9	16.7
	Total	3,648,831.0	100.0
Extraterritorial jurisdiction (ETJ)	Live oak	1,300,660.5	25.9
	Ashe juniper	1,236,321.4	24.6
	Honey mesquite	666,286.5	13.3
	Cedar elm	423,321.6	8.4
	Texas persimmon	237,206.9	4.7
	Black willow	175,171.1	3.5
	Mescal bean	157,551.5	3.1
	Sugarberry	156,673.6	3.1
	Black hickory	141,863.9	2.8
	Blackjack oak	86,867.9	1.7
	Other species	446,062.3	8.9
	Total	5,027,987.3	100.0
Combined city and ETJ	Live oak	2,235,339.4	25.8
	Ashe juniper	1,555,379.6	17.9
	Honey mesquite	1,051,689.7	12.1
	Cedar elm	682,733.3	7.9
	Sugarberry	571,935.0	6.6
	Pecan	307,862.2	3.5
	Texas persimmon	277,353.1	3.2
	Mescal bean	221,134.7	2.5
	Black willow	175,171.1	2.0
	Velvet ash	171,722.1	2.0
	Other species	1,426,498.0	16.4
	Total	8,676,818.3	100.0

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

URBAN FOREST VALUES

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. San Antonio's urban forest may provide many other functional values that are not quantified in this bulletin (e.g., reduction in ultraviolet radiation, wildlife habitat, enhanced recreational opportunities, fostering social cohesion, and community health and well-being). Thus, the functional estimates provided in this bulletin represent only a portion of the total forest functional value. 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 with increased number and size of healthy trees 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 (McPherson et al. 2005).

Urban forest ecosystem services associated with air pollution removal, avoided runoff, carbon sequestration, and compensatory value exclude dead trees, because 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.



The urban forests and green spaces of San Antonio provide a pleasant environment in which to live. They also sequester carbon, mitigate temperatures, help retain storm water, and provide other ecosystem services.

Air pollution removal

Poor air quality is a common problem in urban areas. Air pollution can adversely affect human health through increased 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. Though 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 Antonio was greatest for O_3 (5,374.6 tons per year), followed by nitrogen dioxide (NO_2 , 696.5 tons per year), particulate matter <2.5 microns ($PM_{2.5}$, 195.4 tons per year), sulfur dioxide (SO_2 , 173.1 tons per year), and carbon monoxide (CO, 125.8 tons per year) (fig. 12). The estimated value associated with pollution removal was greatest for $PM_{2.5}$ (\$41.1 million), followed by O_3 (\$21.6 million), NO_2 (\$487,508), CO (\$166,939), and SO_2 (\$31,236).

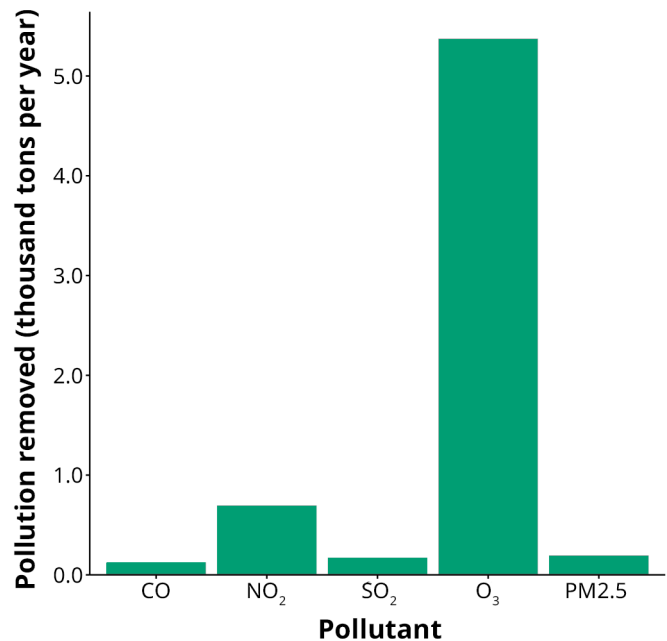


Figure 12—Air pollution removal in the combined city and extraterritorial jurisdiction's urban forest, San Antonio, 2018.

Reduction in the concentration of various air pollutants due to removal by trees is expected to have a positive effect on human health in San Antonio (EPA 2012, Nowak et al. 2014). The estimated economic value of pollution removal is based on avoided health effects due to lower pollution concentrations. By using measured field data and pollution data from 2015, air quality improvements from trees resulted in numerous health effects including an estimated 7,790 fewer cases of acute respiratory symptoms per year with an associated annual value of over \$675,928 (table 18).

Trees in San Antonio and its ETJ emitted an estimated 12,961.8 tons of VOCs (11,056.3 tons of isoprene and 1,905.5 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. Oaks and junipers contributed most of the VOC emissions (fig. 13). These VOCs are precursor chemicals to ozone formation.

SAN ANTONIO'S URBAN FOREST, 2018

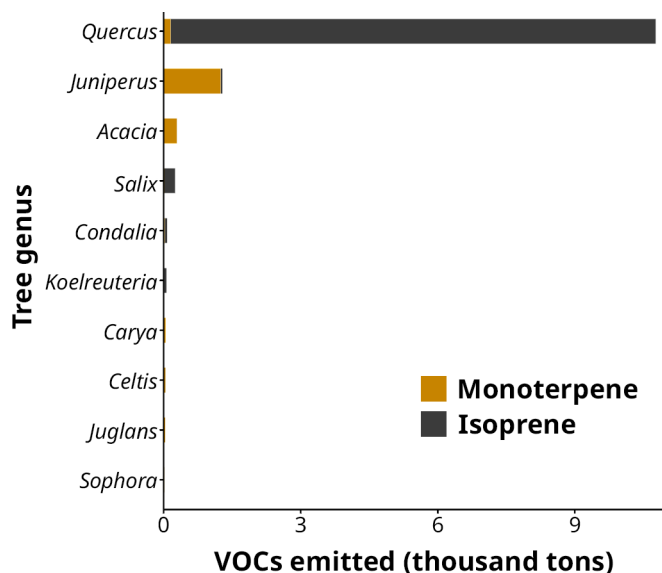
Table 18—Associated value and incidence of avoided health effects from changes in pollution concentrations due to pollution removal by trees in San Antonio's urban forest

Health factor	NO ₂		SO ₂		O ₃		PM2.5		Total	
	Value	Incidence	Value	Incidence	Value	Incidence	Value	Incidence	Value	Incidence
	<i>dollars per year</i>	<i>cases per year</i>	<i>dollars per year</i>	<i>cases per year</i>	<i>dollars per year</i>	<i>cases per year</i>	<i>dollars per year</i>	<i>cases per year</i>	<i>dollars per year</i>	<i>cases per year</i>
Acute bronchitis	—	—	—	—	—	—	366.0	4.2	366.0	4.2
Acute myocardial infarction	—	—	—	—	—	—	90,828.8	1.0	90,828.8	1.0
Acute respiratory symptoms	7,612.6	241.1	631.5	20.0	479,297.3	5,606.6	188,386.9	1,922.0	675,928.3	7,789.6
Asthma exacerbation	305,348.0	3,642.6	13,696.7	174.0	—	—	148,809.7	1,830.6	467,854.4	5,647.2
Chronic bronchitis	—	—	—	—	—	—	427,407.1	1.5	427,407.1	1.5
Emergency room visits	1,211.8	2.9	286.8	0.7	1,221.9	2.9	1,059.0	2.6	3,779.4	9.1
Hospital admissions	173,335.2	5.9	16,620.6	0.5	187,433.3	6.2	—	—	377,389.0	12.6
Hospital admissions, cardiovascular	—	—	—	—	—	—	21,856.6	0.6	21,856.6	0.6
Hospital admissions, respiratory	—	—	—	—	—	—	11,461.7	0.4	11,461.7	0.4
Lower respiratory symptoms	—	—	—	—	—	—	2,748.2	52.9	2,748.2	52.9
Mortality	—	—	—	—	20,684,283.0	2.7	40,149,090.2	5.2	60,833,373.2	7.8
School loss days	—	—	—	—	262,432.2	2,672.7	—	—	262,432.2	2,672.7
Upper respiratory symptoms	—	—	—	—	—	—	1,778.4	39.6	1,778.4	39.6
Work loss days	—	—	—	—	—	—	45,779.1	324.7	45,779.1	324.7
Total	487,507.6	3,892.5	31,235.5	195.2	21,614,667.6	8,291.1	41,089,571.6	4,185.1	63,222,982.4	16,563.8

— = value is not estimated for that pollutant and health effect. The same health effects were not analyzed for each pollutant.

2015 atmospheric conditions were used for pollution removal calculations.

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



San Antonio's tree cover helps to remove pollutants from the air and mitigate increased temperatures in developed urban areas, reducing the formation of urban heat islands.

Figure 13—Volatile organic compounds (VOCs) emissions by tree genus, San Antonio, 2018.

Avoided runoff

Surface water runoff (commonly referred to as surface runoff or stormwater runoff) can contribute pollution to 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 and speed of surface runoff, contributing to flooding.

Urban trees can reduce surface runoff. Tree canopies intercept precipitation, and 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 the combined city and ETJ were estimated to reduce runoff by 381.7 million cubic feet per year (2.9 billion gallons annually), with an estimated value of \$25.5 million per year based on a national average cost of stormwater control and treatment of \$0.008936 per gallon (Nowak 2021, Baer et al. 2024: estimation of urban forest effects, avoided runoff subsection). The majority of this avoided runoff was attributable to interception by tree canopies. Tree species with the greatest overall impact on runoff were Ashe juniper, sugarberry, and live oak because of their large leaf surface area (fig. 14).

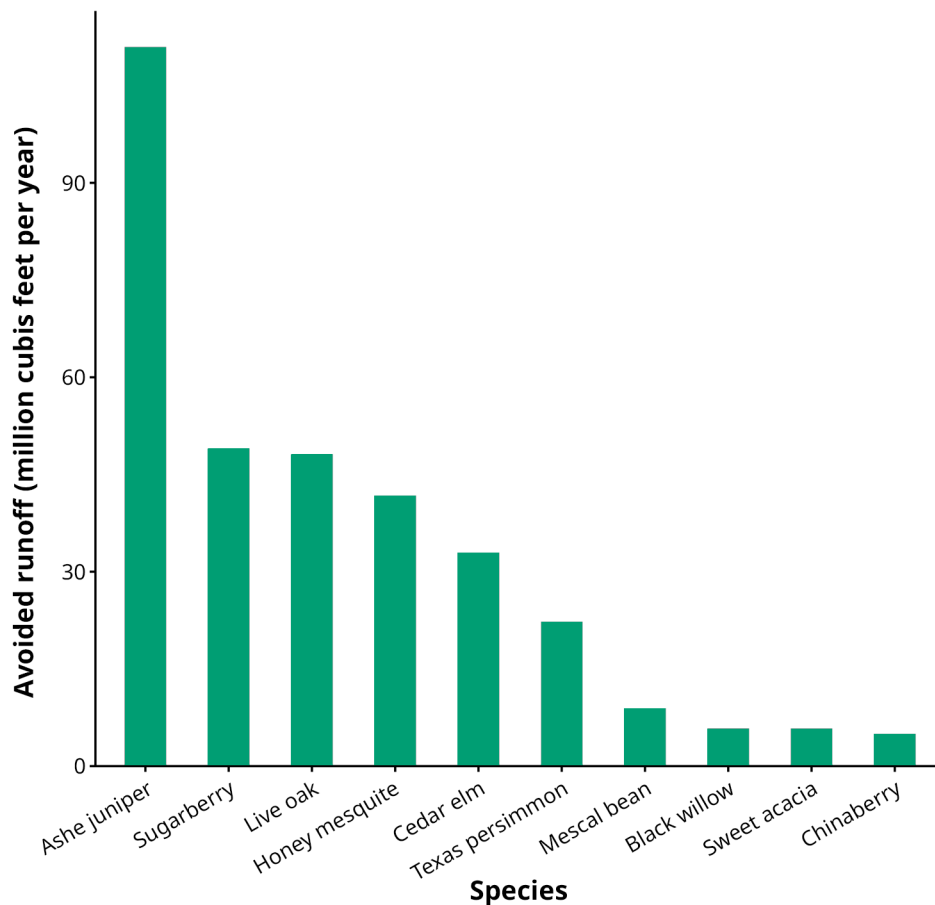


Figure 14—Avoided runoff for the 10 tree species with the greatest leaf area, San Antonio, 2018.



Urban trees and green spaces increase stormwater retention and dampen the potentially negative effects of extreme rainfall events.

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 azimuth to space-conditioned residential buildings (McPherson and Simpson 1999, Nowak 2021, Nowak et al. 2008).

In San Antonio, interactions between buildings and trees ≥ 5.0 inches in diameter were projected to annually decrease energy requirements by 320,635.8 gigajoules during the heating and cooling seasons (an energy equivalent of 6.1 million gallons of oil) (table 19), with an annual savings in energy costs of \$22.4 million based on average energy costs in 2012 (table 20). Savings in residential energy costs were calculated based on State average 2012 costs for natural gas (EIA 2014b), 2012/2013 heating season fuel oil costs (EIA 2014c), 2012 residential electricity costs (EIA 2012a, b), and 2012 costs of wood (EIA 2014a). Trees in the urban forest also were estimated to reduce carbon dioxide (CO₂) emissions from fossil fuel-based power sources by 117,773.9 tons annually (32,120.1 tons of carbon, \$5.5 million), equivalent to the burning of over 117.7 million pounds of coal or roughly 247,363 barrels of oil (EPA 2020, Hong and Slatick 1994).

Table 19—Annual energy savings and avoided carbon emissions due to trees ≥ 5 inches in diameter near residential buildings, San Antonio, 2018

Energy use	City		Extraterritorial jurisdiction (ETJ)		Combined city and ETJ	
	Gigajoules	Avoided tons of carbon	Gigajoules	Avoided tons of carbon	Gigajoules	Avoided tons of carbon
Cooling	796,787.5	40,082.5	143,945.2	7,241.2	940,732.7	47,323.7
Heating	-616,138.9	-15,154.7	-3,958.0	-48.9	-620,096.9	-15,203.6
Total	180,648.6	24,927.8	139,987.2	7,192.3	320,635.8	32,120.1

GJ = gigajoule (one billion [10⁹] joules).

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

Negative values indicate an increase in energy requirements.

To convert carbon estimates to CO₂, multiply carbon value by 3.667.

Table 20—Annual monetary savings due to trees ≥ 5 inches in diameter near residential buildings during heating and cooling seasons, San Antonio, 2018

City		Extraterritorial jurisdiction (ETJ)		Combined city and ETJ	
Energy effects savings	Carbon emissions avoided savings	Energy effects savings	Carbon emissions avoided savings	Energy effects savings	Carbon emissions avoided savings
\$17,520,010.86	\$4,251,455.95	\$4,890,541.32	\$1,226,658.32	\$22,410,552.17	\$5,478,114.26

Based on 2012 statewide energy costs (EIA 2012a, b; 2014b, c) and 2015 social cost of carbon (EPA 2015, Interagency Working Group 2013).



The shade from urban trees can help reduce the cost of cooling residential buildings.

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 (IPCC 2014). Reduction in the amount of energy required to heat or cool residential buildings described in the energy conservation section of this bulletin lead to reduced CO₂ 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 CO₂) and storing carbon in their accumulated tissue (i.e., biomass). Although FIA volume and biomass models use species specific calculations, it is generally accepted that approximately half of the biomass in a tree is carbon (Westfall et al. 2023).

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. 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 Antonio stored an estimated 3.5 million tons of carbon (12.8 million tons of CO₂) valued at \$594.4 million (table 21). Tree carbon values are based on the 2015 estimated social costs of carbon (\$170.60 per ton of carbon) (Interagency Working Group on Social Cost of Carbon 2013, IPCC 2014). The social cost of carbon is a monetary value that encompasses the economic impact of increased carbon emissions on factors such as agricultural productivity, human health, and property damage.

Carbon storage varied across the sample area (fig. 15), among land-use classes, and by species. The species that stored the most carbon were live oak, Ashe juniper, and honey mesquite (fig. 16).

Looking at all trees in the combined city and ETJ, trees with diameters of 9.1 to 11.0 inches stored the greatest amount of carbon in San Antonio, followed closely by those of 3.1 to 5.0 inches (fig. 17). Larger trees store more carbon per tree due to their greater size. Accordingly, trees with diameters of 25.1 to 27.0 inches stored the greatest amount of carbon on a per tree basis (fig. 18).

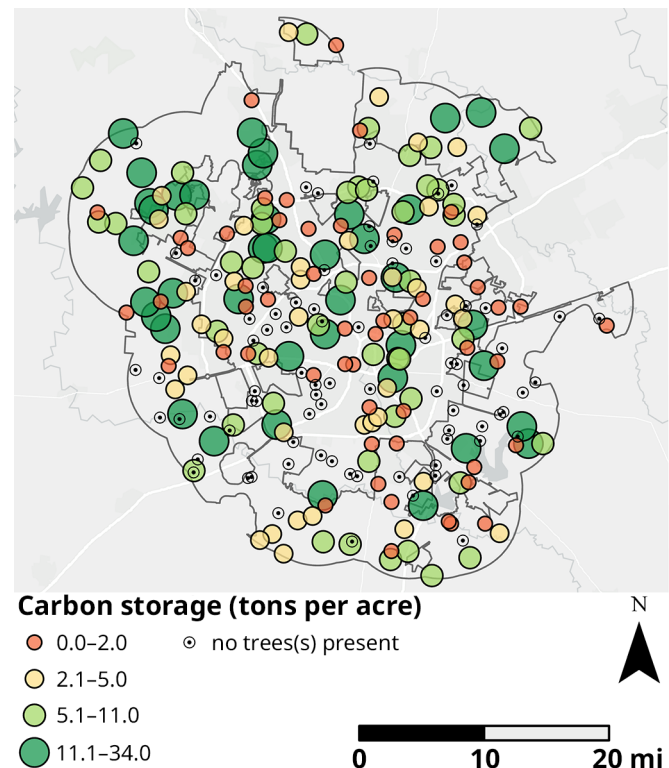


Figure 15—Carbon storage per acre by plot, San Antonio, 2018.

Table 21—Carbon in live and standing dead trees by Forest Inventory and Analysis land-use class, San Antonio, 2018

Land use	City				Extraterritorial jurisdiction (ETJ)				Combined city and ETJ			
	Aboveground live	Belowground live	Standing dead	Total number of trees	Aboveground live	Belowground live	Standing dead	Total number of trees	Aboveground live	Belowground live	Standing dead	Total number of trees
<i>tons</i>												
Agriculture	593.9	115.4	0.0	709.3	28,243.1	5,660.0	2,359.0	36,262.1	28,837.0	5,775.4	2,359.0	36,971.4
Commercial/ industrial	102,323.5	19,854.3	2,006.4	124,184.1	2,366.8	462.9	0.0	2,829.7	104,690.3	20,317.2	2,006.4	127,013.8
Forest	435,643.5	90,308.3	17,254.2	543,206.1	1,298,038.2	272,045.5	51,547.4	1,621,631.1	1,733,681.7	362,353.8	68,801.6	2,164,837.2
Multifamily residential	18,804.6	3,625.8	0.0	22,430.4	4,475.1	863.7	0.0	5,338.7	23,279.6	4,489.5	0.0	27,769.1
Rangeland/ chaparral	0.0	0.0	0.0	0.0	34,095.0	6,495.2	0.0	40,590.2	34,095.0	6,495.2	0.0	40,590.2
Recreation/ cemetery	16,576.4	3,228.4	0.0	19,804.8	0.0	0.0	0.0	0.0	16,576.4	3,228.4	0.0	19,804.8
Residential	550,490.1	106,749.3	3,536.0	660,775.5	292,072.3	57,670.5	10,523.0	360,265.8	842,562.5	164,419.8	14,059.0	1,021,041.2
Rights-of- way	39,026.1	7,594.2	2,021.6	48,641.9	990.7	193.6	0.0	1,184.3	40,016.9	7,787.8	2,021.6	49,826.3
Total	1,163,458.1	231,475.7	24,818.2	1,419,752.1	1,660,281.3	343,391.3	64,429.4	2,068,102.1	2,823,739.4	574,867.1	89,247.6	3,487,854.1

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

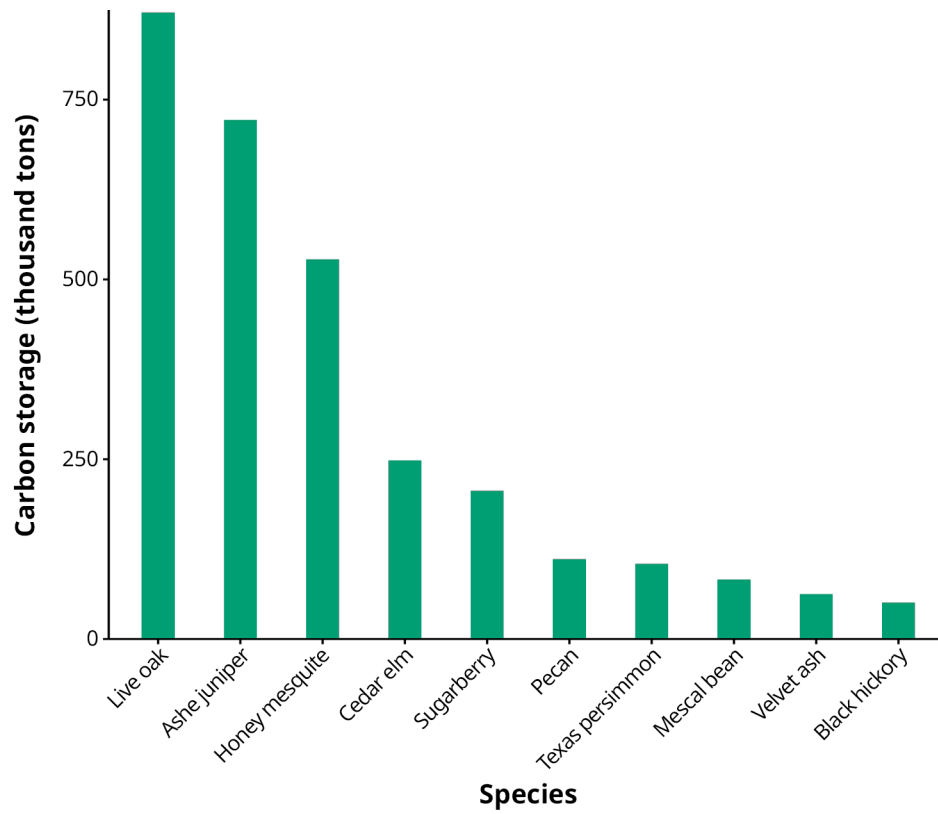


Figure 16—Carbon storage for 10 tree species with the greatest amount of carbon storage, San Antonio, 2018.

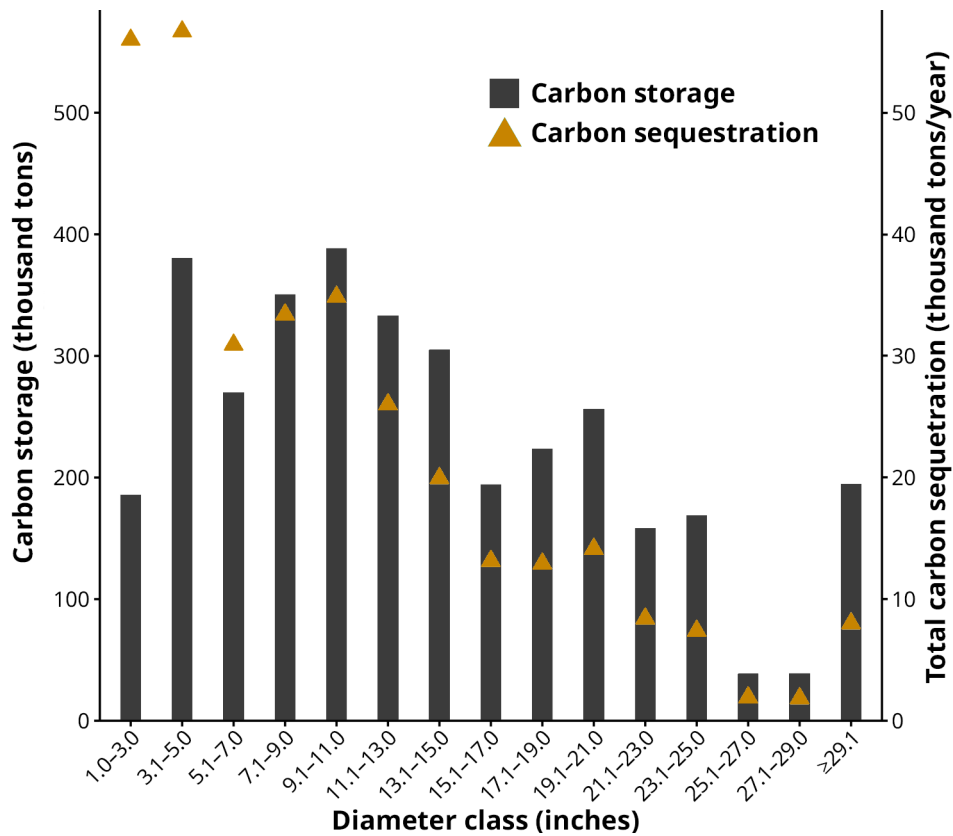


Figure 17—Total carbon storage and sequestration by diameter class, San Antonio, 2018.

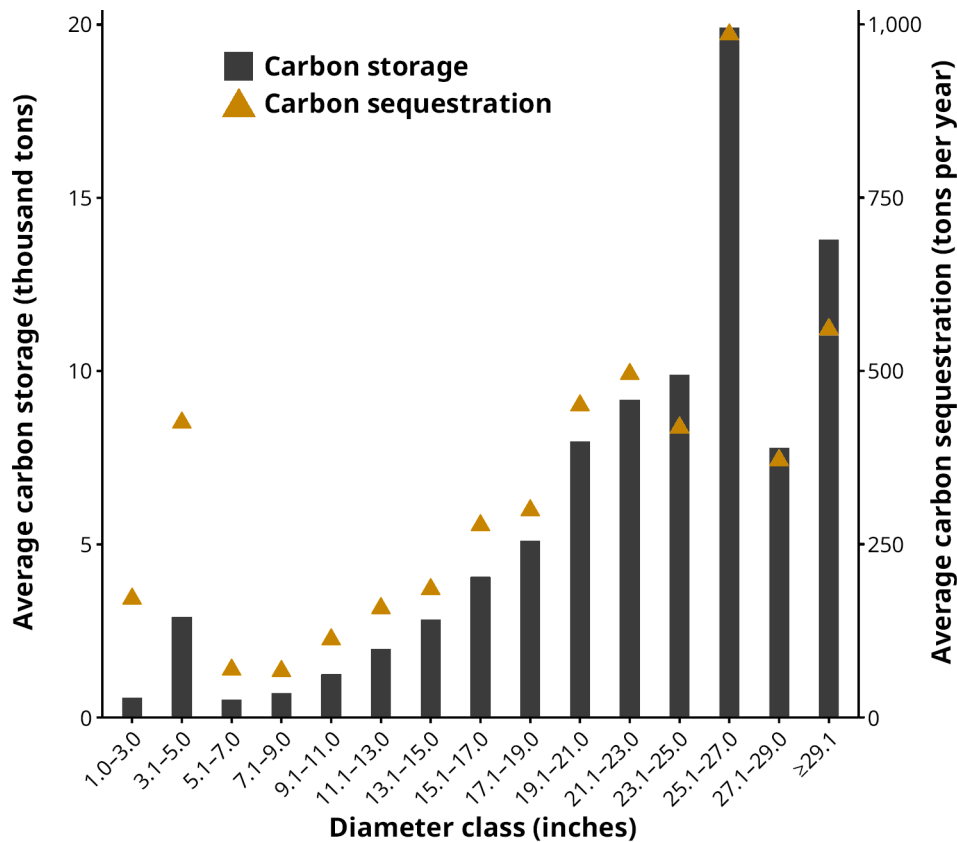


Figure 18—Average per tree carbon storage and sequestration by diameter class, San Antonio, 2018.

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 Antonio (combined city and ETJ) was about 320,059 tons of carbon per year (1.2 million tons per year of CO₂) with an associated value of \$54.5 million per year, which is roughly equivalent to the annual emissions associated with 253,383 passenger vehicles or energy usage by 138,837 homes (EPA 2020). Ashe juniper was estimated to sequester the most carbon of all species in the urban forest (73,309 tons per year; 22.6 percent of all sequestered carbon) (fig. 19). Estimates of carbon storage and sequestration in developed and undeveloped land-use classes, 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.

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 (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

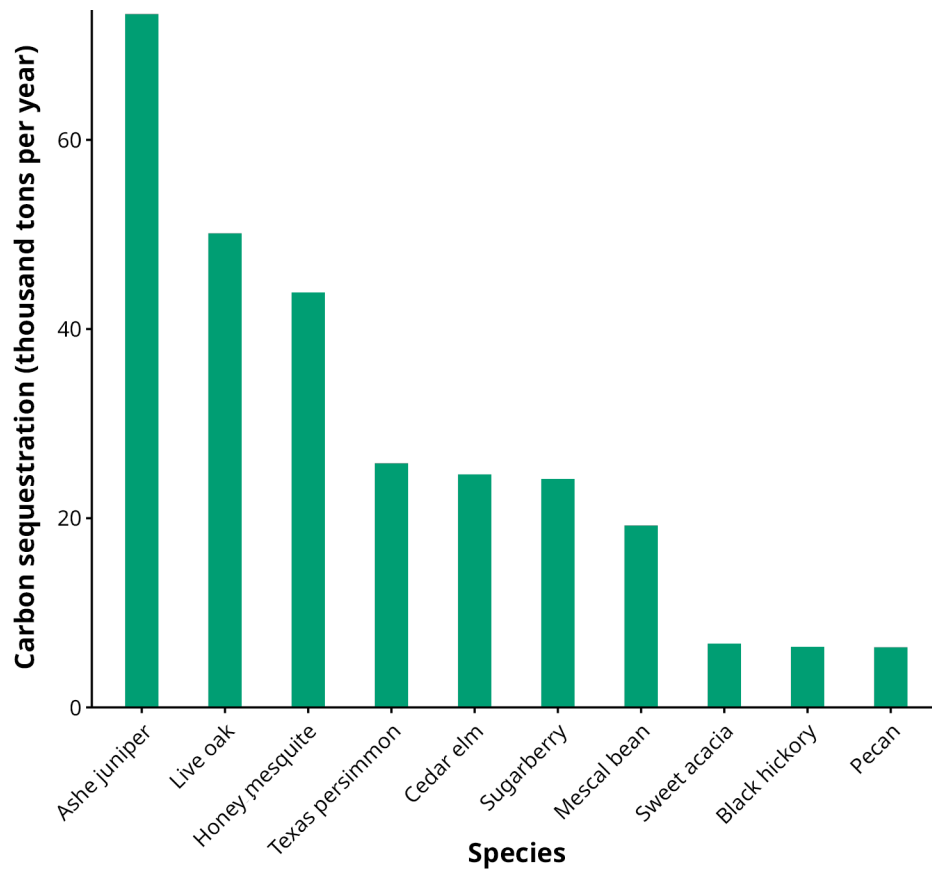


Figure 19—Annual carbon sequestration for the 10 tree species with the greatest amount of carbon storage, San Antonio, 2018.

the species is native, nonnative, or invasive. Additionally, invasive species still contribute ecosystem services.

The compensatory value of the trees in the combined city and ETJ was estimated to be about \$33.1 billion (\$15.9 billion in the city and \$17.3 billion in the ETJ). This compensatory value is a function of the number, health, diameter, and species of all trees measured, as well as the land-use class where they occurred. The species with the largest compensatory values were Ashe juniper, live oak, and honey mesquite (fig. 20). The mean compensatory value per acre for the combined city and ETJ was \$47,318; for the 68.9 percent of these plots that contained trees, the mean compensatory value per acre was \$67,700 (fig. 21). In the city of San Antonio, the mean compensatory value per acre for those plots that contained trees was \$76,744; in the ETJ it was

\$60,434. However, when considering only sample plots with the highest compensatory value (in the upper quartile), within the combined city and ETJ, the per acre compensatory value exceeded \$103,000. The structural value of urban trees in San Antonio and its ETJ was a combination of their compensatory value (estimated at \$33.1 billion) and the value associated with carbon storage by the trees (estimated at \$8.0 million).

URBAN FOREST HEALTH

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 Antonio. Detailed methods of invasive species as indicators of urban forest health metrics are

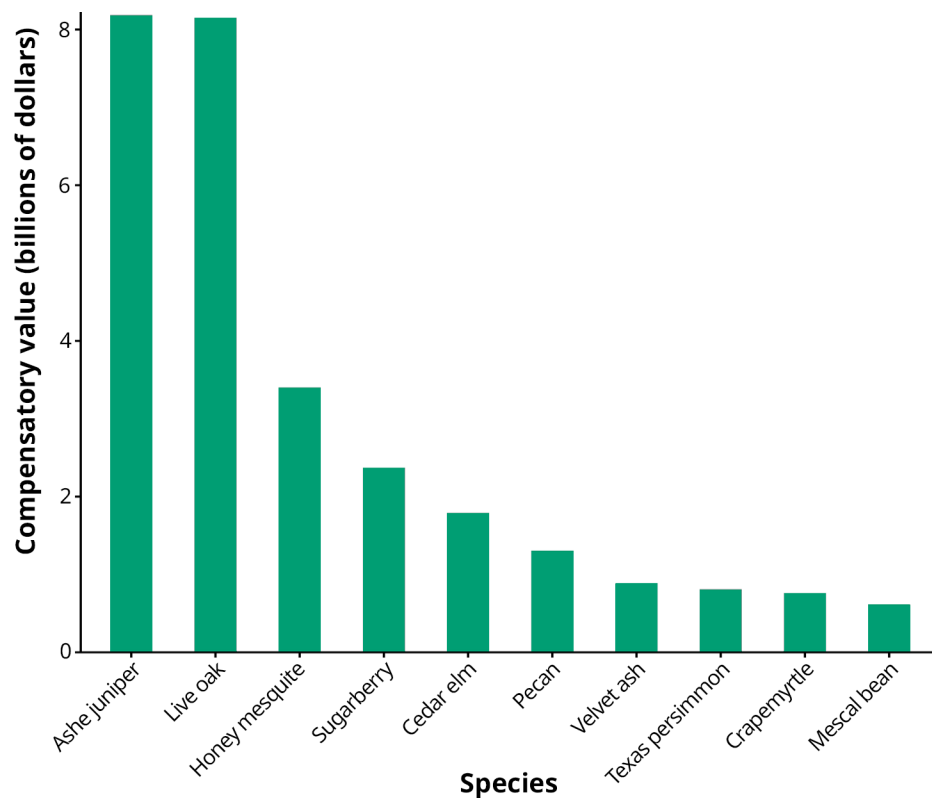


Figure 20—Compensatory value by tree species, San Antonio, 2018.

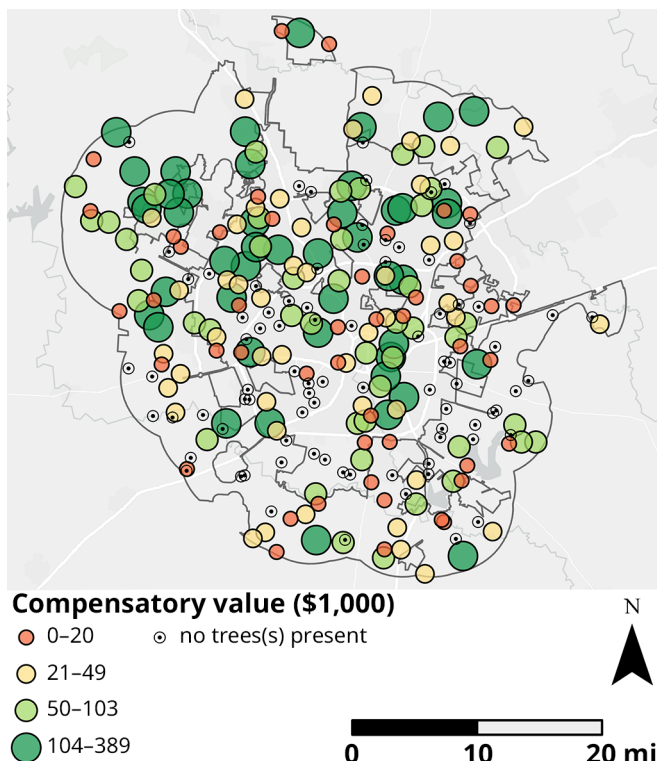


Figure 21—Compensatory per acre value by plot throughout the city and extraterritorial jurisdiction, San Antonio, 2018.

presented in the *National Urban FIA Plot Field Guide, Version 9.3* (USDA Forest Service 2023c).

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, and 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. Of the tree species that had a minimum sample size of 10 trees and showed evidence of dieback, black willow in the ETJ had the highest average dieback (23.1 percent) (table 22). Approximately 30.8 percent of black willow displayed >25 percent

crown dieback, indicating that this species may be threatened by insect, disease, or environmental stressors in San Antonio's ETJ.

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 percentage of the main stem that was rotten or cull (i.e., missing or rotten main stem or large branches

volume, usually indicated by cankers, punky knots, hollow sounding stems, or imbedded metal in the wood) between 1 foot above the ground and approximately the 4.0-inch top diameter outside of bark was recorded for all trees ≥ 5.0 inches in diameter. Of species with a minimum sample size of 10 trees, the species with the highest average rotten/cull amounts were mescal bean in the ETJ and combined city and ETJ, and velvet ash in the city (table 23).

Table 22—Tree species with greatest average dieback, San Antonio, 2018

	Common name	Average dieback (%)	Percentage of trees with >25% dieback
City	Callery pear	3.4	0.0
	Ashe juniper	2.7	3.8
	Chinaberry	2.1	0.0
	Honey mesquite	1.3	5.5
	Mescal bean	1.0	0.0
	Sweet acacia	0.9	0.0
	Cedar elm	0.8	3.6
	Live oak	0.7	0.6
	Texas live oak	0.6	0.0
	Sugarberry	0.5	0.2
	Pecan	0.4	0.0
	Japanese privet	0.3	0.0
	Crapemyrtle	0.2	0.0
	Texas persimmon	0.1	0.0
Extraterritorial jurisdiction (ETJ)	Black willow	23.1	30.8
	Ashe juniper	2.4	4.5
	Honey mesquite	2.3	0.6
	Cedar elm	2.3	0.0
	Mescal bean	2.0	0.2
	Live oak	1.6	0.7
	Sugarberry	1.2	0.0
	Bluewood	0.6	0.0
	Texas persimmon	0.5	0.0
	Black hickory	0.1	0.0

Table 22—Tree species with greatest average dieback, San Antonio, 2018 (continued)

	Common name	Average dieback (%)	Percentage of trees with >25% dieback
Combined city and ETJ	Black willow	23.1	30.8
	Callery pear	3.4	0.0
	Ashe juniper	2.5	4.4
	Honey mesquite	1.9	2.0
	Mescal bean	1.7	0.1
	Chinaberry	1.6	0.0
	Cedar elm	1.5	1.5
	Live oak	1.2	0.7
	Texas live oak	0.8	0.0
	Sweet acacia	0.7	0.0
	Sugarberry	0.6	0.1
	Pecan	0.4	0.0
	Texas persimmon	0.4	0.0
	Bluewood	0.4	0.0
	Japanese privet	0.3	0.0
	Velvet ash	0.2	0.0
	Crapemyrtle	0.2	0.0
	Black hickory	0.1	0.0

Only species with a minimum sample size of 10 live trees were included in this analysis to minimize effect of small sample size on percentage estimates.

Table 23—Tree species with the greatest average rot, San Antonio, 2018

	Common name	Average rot (%)	Percentage of trees with >15% rot
City	Velvet ash	13.7	36.8
	Sweet acacia	9.0	19.1
	Texas live oak	8.9	21.4
	Honey mesquite	8.0	10.6
	Live oak	5.6	10.2
	Chinaberry	4.7	0.0
	Sugarberry	4.2	5.3
	Pecan	4.0	4.1
	Bluewood	3.6	0.0
	Ashe juniper	3.0	0.8
	Callery pear	2.5	0.0
	Cedar elm	1.9	1.6
	Japanese privet	1.4	0.0
	Crapemyrtle	1.2	0.0
Extraterritorial jurisdiction (ETJ)	Mescal bean	18.5	42.5
	Bluewood	13.4	13.1
	Sugarberry	9.7	14.8
	Honey mesquite	8.6	13.4
	Live oak	8.5	9.2
	Black willow	6.5	7.7
	Cedar elm	6.1	3.0
	Texas persimmon	3.4	0.0
	Ashe juniper	3.0	0.8
	Black hickory	1.9	0.0

Tree damage and potential infrastructure issues

Urban trees are susceptible to a wide range of insect, disease, and abiotic (e.g., soil compaction) damages that may affect tree survival, growth, and wood quality. Many biotic agents are host specific and their impacts may vary by regional and local growing conditions. Live trees >1.0 inch in diameter were examined for indications

Table 23—Tree species with the greatest average rot, San Antonio, 2018 (continued)

	Common name	Average rot (%)	Percentage of trees with >15% rot
Combined city and ETJ	Mescal bean	17.9	41.5
	Velvet ash	11.9	24.7
	Bluewood	9.8	9.5
	Honey mesquite	8.3	12.4
	Texas live oak	7.9	16.6
	Live oak	7.1	9.5
	Black willow	6.5	7.7
	Sweet acacia	6.4	11.7
	Sugarberry	5.5	8.4
	Cedar elm	3.9	2.5
	Chinaberry	3.9	0.0
	Pecan	3.6	3.3
	Texas persimmon	3.1	0.0
	Ashe juniper	3.0	0.8
	Callery pear	2.5	0.0
	Black hickory	1.9	0.0
	Japanese privet	1.4	0.0
	Crapemyrtle	1.2	0.0

Only species with a minimum sample size of 10 live trees were included in this analysis to minimize effect of small sample size on percentage estimates.

Rot was only measured on trees ≥5 inches in diameter.

of several damages. Up to three damages were recorded per tree; each one was required to meet a minimum severity threshold (e.g., 20 percent of the foliage affected). If more than three damages were observed on a tree, the top three were prioritized according to their ability to 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 the tree's marketable wood products. The full list of potential damages is presented in the *National Urban FIA Plot Field Guide, Version 9.3* (USDA Forest Service 2023c). Stem decay was by far the most common damage observed, affecting 18.5, 42.5, and 34.5 percent of trees in the city, ETJ, and combined city and ETJ, respectively (table 24).

Table 24—Percentage of trees with observed damages, San Antonio, 2018

Damage type		City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
		<i>Percent</i>		
Boring insects		0.03	0.02	0.02
General diseases		0.04	0.10	0.10
Root/butt diseases		0.30	0.50	0.40
Cankers		0.10	0.04	0.05
Stem decay	Unspecified	18.50	42.50	34.50
	Heart rot	0.40	1.30	1.00
Parasitic/epiphytic plants		0.10	—	0.04
Decline complexes/dieback/wilts		—	0.90	0.60
Wild animals	Unspecified	0.02	—	0.01
	Sapsuckers	—	0.10	0.04
Abiotic damage	Lightning	—	0.02	0.01
	Wind	0.03	0.10	0.10
Competition		0.03	0.02	0.02
Human activities	Unspecified	1.90	0.10	0.70
	Imbedded objects	1.90	0.10	0.70
Other damages and symptoms	Unspecified	0.03	—	0.01
	Broken top	—	0.50	0.30

— = no occurrence.

In addition to damages, each live tree >1.0 inch in diameter was evaluated for the presence of the following infrastructure issues that affect urban trees (full definitions of each are given in the glossary):

- [Stem girdling from roots](#)
- [Conflict with roots \(sidewalk-root conflict/infrastructure damage\)](#)
- [Severe topping or poor pruning](#)
- [Conflict with crowns and overhead wires \(branches within 5 feet of overhead wires\)](#)

- [Trunk-bark inclusion](#)
- [Improper planting](#)
- [Excessive mulch](#)

Trunk-bark inclusion was the most common issue in the combined sample area, occurring in 2.3 percent of trees (fig. 22). Severe topping or poor pruning and conflicts with roots and sidewalks were the second and third most common urban-specific infrastructure issues (fig. 22).

Differences exist in the prevalence of these issues among the FIA-designated land-use

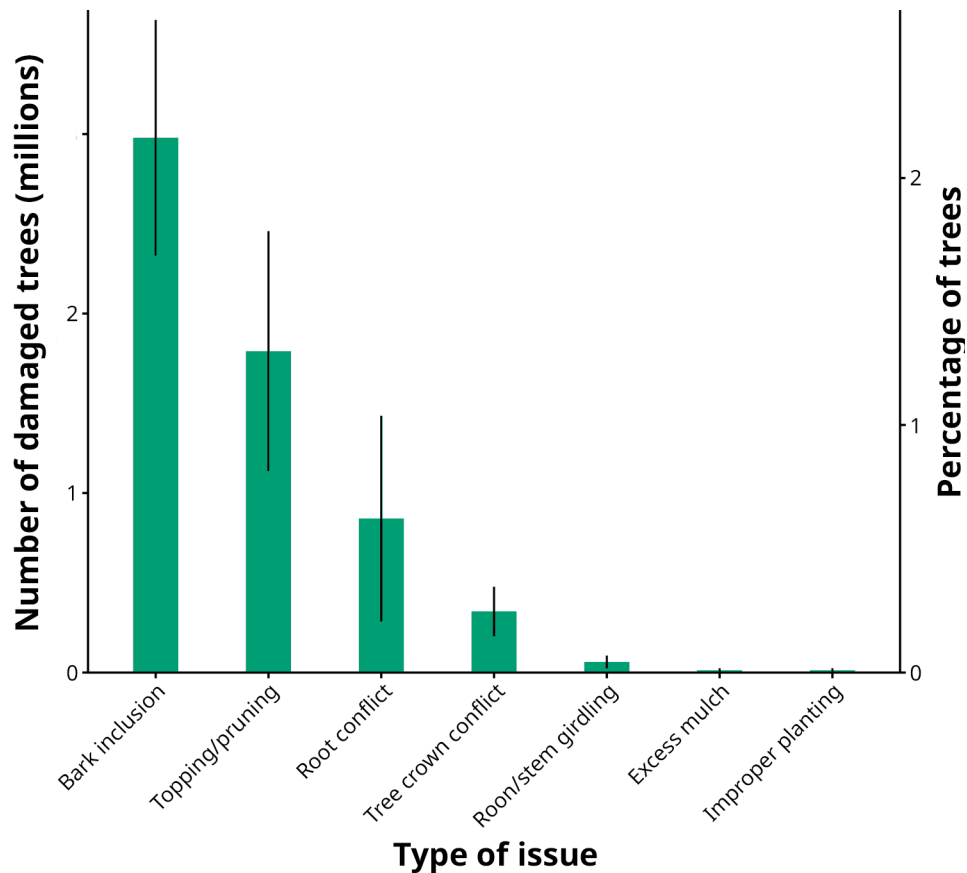


Figure 22—Number and percentage of trees by urban infrastructure issue category, with y-axes scaled such that bars represent both sets of values, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

classes and may further inform forest health and management priorities. In the city of San Antonio residential land (where most of these urban infrastructure issues were observed), 10.0 percent of trees suffered from severe topping or poor pruning, 8.7 percent of trees had bark inclusions, 7.1 percent had sidewalk conflicts, and 2.7 percent had overhead wires.

The species with the greatest proportion of the population affected by any one of the urban-specific damages within the combined city and ETJ were Callery pear with 36.4 percent affected by severe topping or poor pruning and velvet ash with 28.6 percent affected by trunk-bark inclusion (table 25). See table A5 for the percentage of live trees identified with damage, maintenance, and site issues in San Antonio, 2018.

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Table 25—Percentage of live trees identified with damage, maintenance, and site issues, San Antonio, 2018

	Damage type	Common name	Percent
City	Conflict with crowns and overhead wires	Pecan	20.5
		Live oak	7.1
		Velvet ash	4.5
		Japanese privet	2.9
		Crapemyrtle	2.5
		Loquat	0.8
		Sugarberry	0.4
		Honey mesquite	0.3
	Conflict with roots and sidewalks	Pecan	9.0
		Chinaberry	7.9
		Sugarberry	6.9
		Velvet ash	3.8
		Live oak	3.5
		Crapemyrtle	2.5
		Loquat	1.1
		Cedar elm	0.8
	Excessive mulch	Cedar elm	0.3
	Improper planting	Cedar elm	0.3
	Severe topping or poor pruning	Callery pear	36.4
		Crapemyrtle	22.2
		Velvet ash	12.9
		Pecan	12.3
		Sugarberry	8.1
		Japanese privet	4.9
		Loquat	2.8
		Honey mesquite	1.7
		Live oak	1.7
		Cedar elm	0.2
	Stem girdling from roots	Sugarberry	0.3
		Cedar elm	0.3
	Trunk-bark inclusion	Chinaberry	31.4
		Velvet ash	25.6
		Crapemyrtle	21.0
		Callery pear	18.2
		Japanese privet	11.9
		Goldenrain tree	10.4

Table 25—Percentage of live trees identified with damage, maintenance, and site issues, San Antonio, 2018 (continued)

	Damage type	Common name	Percent
City (continued)	Trunk-bark inclusion (continued)	Live oak	6.4
		Pecan	4.1
		Sugarberry	3.6
		Loquat	2.8
Extraterritorial jurisdiction (ETJ)	Conflict with crowns and overhead wires	Ashe juniper	0.1
	Conflict with roots and sidewalks	Live oak	0.5
	Excessive mulch	Not observed	0.0
	Improper planting	Damage subtotal	0.0
	Severe topping or poor pruning	Mescal bean	2.6
		Live oak	0.5
		Ashe juniper	0.5
	Stem girdling from roots	Live oak	0.5
	Trunk-bark inclusion	Velvet ash	100.0
		Honey mesquite	9.2
		Live oak	6.2
		Sugarberry	4.5
		Bluewood	1.7
		Cedar elm	0.7
		Ashe juniper	0.4
		Mescal bean	0.2
		Texas persimmon	0.1
Combined city and ETJ	Conflict with crowns and overhead wires	Pecan	16.7
		Velvet ash	3.7
		Japanese privet	2.9
		Live oak	2.4
		Crapemyrtle	2.4
		Loquat	0.8
		Sugarberry	0.3
		Honey mesquite	0.1
		Ashe juniper	0.1
	Conflict with roots and sidewalks	Pecan	7.3
		Chinaberry	6.2

Table 25—Percentage of live trees identified with damage, maintenance, and site issues, San Antonio, 2018 (continued)

	Damage type	Common name	Percent
Combined city and ETJ (continued)	Conflict with roots and sidewalks (continued)	Sugarberry	4.9
		Velvet ash	3.2
		Crapemyrtle	2.4
		Live oak	1.5
		Loquat	1.1
		Cedar elm	0.3
	Excessive mulch	Cedar elm	0.1
	Improper planting	Cedar elm	0.1
	Severe topping or poor pruning	Callery pear	36.4
		Crapemyrtle	26.6
		Velvet ash	10.6
		Pecan	10.0
		Sugarberry	5.8
		Japanese privet	4.9
		Loquat	2.8
		Mescal bean	1.7
		Live oak	0.9
		Honey mesquite	0.5
	Stem girdling from roots	Live oak	0.3
		Sugarberry	0.2
		Cedar elm	0.1
	Trunk-bark inclusion	Velvet ash	28.6
		Chinaberry	24.9
		Crapemyrtle	19.8
		Callery pear	18.2
		Japanese privet	11.9
		Goldenrain tree	10.4
		Honey mesquite	7.1
		Live oak	6.2
		Sugarberry	3.9
		Pecan	3.3

Only species with a minimum sample size of 10 live trees were included in this analysis to minimize effect of small sample size on estimates.

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 or 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 or transportation corridors, are generally 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.

Standing dead trees were found on five plots in the combined city and ETJ. Of the total live and dead tree population, 5.7 percent were estimated to be standing dead trees. The tree species with the highest percentage of standing dead trees were Italian cypress, bur oak, and white mulberry (table 26). The species that comprised the largest

Table 26—Trees classified as standing dead by species and the percentage that were dead, San Antonio, 2018

	Common name	Total number of trees	Percent
City	Italian cypress	124,069.9	100.0
	Bur oak	171,139.1	79.7
	Eastern baccharis	293,544.2	40.0
	Bluewood	360,096.8	28.2
	Loquat	342,278.2	21.1
	Texas live oak	97,272.8	15.1
	Live oak	240,467.3	11.7
	Mescal bean	346,200.7	7.2
	Ashe juniper	357,071.7	5.3
	Chinaberry	13,896.1	3.9
	Sweet acacia	69,480.6	2.5
	Honey mesquite	68,955.5	2.1
	Sugarberry	27,267.2	0.3

Table 26—Trees classified as standing dead by species and the percentage that were dead, San Antonio, 2018 (continued)

	Common name	Total number of trees	Percent
Extraterritorial jurisdiction (ETJ)	White mulberry	27,566.3	50.0
	Post oak	40,141.1	41.3
	Blackjack oak	38,814.1	29.0
	Black willow	58,221.1	18.8
	Bluewood	235,409.0	17.3
	Live oak	760,110.5	17.0
	Texas red oak	24,493.6	12.5
	Lacey oak	24,493.6	12.5
	Ashe juniper	3,042,884.8	8.1
	Honey mesquite	500,142.2	6.2
	Cedar elm	360,193.8	6.0
	Mescal bean	629,574.2	5.4
	Sugarberry	37,593.6	1.2
Combined city and ETJ	Italian cypress	124,069.9	100.0
	Bur oak	171,139.1	79.7
	White mulberry	27,566.3	42.3
	Post oak	40,141.1	41.3
	Eastern baccharis	293,544.2	40.0
	Blackjack oak	38,814.1	29.0
	Bluewood	595,505.8	22.6
	Loquat	342,278.2	21.1
	Black willow	58,221.1	18.8
	Live oak	1,000,577.9	15.3
	Texas live oak	97,272.8	13.2
	Lacey oak	24,493.6	12.5
	Texas red oak	24,493.6	12.5
	Ashe juniper	3,399,956.6	7.7
	Mescal bean	975,774.9	6.0
	Honey mesquite	569,097.7	5.0
	Cedar elm	360,193.8	3.6
	Chinaberry	13,896.1	2.9
	Sweet acacia	69,480.6	2.2
	Sugarberry	64,860.8	0.6

percentage of the dead tree population was Ashe juniper (table 27). Lands with the highest estimated number of standing dead trees were forest, residential, and commercial/industrial (fig. 23). The majority of standing dead trees were observed on unmaintained forest land.

Invasive plant species

Invasive plant species are often noted for their vigor, ability to adapt to novel environments, high reproductive capacity, and lack of natural enemies. These factors may enable them to displace native plants and threaten natural areas (Davis 2009, Simberloff 2013). Important considerations for invasive plant control efforts include weighing short- and long-term tradeoffs 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 Antonio examined each plot for the presence of select invasive species based on the species list shown in table A5. Of the 267 plots examined in the combined city and ETJ, invasive species were identified on 31.8 percent (85 plots) of them. Invasive species found in San Antonio are presented in figure 24. Beyond noting simple

Table 27—Percentage of total dead tree population by species, San Antonio, 2018

Common name	City	Extraterritorial jurisdiction (ETJ)	Combined city and ETJ
Ashe juniper	26.0	75.3	43.8
Mescal bean	29.4	0.0	18.8
Live oak	19.4	0.0	12.4
Bur oak	14.5	0.0	9.3
Texas live oak	8.3	0.0	5.3
Honey mesquite	1.2	7.4	3.4
Black willow	0.0	8.8	3.2
Sugarberry	0.0	5.7	2.0
Blackjack oak	0.0	2.9	1.1
Chinaberry	1.2	0.0	0.8

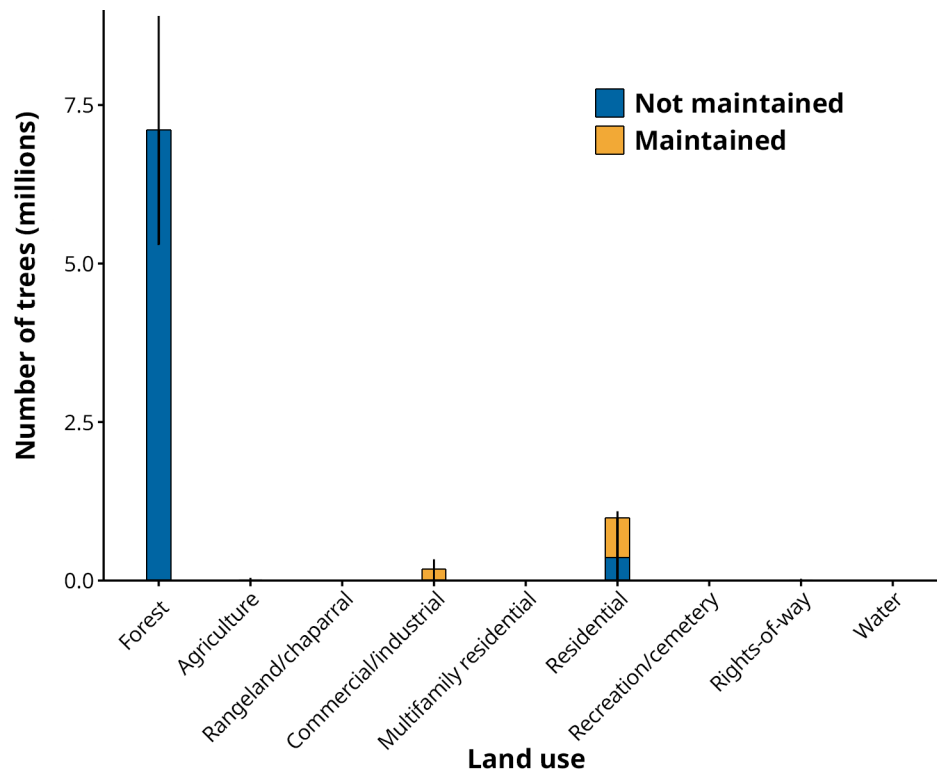


Figure 23—Number of standing dead trees by land-use class and maintenance status, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

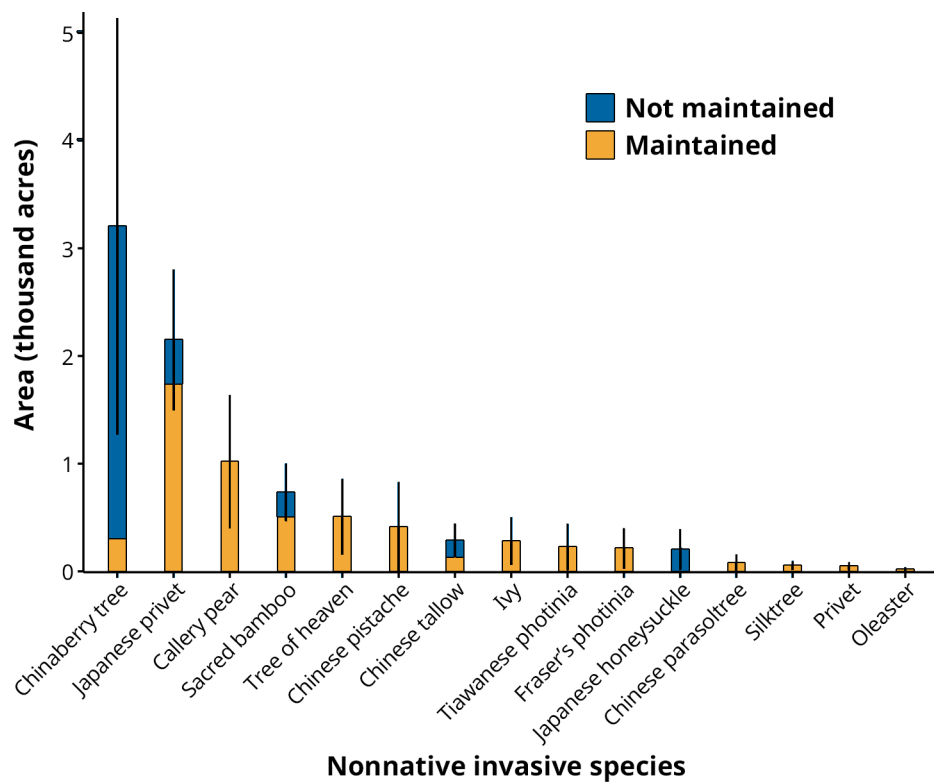


Figure 24—Land area with nonnative invasive plant species present by maintenance status, San Antonio, 2018. Error bars represent 68-percent confidence intervals around the estimated means.

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 combined city and ETJ (Bechtold and Scott 2005). These estimated areas may offer insights into which species are having the greatest impact. Of the invasive species recorded, Chinaberry (3,205 acres, 0.46 percent of the combined city and ETJ), Japanese privet (2,150 acres, 0.31 percent of the combined city and ETJ), and Callery pear (1,018 acres, 0.15 percent of the combined city and ETJ) 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



The Chinaberry tree (*Melia azedarach*) was estimated to cover the largest area of any invasive plant species in San Antonio, TX. (Photo courtesy of Jonathan Motsinger, Texas A&M Forest Service)

and altering local ecosystems (Pimentel et al. 2000). Chinaberry was also the most prevalent invasive species in the ETJ (1,338 acres, 0.34 percent of the ETJ sampling area) and Japanese privet was slightly more prevalent in the city (1,933 acres, [0.65 percent of the city sampling area] versus 1,863 acres [0.62 percent of the city sampling area] for Chinaberry).

Additional measurements were recorded in the field for most tree species. Because some of the species on the invasive plants list for San Antonio are classified as trees, data on individual trees were collected in addition to descriptions of species cover on the plot. Tree data were collected for ailanthus, silktree (also known as mimosa), Callery pear, Chinaberry, Chinese parasol tree, Chinese pistache, Chinese tallow, Japanese privet, and privet. Taken together, these invasive trees are estimated to account for 1.1 percent of all live trees surveyed (estimated total trees: 1.6 million) and 2.6 percent of total leaf area.

Pests and pathogens

Pathogens and insect pests can affect the health, sustainability, and benefits of urban forests. Identifying pathogens and insects of concern and their potential host-specific impacts allows managers to prioritize specific insects and diseases for monitoring and control measures. We evaluated 53 insects and diseases, along with their tree hosts in San Antonio, to quantify their potential impact on the urban forest (table 28). Seventeen insects and diseases were found to be potential risks to the urban trees of San Antonio and its ETJ. The number of trees at risk (fig. 25) reflects all the known host tree species that could experience damage or mortality either directly or indirectly due to the insect or disease and does not necessarily include only trees that are known to be directly at risk of attack or infection. Because FIA crews did not attribute tree damage or mortality to specific insects or diseases, it was not possible to identify what portion of each host tree's population was directly at risk from or

Table 28—Potential risk associated with insects and diseases, San Antonio, 2018

Common name	Proximity to county	Trees at risk	As proportion of all trees	Compensatory value
	<i>miles</i>	<i>number</i>	<i>percent</i>	<i>dollars</i>
Dutch elm disease	Within county	9,719,382.0	7.1	1,796,165,384
Oak wilt	Within county	7,289,386.3	5.3	9,664,602,478
Fusiform rust	Within 250 miles	7,289,386.3	5.3	9,664,602,478
Emerald ash borer	Within 250 miles	301,177.5	0.2	923,693,749
Forest tent caterpillar	Within 750 miles	17,776,191.3	12.9	12,558,350,996
Butternut canker	Within 750 miles	348,401.4	0.3	48,541,373
Thousand cankers disease	Within 750 miles	348,401.4	0.3	48,541,373
Large aspen tortrix	Within 750 miles	319,473.5	0.2	164,762,646
Bur oak blight	Within 750 miles	43,485.2	0.0	91,469,538
Polyphagous shot hole borer	Farther than 750 miles	24,683,516.9	17.9	15,953,423,301
Spotted lanternfly	Farther than 750 miles	23,192,609.0	16.8	13,910,552,021
Browntail moth	Farther than 750 miles	17,469,632.2	12.7	11,893,059,568
Winter moth	Farther than 750 miles	16,192,133.7	11.8	11,965,661,127
Asian longhorned beetle	Farther than 750 miles	10,251,325.9	7.4	2,373,349,903
Spongy moth	Farther than 750 miles	7,694,850.7	5.6	10,061,760,818
Mediterranean oak borer	Farther than 750 miles	7,289,386.3	5.3	9,664,602,478
Aspen leafminer	Farther than 750 miles	319,473.5	0.2	164,762,646

affected by the focal insects and diseases. Pest range maps (Nowak 2021, USDA Forest Service 2023a) were used to determine the proximity of each pest to the area. For San Antonio, proximity was classified for insects and diseases in Bexar County; within 250 miles of this county; between 250 and 750 miles of the county; or greater than 750 miles away. Because there are no pest range maps for Dutch elm disease and chestnut blight, the ranges of these diseases were based on known occurrence and the known host range, respectively (Nowak 2021). Proximity data for insects and diseases, along with the numbers of trees potentially affected and their compensatory values, are presented in table 28.

Based on the host tree species for each insect and disease and the current range of the insect or disease, it is possible to estimate the risk faced by

each tree species sampled in the urban forest to attack by each of these biotic agents and assign each tree species a relative risk weight. In table 29, each agent that could pose a risk to a tree species is rated as 4 if it occurs within Bexar County, 3 if it occurs within 250 miles of the county, 2 if it occurs within 750 miles of the county, and 1 if it is not present within 750 miles of the county. These values were summed across each row to determine the relative risk weight score for each tree species recorded. Tree species that were sampled in San Antonio and its ETJ, but are not listed in the table 29 matrix, are not known to be hosts to any of the 45 insects and diseases evaluated. This table also excludes the insects and diseases that were not a threat to any of the tree species sampled.

SAN ANTONIO'S URBAN FOREST, 2018

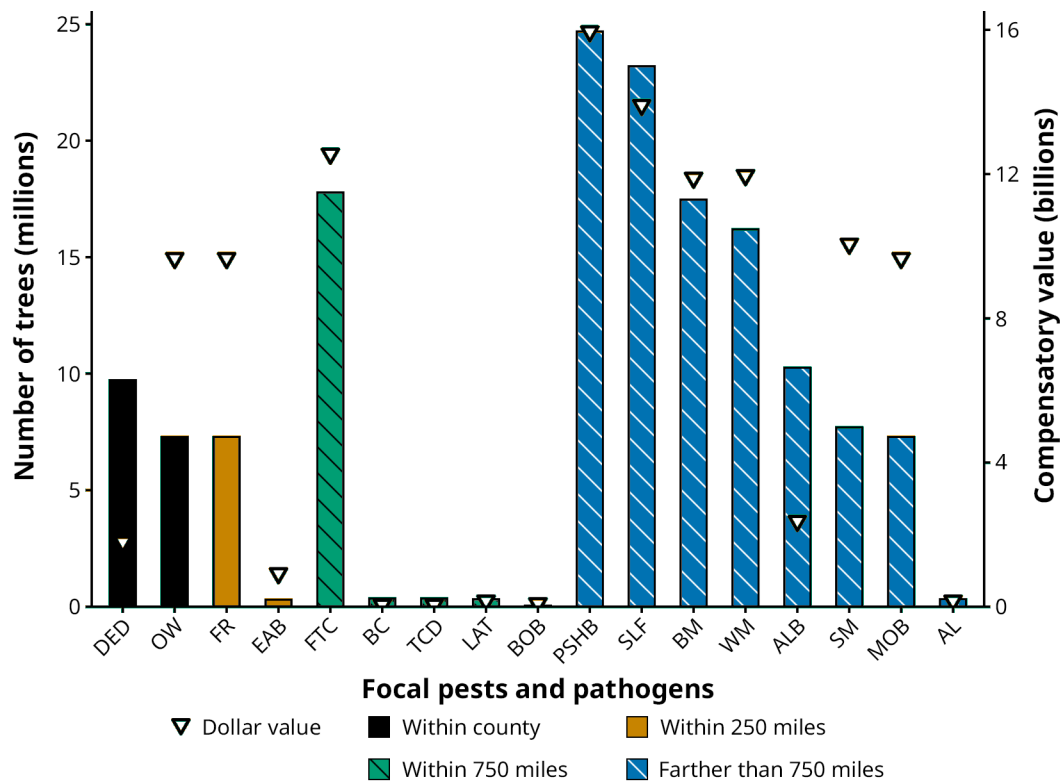


Figure 25—Number of trees at risk to insects and diseases shaded by the distance they can be found in relation to Bexar County, TX, and their associated compensatory values (open triangles), San Antonio, 2018. DED = Dutch elm disease, OW = oak wilt, FR = fusiform rust, EAB = emerald ash borer, FTC = forest tent caterpillar, BC = butternut canker, TCD = thousand cankers disease, LAT = large aspen tortrix, BOB = bur oak blight, PSHB = polyphagous shot hole borer, SLF = spotted lanternfly, BM = browntail moth, WM = winter moth, ALB = Asian longhorned beetle, SM = spongy moth, MOB = Mediterranean oak borer, AL = aspen leafminer.

Table 29—Insect and disease risk rating by tree species, San Antonio, 2018

Score	Common name	Dutch elm disease	Oak wilt	Fusiform rust	Emerald ash borer	Forest tent caterpillar	Butternut canker	Thousand cankers disease	Large aspen tortrix	Bur oak blight	Polyphagous shot hole borer	Spotted lanternfly	Browntail moth	Winter moth	Asian longhorned beetle	Spongy moth	Mediterranean oak borer	Aspen leafminer
17	Bur oak		4	3		2				2	1	1	1	1		1	1	
15	Buckley oak		4	3		2					1	1	1	1		1	1	
15	Live oak		4	3		2					1	1	1	1		1	1	
15	Shumard oak		4	3		2					1	1	1	1		1	1	
14	Blackjack oak		4	3		2						1	1	1		1	1	
14	Mexican white oak		4	3		2					1	1	1			1	1	
14	Post oak		4	3		2						1	1	1		1	1	
13	Durand oak		4	3		2						1	1			1	1	
13	Havard oak		4	3		2						1	1			1	1	
13	Lacey oak		4	3		2						1	1			1	1	
13	Texas live oak		4	3		2						1	1			1	1	

Table 29—Insect and disease risk rating by tree species, San Antonio, 2018 (continued)

Score	Common name	Dutch elm disease	Oak wilt	Fusiform rust	Emerald ash borer	Forest tent caterpillar	Butternut canker	Thousand cankers disease	Large aspen tortrix	Bur oak blight	Polyphagous shot hole borer	Spotted lanternfly	Browntail moth	Winter moth	Asian longhorned beetle	Spongy moth	Mediterranean oak borer	Aspen leafminer
13	Nuttall oak		4	3		2						1	1			1	1	
11	Chinese elm	4				2					1	1	1		1	1		
10	Black willow					2			2			1	1	1	1	1		1
10	Cedar elm	4				2						1	1	1	1			
10	Peach					2			2		1	1	1	1	1			1
9	Black cherry					2			2			1	1	1	1			1
8	Green ash				3	2						1		1	1			
8	Velvet ash				3	2					1	1		1				
6	Black walnut						2	2			1	1						
5	Callery pear										1	1	1		1	1		
4	Apple species											1	1		1	1		
3	White mulberry										1	1			1			
2	Catclaw acacia										1	1						
2	Chinaberry										1	1						
2	Chinese parasol tree										1	1						
2	Citrus species					2												
2	Sweet acacia										1	1						
2	Ailanthus										1	1						
1	Chinese pistache										1							
1	Chinese tallow tree										1							
1	Glossy privet											1						
1	Goldenrain tree										1							
1	Honey mesquite										1							
1	Jerusalem thorn										1							
1	Texas walnut											1						
1	Loquat										1							
1	Mexican buckeye										1							
1	Washington fan palm										1							
1	Hackberry														1			
1	Oriental arborvitae											1						
1	Pecan										1							
1	Red mulberry														1			
1	Southern magnolia										1							

4 = present within Bexar County; 3 = occurs within 250 miles of Bexar County; 2 = occurs within 750 miles of Bexar County; 1 = not present within 750 miles of Bexar County.

MANAGEMENT IMPLICATIONS

The primary goal of the Urban FIA Program 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 bulletin presents information about the current state of the San Antonio urban forest and the benefits it provides to residents of the city and surrounding ETJ. A close inspection of these data can help planners understand where improvements can be made and develop tree planting, management, and conservation goals for the future. The data will also serve as a baseline against which the future results from continued monitoring can be compared. 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 corresponding changes in benefits associated with the urban forest.

As the metropolis of San Antonio enters its fourth century, it faces a growing number of challenges, vulnerabilities, and risks. The population is expected to increase by 1 million residents by 2040, and during that time the city can also be expected to experience significant changes in its climate (City of San Antonio 2019b). As previously mentioned, 9 of the 12 priority risk areas identified by the city can be linked to urban trees and forests, including all 3 of the highest priority risks (City of San Antonio 2019b, c).



Healthy, well-maintained urban trees complement San Antonio's architectural beauty.

The first cited high risk is increasing exposure to higher temperatures. The average temperature in San Antonio is predicted to increase by 4 °F by 2040, with more than 30 days per year over 100 °F (City of San Antonio 2019b, c). By the end of the century, average temperatures are expected to have increased by 6 to 10 °F. These increased temperatures could increase the death rate of vulnerable populations such as the elderly with chronic health conditions by 9 to 20 percent by 2100 (City of San Antonio 2019c). Increasing urban tree cover has been shown to be effective in lowering ambient temperatures and combatting the formation of urban heat islands. Heat islands form in urban areas where structures such as buildings and roads are highly concentrated and greenery is limited (EPA 2008). In its review of research studies and data, the Environmental Protection Agency found that in the United States, the heat island effect results in daytime temperatures in urban areas about 1 to 7 °F higher than temperatures in outlying areas and nighttime temperatures about 2 to 5 °F higher (EPA 2008).

The next cited high risk was increased ground-level O₃ concentrations from the reaction of VOCs and nitrogen oxides, which also pose significant human health risks (City of San Antonio 2019c). Though the relationship is complex and urban trees themselves can produce VOCs, increasing urban tree cover tends to reduce O₃ formation. The third high risk was increased infrastructure damage caused by wildfires (City of San Antonio 2019b, c). An estimated 15,649 homes are already considered to be in areas of high wildfire risk (City of San Antonio 2019a). With predictions of an average of 3 inches less rain per year by the end of the century and an increasing frequency of droughts, an even greater portion of the city's buildings and infrastructure could be at risk from wildfires (City of San Antonio 2019b, c). San Antonio's urban forests can play an important role in mitigating these risks. Urban forest monitoring can track progress toward those goals and facilitate informed, adaptive management in response to climate change.

The city of San Antonio has expressed its support for the Mayor's National Climate Action Agenda, a commitment by over 400 U.S. mayors to uphold the goals of the Paris Climate Agreement, in its strategic plan for climate action and adaptation (City of San Antonio 2019b). San Antonio's goal of carbon neutrality by 2050 will require the exploration of negative emissions solutions such as carbon stock enhancement, as called for in that plan's mitigation strategies. San Antonio's total community emissions in 2019 were 19.2 tons (17.3 million metric tons) of CO₂ equivalents (City of San Antonio 2019a). This urban forest inventory's data estimates that 1.2 million tons of CO₂ equivalents are being removed from the atmosphere annually by the woody vegetation in the city and its ETJ. The urban forest inventory could identify opportunities for increasing that sequestration by, for example, indicating if there are areas that are relatively barren or lacking in tree cover, or areas with noticeably high populations of old or large trees that are senescing and could be replaced by more vigorously growing trees. Also, 48 percent of greenhouse gas emissions in the city in 2016 were from building energy use (City of San Antonio 2019b). These emissions would also be reduced indirectly by increased tree shade, which would decrease the energy needed for residential cooling, further contributing to the city's carbon neutrality goals.

Active, carefully thought-out management of the urban forest will allow managers to prepare it for changing environmental conditions. As the city expands, new development can better incorporate tree and green spaces into their designs. In already urbanized areas, the planted and maintained urban forest species composition can be gradually shifted toward a more diverse and drought tolerant suite of native species as existing trees die and need to be replaced, thereby increasing the urban forest ecosystem's resilience to climate change.

CONCLUSIONS

San Antonio's urban forest contributes to the city's environmental, economic, and social well-being. Throughout the city, an estimated 137.8 million trees, representing 65 species, provide an estimated tree canopy cover of 29.3 percent. These trees provide 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. The estimated \$168.7 million in annual ecosystem services benefits and \$33.1 billion compensatory value only captures those services for which we have models that can convert them to monetary values. The true value of San Antonio's forests certainly exceeds those amounts.

There are forces that may impact this urban forest's structure, health, and the environmental benefits it provides to the city's residents in the future. These include insect and disease damages, the potential expansion of currently present invasive species and the introduction of new ones, changes in the management and use of the urban forest due to socioeconomic forces or political decisions, and growth of the human population. Effective monitoring allows for the development of data-driven management strategies to maximize the benefits of San Antonio's urban forest while minimizing the cost associated with its maintenance. This analysis provides a baseline for this future monitoring. Data from this bulletin capture attributes of the current urban forest resource and associated ecosystem services and values, and future monitoring will identify how the forest is changing over time. The plots measured in San Antonio will be remeasured on a 10-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 urban 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 Antonio. In the future, change analyses can be used to evaluate the success of urban forest management programs.



San Antonio's urban trees are part of its heritage.

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GLOSSARY OF TERMS

Bark inclusion—Weak branch unions are places where branches are not strongly attached to the tree. A weak union occurs when two or more branches grow so closely together that bark grows between the branches and inside the union. This ingrown, or included, bark does not have the structural strength of wood and the union can become very weak. The inside bark may also act as a wedge and force the branch union to split apart. Trees with a tendency to form upright branches, such as elm and maple, often produce weak branch unions.

Board foot—A unit of measure indicating the amount of wood contained in an unfinished board 1.0 foot wide, 1.0 foot long, and 1.0 inch thick.

Conflict with roots—Damage to infrastructure such as sidewalks, driveways, roads, or other hardscapes directly caused by roots. Tree roots grow under sidewalks and asphalt. They do this in many instances because that is where the soil oxygen and moisture are located. Conflicts with curbs, driveways, or roads are all considered conflicts with roots.

Conflict with tree crown—The tree branches, foliage, or bole are within 5 feet of utility wires of any type, including drop lines that extend from the main line to a building. Conflict with overhead wires can cause problems for both trees and wires, creating maintenance problems and hazard situations.

Diameter—For timber species, diameter is measured at breast height (d.b.h.), which is usually 4.5 feet above the ground line on the uphill side of the tree. For woodland species, if the tree has multiple stems, the diameter of each is taken 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 A1.

Excessive mulch—Root flare is not visible at base of trunk because of mulch. Mulch piled high around the stem and mulch depth >3 inches. Overmulching of landscape plants, sometimes to the extent of creating mountainous mulch “volcanoes”, can result in disease or death of the tree. Mulch can take the form of many different materials and is not limited to wood chips (USDA Forest Service 2023c).

Extraterritorial jurisdiction—The extraterritorial jurisdiction (ETJ) is the unincorporated land within 5 miles of the city of San Antonio boundaries and includes all unincorporated territory that is not located in another city’s municipal boundary or ETJ. It is the area in which the city of San Antonio is the only authorized entity able to annex land. The ETJ enables the city to extend regulations to adjacent land where development can affect the quality of life within the city. ETJ regulations help to ensure that subdivisions that may be annexed in the future meet certain minimum standards (City of San Antonio 2020).

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 <120 feet in width or 1 acre in area. Forest land is divided into timberland, reserved forest land, and other forest land (such as woodland).

Improper planting—Evidence of improper planting may include burlap, twine, or root ball wire not removed prior to planting, or root flare buried (USDA Forest Service 2023c).

Invasive plant/tree species—A nonnative species whose introduction causes or is likely to cause economic or environmental harm or

harm to human health (The White House 1999). A list of potential invasive species included in this inventory is presented in table A5. Invasive species that were also measured as trees are identified in the invasive species column of tables A1 and A2.

Rights-of-way—Developed land including improved or maintained roads, railways, power or gas line clearings, and maintained canals.

Rotten or cull—Missing or rotten main stem or large branch volume caused by pathogens or abiotic factors, and includes cankers, punky knots, hollow sounding stems, or embedded metal in the wood (USDA Forest Service 2016b, 2017).

Sawtimber—A live tree of a commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8.0 feet or longer and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h. (USDA Forest Service 2016b).

Sawtimber volume—Net volume of the saw log portion of live sawtimber in board feet, International 1/4-inch Rule (unless specified otherwise), from stump to a minimum 7.0 inches top diameter outside bark for softwoods and a minimum 9.0 inches top diameter outside bark for hardwoods (USDA Forest Service 2016b).

Severe topping or poor pruning—A tree is considered to have been severely topped when it has been reduced to a single “pole” due to severe overpruning and branch removal. Topping is the cutting of branches to stubs, or, if 25 percent or more at the main stem has been cut to reduce tree height. Topping usually results in a profusion of shoots rendering the tree more susceptible to wind damage. Poor pruning techniques include leaving stubs outside the branch collar or cutting into the branch collar. A tree with proper pruning may still maintain the look and shape of the tree, only it is shorter.

Shannon-Weiner diversity index—An index of species diversity (also known as the Shannon diversity index) that 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 p_i = proportion of the total assemblage of individuals represented by individuals of species i . (Shannon 1948). The Shannon-Weiner index can range from 0 to 5, but mostly is in the range of 1.5 to 3.5.

Stem girdling—Roots begin to grow around the main stem of the tree and cut off or restrict the movement of water, plant nutrients, and stored food reserves. Certain trees are more prone to this problem than others. Lindens, magnolias, pines, and maples (other than silver maple) are susceptible to root girdling (USDA Forest Service 2023c).

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 multitemmed growth form; timber species generally grow from a single central stem. This difference in typical form resulted in some differences in data collection and calculation, such as how diameters were determined (see [diameter](#) definition). Woodland species are identified in the woodland species column of tables A1 and A2.

APPENDIX: SUPPLEMENTAL TABLES

Table A1—List of all live tree species and their characteristics, San Antonio, 2018

Species	Variety	Common name	Woodland species	Invasive species	City				Extraterritorial jurisdiction (ETJ)					Combined city and ETJ					
					Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter
					1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0		
					total number of trees					total number of trees					total number of trees				
<i>Acacia farnesiana</i>		Sweet acacia	X		2,419,482.3	263,501.1	27,792.2	2,710,775.6	3.4	235,409.0	184,456.0	0.0	419,865.0	5.8	2,654,891.3	447,957.0	27,792.2	3,130,640.6	3.6
<i>Acacia greggii</i>		Catclaw acacia	X		0.0	0.0	0.0	0.0	–	483,496.9	82,714.7	0.0	566,211.7	4.4	483,496.9	82,714.7	0.0	566,211.7	4.4
<i>Ailanthus altissima</i>		Ailanthus		X	620,349.4	75,187.8	21,742.6	717,279.8	4.3	0.0	0.0	0.0	0.0	–	620,349.4	75,187.8	21,742.6	717,279.8	4.3
<i>Baccharis halimifolia</i>		Eastern baccharis			440,316.2	0.0	0.0	440,316.2	2.2	0.0	0.0	0.0	0.0	–	440,316.2	0.0	0.0	440,316.2	2.2
<i>Carya illinoensis</i>		Pecan			0.0	65,256.3	152,198.1	217,454.5	17.7	0.0	0.0	27,566.3	27,566.3	11.8	0.0	65,256.3	179,764.4	245,020.7	17.4
<i>Carya texana</i>		Black hickory			0.0	0.0	0.0	0.0	–	241,748.5	619,804.5	57,610.9	919,163.9	6.5	241,748.5	619,804.5	57,610.9	919,163.9	6.5
<i>Celtis laevigata</i>		Sugarberry			6,513,513.5	1,161,959.3	278,653.7	7,954,126.6	3.5	2,430,131.6	538,956.4	132,187.9	3,101,275.9	4.1	8,943,645.1	1,700,915.7	410,841.7	11,055,402.5	3.6
<i>Celtis laevigata</i>	<i>reticulata</i>	Netleaf hackberry			0.0	0.0	0.0	0.0	–	0.0	48,987.3	0.0	48,987.3	8.2	0.0	48,987.3	0.0	48,987.3	8.2
<i>Celtis occidentalis</i>		Hackberry			0.0	9,960.1	0.0	9,960.1	5.2	0.0	0.0	0.0	0.0	–	0.0	9,960.1	0.0	9,960.1	5.2
<i>Citrus</i> spp.		Citrus species			146,772.1	0.0	0.0	146,772.1	2.1	0.0	0.0	0.0	0.0	–	146,772.1	0.0	0.0	146,772.1	2.1
<i>Condalia hookeri</i>		Bluewood	X		692,401.4	222,337.8	0.0	914,739.2	4.4	540,520.0	568,489.2	19,407.0	1,128,416.2	5.7	1,232,921.4	790,826.9	19,407.0	2,043,155.4	5.0
<i>Cyathea tenera</i>		Helecho gigante			0.0	0.0	0.0	0.0	–	0.0	38,814.1	0.0	38,814.1	7.3	0.0	38,814.1	0.0	38,814.1	7.3
<i>Cycas circinalis</i>		Queen sago			0.0	0.0	0.0	0.0	–	0.0	0.0	27,566.3	27,566.3	16.3	0.0	0.0	27,566.3	27,566.3	16.3
<i>Diospyros texana</i>		Texas persimmon	X		7,362,368.9	13,896.1	0.0	7,376,265.0	1.7	19,660,356.3	219,503.3	0.0	19,879,859.6	2.2	27,022,725.1	233,399.4	0.0	27,256,124.5	2.0
<i>Ehretia anacua</i>		Anacua knockaway	X		0.0	9,960.1	9,960.1	19,920.1	18.5	0.0	0.0	0.0	0.0	–	0.0	9,960.1	9,960.1	19,920.1	18.5
<i>Eriobotrya japonica</i>		Loquat			1,197,973.5	84,357.4	0.0	1,282,330.9	2.2	0.0	0.0	0.0	0.0	–	1,197,973.5	84,357.4	0.0	1,282,330.9	2.2
Family <i>Arecaceae</i>		Other palms			0.0	0.0	0.0	0.0	–	0.0	27,566.3	0.0	27,566.3	8.9	0.0	27,566.3	0.0	27,566.3	8.9
<i>Firmiana simplex</i>		Chinese parasoltree		X	0.0	11,782.5	0.0	11,782.5	7.8	0.0	0.0	0.0	0.0	–	0.0	11,782.5	0.0	11,782.5	7.8
<i>Fraxinus pennsylvanica</i>		Green ash			0.0	0.0	13,633.6	13,633.6	14.8	0.0	0.0	0.0	0.0	–	0.0	0.0	13,633.6	13,633.6	14.8
<i>Fraxinus velutina</i>		Velvet ash			146,772.1	19,920.1	93,285.4	259,977.6	12.6	0.0	0.0	27,566.3	27,566.3	11.4	146,772.1	19,920.1	120,851.7	287,543.9	12.6
<i>Juglans microcarpa</i>		Texas walnut			0.0	0.0	0.0	0.0	–	0.0	73,480.9	24,493.6	97,974.5	8.8	0.0	73,480.9	24,493.6	97,974.5	8.8
<i>Juglans nigra</i>		Black walnut			0.0	0.0	0.0	0.0	–	305,111.0	24,493.6	18,796.8	348,401.4	2.9	305,111.0	24,493.6	18,796.8	348,401.4	2.9

SAN ANTONIO'S URBAN FOREST, 2018

Table A1—List of all live tree species and their characteristics, San Antonio, 2018 (continued)

Species	Variety	Common name	Woodland species	Invasive species	City				Extraterritorial jurisdiction (ETJ)					Combined city and ETJ					
					Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter
					1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0		
					total number of trees					total number of trees					total number of trees				
<i>Juniperus ashei</i>	Ashe juniper	X			3,063,149.7	2,616,224.2	753,994.1	6,433,368.1	5.6	22,177,327.1	10,195,712.6	2,006,413.4	34,379,453.0	4.8	25,240,476.8	12,811,936.8	2,760,407.5	40,812,821.1	5.0
<i>Koelreuteria paniculata</i>	Goldenrain tree				173,100.3	11,782.5	11,782.5	196,665.4	5.8	0.0	0.0	0.0	0.0	–	173,100.3	11,782.5	11,782.5	196,665.4	5.8
<i>Lagerstroemia indica</i>	Crapemyrtle	X			440,316.2	391,693.8	92,437.8	924,447.8	6.4	0.0	55,132.5	0.0	55,132.5	8.0	440,316.2	446,826.3	92,437.8	979,580.3	6.4
<i>Ligustrum japonicum</i>	Japanese privet	X	X		372,209.6	212,285.6	94,346.0	678,841.2	5.6	0.0	0.0	0.0	0.0	–	372,209.6	212,285.6	94,346.0	678,841.2	5.6
<i>Ligustrum lucidum</i>	Glossy privet	X	X		0.0	0.0	0.0	0.0	–	0.0	19,407.0	0.0	19,407.0	5.2	0.0	19,407.0	0.0	19,407.0	5.2
<i>Ligustrum sinense</i>	Chinese privet	X	X		0.0	9,960.1	0.0	9,960.1	7.7	0.0	0.0	0.0	0.0	–	0.0	9,960.1	0.0	9,960.1	7.7
<i>Maclura pomifera</i>	Osage-orange				0.0	29,880.2	0.0	29,880.2	7.3	0.0	0.0	0.0	0.0	–	0.0	29,880.2	0.0	29,880.2	7.3
<i>Magnolia grandiflora</i>	Southern magnolia				0.0	11,782.5	13,633.6	25,416.1	10.6	0.0	0.0	0.0	0.0	–	0.0	11,782.5	13,633.6	25,416.1	10.6
<i>Malus</i> spp.	Apple species				0.0	11,782.5	0.0	11,782.5	6.0	0.0	0.0	0.0	0.0	–	0.0	11,782.5	0.0	11,782.5	6.0
<i>Melia azedarach</i>	Chinaberry			X	0.0	276,376.4	66,841.9	343,218.3	8.2	0.0	115,832.0	0.0	115,832.0	7.4	0.0	392,208.4	66,841.9	459,050.3	8.1
<i>Morus alba</i>	White mulberry				0.0	0.0	9,960.1	9,960.1	17.4	0.0	27,566.3	0.0	27,566.3	5.9	0.0	27,566.3	9,960.1	37,526.3	11.7
<i>Morus rubra</i>	Red mulberry				0.0	0.0	9,960.1	9,960.1	22.6	0.0	0.0	0.0	0.0	–	0.0	0.0	9,960.1	9,960.1	22.6
<i>Parkinsonia aculeata</i>	Jerusalem thorn				173,100.3	11,782.5	0.0	184,882.9	1.9	265,880.0	0.0	0.0	265,880.0	1.3	438,980.3	11,782.5	0.0	450,762.9	1.6
<i>Pistacia chinensis</i>	Chinese pistache			X	0.0	9,960.1	11,782.5	21,742.6	11.4	0.0	0.0	0.0	0.0	–	0.0	9,960.1	11,782.5	21,742.6	11.4
<i>Platycladus orientalis</i>	Oriental arborvitae				0.0	33,525.1	0.0	33,525.1	7.6	0.0	0.0	0.0	0.0	–	0.0	33,525.1	0.0	33,525.1	7.6
<i>Prosopis glandulosa</i>	Honey mesquite	X			1,902,142.6	693,755.4	562,350.8	3,158,248.8	6.1	5,278,805.2	1,369,565.1	904,361.7	7,552,731.9	5.0	7,180,947.7	2,063,320.5	1,466,712.5	10,710,980.7	5.5
<i>Prunus persica</i>	Peach				0.0	0.0	0.0	0.0	–	0.0	42,688.5	0.0	42,688.5	6.6	0.0	42,688.5	0.0	42,688.5	6.6
<i>Prunus serotina</i>	Black cherry				0.0	0.0	0.0	0.0	–	0.0	24,493.6	0.0	24,493.6	8.6	0.0	24,493.6	0.0	24,493.6	8.6
<i>Pyrus calleryana</i>	Callery pear			X	0.0	47,130.1	82,477.8	129,607.9	12.5	0.0	0.0	0.0	0.0	–	0.0	47,130.1	82,477.8	129,607.9	12.5
<i>Quercus buckleyi</i>	Buckley oak				0.0	23,593.6	23,565.1	47,158.7	12.4	0.0	24,493.6	0.0	24,493.6	8.2	0.0	48,087.3	23,565.1	71,652.3	11.6
<i>Quercus fusiformis</i>	Texas live oak				173,100.3	361,298.9	13,896.1	548,295.4	6.3	0.0	56,390.4	37,593.6	93,984.1	9.8	173,100.3	417,689.3	51,489.7	642,279.4	6.7
<i>Quercus havardii</i>	Havard oak				0.0	0.0	0.0	0.0	–	305,111.0	97,974.5	0.0	403,085.5	4.7	305,111.0	97,974.5	0.0	403,085.5	4.7

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Table A1—List of all live tree species and their characteristics, San Antonio, 2018 (continued)

Species	Variety	Common name	Woodland species	Invasive species	City			Extraterritorial jurisdiction (ETJ)					Combined city and ETJ						
					Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter	Diameter class (inches)			Live trees	Average diameter
					1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0			1.0–4.9	5.0–10.9	≥11.0		
					total number of trees					total number of trees					total number of trees				
			inches						inches						inches				
<i>Quercus laceyi</i>		Lacey oak			0.0	0.0	0.0	0.0	–	0.0	73,480.9	97,974.5	171,455.4	11.2	0.0	73,480.9	97,974.5	171,455.4	11.2
<i>Quercus macrocarpa</i>		Bur oak			0.0	9,960.1	33,525.1	43,485.2	11.5	0.0	0.0	0.0	0.0	–	0.0	9,960.1	33,525.1	43,485.2	11.5
<i>Quercus marilandica</i>		Blackjack oak			0.0	0.0	0.0	0.0	–	0.0	38,814.1	56,390.4	95,204.5	16.1	0.0	38,814.1	56,390.4	95,204.5	16.1
<i>Quercus polymorpha</i>		Mexican white oak			0.0	23,593.6	0.0	23,593.6	7.7	0.0	0.0	0.0	0.0	–	0.0	23,593.6	0.0	23,593.6	7.7
<i>Quercus shumardii</i>		Shumard oak			0.0	41,662.7	29,880.2	71,542.9	10.1	0.0	0.0	0.0	0.0	–	0.0	41,662.7	29,880.2	71,542.9	10.1
<i>Quercus sinuata</i>	<i>sinuata</i>	Durand oak			0.0	0.0	13,633.6	13,633.6	15.7	0.0	0.0	0.0	0.0	–	0.0	0.0	13,633.6	13,633.6	15.7
<i>Quercus sinuata</i>	<i>breviloba</i>	Bastard oak			0.0	0.0	0.0	0.0	–	305,111.0	122,468.2	0.0	427,579.1	3.0	305,111.0	122,468.2	0.0	427,579.1	3.0
<i>Quercus stellata</i>		Post oak			0.0	0.0	0.0	0.0	–	0.0	18,796.8	38,203.8	57,000.7	18.7	0.0	18,796.8	38,203.8	57,000.7	18.7
<i>Quercus texana</i>		Texas red oak			0.0	0.0	0.0	0.0	–	0.0	171,455.4	0.0	171,455.4	8.4	0.0	171,455.4	0.0	171,455.4	8.4
<i>Quercus virginiana</i>		Live oak			173,100.3	951,122.2	698,496.3	1,822,718.9	11.8	343,385.8	2,356,889.7	1,002,003.3	3,702,278.8	9.8	516,486.2	3,308,012.0	1,700,499.6	5,524,997.8	10.7
<i>Salix nigra</i>		Black willow			0.0	0.0	0.0	0.0	–	0.0	38,814.1	213,477.3	252,291.4	13.0	0.0	38,814.1	213,477.3	252,291.4	13.0
<i>Sapindus saponaria</i>	<i>drummondii</i>	Western soapberry			0.0	25,416.1	0.0	25,416.1	6.3	0.0	0.0	0.0	0.0	–	0.0	25,416.1	0.0	25,416.1	6.3
<i>Sideroxylon lanuginosum</i>		Chittamwood, gum bumelia			173,100.3	13,633.6	0.0	186,733.9	1.6	305,111.0	0.0	0.0	305,111.0	1.0	478,211.3	13,633.6	0.0	491,844.9	1.3
<i>Sophora affinis</i>		Texas sophora			173,100.3	0.0	0.0	173,100.3	2.5	305,111.0	0.0	0.0	305,111.0	3.5	478,211.3	0.0	0.0	478,211.3	3.0
<i>Sophora secundiflora</i>		Mescal bean			4,105,377.9	360,096.8	0.0	4,465,474.7	2.3	10,411,270.6	535,102.4	0.0	10,946,373.0	2.4	14,516,648.5	895,199.2	0.0	15,411,847.7	2.4
<i>Triadica sebifera</i>		Chinese tallowtree		X	0.0	21,742.6	23,593.6	45,336.2	11.3	0.0	24,493.6	0.0	24,493.6	5.4	0.0	46,236.2	23,593.6	69,829.9	10.1
<i>Ulmus crassifolia</i>		Cedar elm			3,249,419.5	705,153.8	130,218.6	4,084,792.0	3.7	4,287,100.7	1,097,910.3	237,796.5	5,622,807.5	3.6	7,536,520.2	1,803,064.1	368,015.1	9,707,599.4	3.7
<i>Ulmus parvifolia</i>		Chinese elm			0.0	11,782.5	0.0	11,782.5	7.3	0.0	0.0	0.0	0.0	–	0.0	11,782.5	0.0	11,782.5	7.3
<i>Ungnadia speciosa</i>		Mexican buckeye			173,100.3	0.0	0.0	173,100.3	1.1	0.0	0.0	0.0	0.0	–	173,100.3	0.0	0.0	173,100.3	1.1
<i>Washingtonia robusta</i>		Washington fan palm			0.0	19,920.1	9,960.1	29,880.2	11.0	0.0	0.0	0.0	0.0	–	0.0	19,920.1	9,960.1	29,880.2	11.0
Totals					46,042,885.4					91,745,144.0					137,788,029.4				

— = no data.
Due to rounding, not all values add up exactly to totals.

SAN ANTONIO'S URBAN FOREST, 2018

Table A2—Tree statistics by Forest Inventory and Analysis (FIA) land-use class, extrapolated to sampling area scale from plot inventory in San Antonio, 2018

FIA land-use class	Common name	Woodland species	Invasive species	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
				Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter
					<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>
Agriculture	Bluewood	X		0.0	0.0	—	18,796.8	1.0	5.4	18,796.8	1.0	5.4
	Chinaberry		X	0.0	0.0	—	18,796.8	1.7	7.3	18,796.8	1.7	7.3
	Honey mesquite	X		0.0	0.0	—	555,361.1	17.2	3.1	555,361.1	17.2	3.1
	Post oak			0.0	0.0	—	18,796.8	18.7	23.9	18,796.8	18.7	23.9
	Sugarberry			9,960.1	3.5	10.3	837,804.8	35.8	4.4	847,764.8	39.3	4.5
	Sweet acacia	X		0.0	0.0	—	235,409.0	7.6	4.3	235,409.0	7.6	4.3
	Texas persimmon	X		0.0	0.0	—	706,227.1	2.6	1.4	706,227.1	2.6	1.4
Commercial/ industrial	Ailanthus		X	49,800.3	13.5	9.0	0.0	0.0	—	49,800.3	13.5	9.0
	Ashe juniper	X		27,267.2	20.1	17.5	0.0	0.0	—	27,267.2	20.1	17.5
	Buckley oak			9,960.1	1.2	6.1	0.0	0.0	—	9,960.1	1.2	6.1
	Bur oak			19,920.1	7.6	10.5	0.0	0.0	—	19,920.1	7.6	10.5
	Cedar elm			73,365.3	26.1	10.3	0.0	0.0	—	73,365.3	26.1	10.3
	Chinaberry		X	29,880.2	7.5	8.7	0.0	0.0	—	29,880.2	7.5	8.7
	Chinese tallowtree		X	9,960.1	3.3	10.1	0.0	0.0	—	9,960.1	3.3	10.1
	Crapemyrtle	X		61,582.8	19.3	9.6	0.0	0.0	—	61,582.8	19.3	9.6
	Honey mesquite	X		239,307.0	31.5	5.2	0.0	0.0	—	239,307.0	31.5	5.2
	Live oak			29,880.2	43.2	20.8	0.0	0.0	—	29,880.2	43.2	20.8
	Loquat			9,960.1	1.7	7.1	0.0	0.0	—	9,960.1	1.7	7.1
	Oriental arborvitae			9,960.1	2.2	8.1	0.0	0.0	—	9,960.1	2.2	8.1
	Osage-orange			29,880.2	5.5	7.3	0.0	0.0	—	29,880.2	5.5	7.3
	Pecan			29,880.2	39.0	19.6	27,566.3	4.6	11.8	57,446.4	43.6	17.6
	Shumard oak			59,760.3	27.7	11.0	0.0	0.0	—	59,760.3	27.7	11.0
	Sugarberry			577,974.7	92.5	5.3	0.0	0.0	—	577,974.7	92.5	5.3
	Texas persimmon	X		171,139.1	0.6	1.2	0.0	0.0	—	171,139.1	0.6	1.2
	Velvet ash			9,960.1	19.7	24.5	0.0	0.0	—	9,960.1	19.7	24.5
	Western soapberry			13,633.6	0.9	5.1	0.0	0.0	—	13,633.6	0.9	5.1
	White mulberry			9,960.1	9.9	17.4	0.0	0.0	—	9,960.1	9.9	17.4

SAN ANTONIO'S URBAN FOREST, 2018

Table A2—Tree statistics by Forest Inventory and Analysis (FIA) land-use class, extrapolated to sampling area scale from plot inventory in San Antonio, 2018 (continued)

FIA land-use class	Common name	Woodland species	Invasive species	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
				Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter
					<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>
Forest	Ashe juniper	X		6,308,138.5	656.5	5.4	33,163,750.8	1,484.8	4.6	39,471,889.3	2,141.3	4.8
	Bastard oak			0.0	0.0	—	427,579.1	10.5	3.0	427,579.1	10.5	3.0
	Black cherry			0.0	0.0	—	24,493.6	2.4	8.6	24,493.6	2.4	8.6
	Black hickory			0.0	0.0	—	900,367.1	77.6	6.4	900,367.1	77.6	6.4
	Black walnut			0.0	0.0	—	348,401.4	15.4	2.9	348,401.4	15.4	2.9
	Black willow			0.0	0.0	—	252,291.4	76.3	13.0	252,291.4	76.3	13.0
	Blackjack oak			0.0	0.0	—	38,814.1	5.4	9.1	38,814.1	5.4	9.1
	Bluewood	X		914,739.2	45.2	4.4	1,109,619.4	63.1	5.8	2,024,358.5	108.3	5.0
	Buckley oak			0.0	0.0	—	24,493.6	2.2	8.2	24,493.6	2.2	8.2
	Catclaw acacia	X		0.0	0.0	—	566,211.7	20.1	4.4	566,211.7	20.1	4.4
	Cedar elm			3,820,178.8	140.2	3.2	5,518,764.4	216.5	3.5	9,338,943.2	356.6	3.3
	Chinaberry		X	111,168.9	31.2	10.3	97,035.2	9.4	7.4	208,204.0	40.6	9.2
	Chinese tallowtree		X	0.0	0.0	—	24,493.6	1.0	5.4	24,493.6	1.0	5.4
	Chittamwood, gum bumelia			186,733.9	2.6	1.6	305,111.0	0.4	1.0	491,844.9	3.1	1.3
	Eastern baccharis			440,316.2	5.9	2.2	0.0	0.0	—	440,316.2	5.9	2.2
	Goldenrain tree			173,100.3	6.9	4.1	0.0	0.0	—	173,100.3	6.9	4.1
	Havard oak			0.0	0.0	—	403,085.5	13.6	4.7	403,085.5	13.6	4.7
	Helecho gigante			0.0	0.0	—	38,814.1	3.5	7.3	38,814.1	3.5	7.3
	Honey mesquite	X		2,752,725.8	378.5	5.7	6,458,776.7	369.3	4.7	9,211,502.5	747.9	5.1
	Jerusalem thorn			184,882.9	2.0	1.9	265,880.0	0.7	1.3	450,762.9	2.7	1.6
	Lacey oak			0.0	0.0	—	171,455.4	33.7	11.2	171,455.4	33.7	11.2
	Live oak			891,471.0	198.7	8.1	2,444,698.8	402.0	9.7	3,336,169.7	600.7	9.1
	Mescal bean			4,341,404.8	70.6	2.3	10,946,373.0	128.9	2.4	15,287,777.8	199.5	2.3
	Mexican buckeye			173,100.3	0.5	1.1	0.0	0.0	—	173,100.3	0.5	1.1
	Netleaf hackberry			0.0	0.0	—	48,987.3	4.4	8.2	48,987.3	4.4	8.2
	Post oak			0.0	0.0	—	18,796.8	2.8	9.3	18,796.8	2.8	9.3
	Sugarberry			2,740,607.7	75.4	2.7	2,040,425.3	65.5	3.4	4,781,033.0	140.8	2.9
	Sweet acacia	X		2,697,142.0	97.1	3.4	128,065.5	16.3	9.1	2,825,207.5	113.4	3.6
	Texas live oak			548,295.4	62.8	6.3	75,187.3	8.6	7.8	623,482.6	71.4	6.5
	Texas persimmon	X		7,205,125.9	56.5	1.7	19,173,632.5	178.0	2.2	26,378,758.4	234.5	2.0
	Texas red oak			0.0	0.0	—	171,455.4	16.4	8.4	171,455.4	16.4	8.4
	Texas sophora			173,100.3	2.6	2.5	305,111.0	5.0	3.5	478,211.3	7.6	3.0
	Texas walnut			0.0	0.0	—	97,974.5	11.1	8.8	97,974.5	11.1	8.8

SAN ANTONIO'S URBAN FOREST, 2018

Table A2—Tree statistics by Forest Inventory and Analysis (FIA) land-use class, extrapolated to sampling area scale from plot inventory in San Antonio, 2018 (continued)

FIA land-use class	Common name	Woodland species	Invasive species	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
				Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter
					<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>
Multifamily residential	Ashe juniper	X		11,782.5	1.8	7.5	0.0	0.0	—	11,782.5	1.8	7.5
	Chinaberry		X	37,198.7	24.8	14.0	0.0	0.0	—	37,198.7	24.8	14.0
	Crapemyrtle	X		62,614.8	31.6	13.0	0.0	0.0	—	62,614.8	31.6	13.0
	Live oak			21,742.6	9.8	12.2	0.0	0.0	—	21,742.6	9.8	12.2
	Texas live oak			0.0	0.0	—	18,796.8	10.4	17.8	18,796.8	10.4	17.8
Rangeland/chaparral	Blackjack oak			0.0	0.0	—	18,796.8	21.8	25.8	18,796.8	21.8	25.8
	Honey mesquite	X		0.0	0.0	—	18,796.8	4.2	11.3	18,796.8	4.2	11.3
	Live oak			0.0	0.0	—	18,796.8	31.5	31.0	18,796.8	31.5	31.0
	Sugarberry			0.0	0.0	—	37,593.6	8.8	11.6	37,593.6	8.8	11.6
	Sweet acacia	X		0.0	0.0	—	56,390.4	3.2	5.7	56,390.4	3.2	5.7
Recreation/cemetery	Honey mesquite	X		95,435.1	32.8	11.9	0.0	0.0	—	95,435.1	32.8	11.9
	Sugarberry			163,603.0	18.4	6.7	0.0	0.0	—	163,603.0	18.4	6.7
Residential	Ailanthus		X	667,479.5	39.9	3.9	0.0	0.0	—	667,479.5	39.9	3.9
	Anacua knockaway	X		19,920.1	31.1	18.5	0.0	0.0	—	19,920.1	31.1	18.5
	Apple species			11,782.5	1.2	6.0	0.0	0.0	—	11,782.5	1.2	6.0
	Ashe juniper	X		86,179.8	60.2	15.5	1,215,702.2	170.0	9.4	1,301,882.1	230.2	10.1
	Black hickory			0.0	0.0	—	18,796.8	2.2	8.2	18,796.8	2.2	8.2
	Blackjack oak			0.0	0.0	—	37,593.6	22.1	18.3	37,593.6	22.1	18.3
	Buckley oak			37,198.7	25.8	14.5	0.0	0.0	—	37,198.7	25.8	14.5
	Bur oak			23,565.1	10.5	12.6	0.0	0.0	—	23,565.1	10.5	12.6
	Callery pear		X	129,607.9	59.3	12.5	0.0	0.0	—	129,607.9	59.3	12.5
	Cedar elm			165,831.7	75.5	11.0	104,043.0	13.6	9.2	269,874.7	89.1	10.6
	Chinaberry		X	164,970.6	19.0	5.9	0.0	0.0	—	164,970.6	19.0	5.9
	Chinese elm			11,782.5	1.7	7.3	0.0	0.0	—	11,782.5	1.7	7.3
	Chinese parasoltree		X	11,782.5	2.0	7.8	0.0	0.0	—	11,782.5	2.0	7.8
	Chinese pistache		X	21,742.6	9.4	11.4	0.0	0.0	—	21,742.6	9.4	11.4
	Chinese privet	X		9,960.1	1.9	7.7	0.0	0.0	—	9,960.1	1.9	7.7
	Chinese tallowtree		X	35,376.2	14.0	11.6	0.0	0.0	—	35,376.2	14.0	11.6
	Citrus species			146,772.1	1.8	2.1	0.0	0.0	—	146,772.1	1.8	2.1
	Crapemyrtle	X		800,250.2	99.2	5.6	0.0	0.0	—	800,250.2	99.2	5.6
	Durand oak			13,633.6	8.1	15.7	0.0	0.0	—	13,633.6	8.1	15.7
	Glossy privet	X		0.0	0.0	—	19,407.0	0.9	5.2	19,407.0	0.9	5.2
	Goldenrain tree			23,565.1	25.5	16.3	0.0	0.0	—	23,565.1	25.5	16.3

SAN ANTONIO'S URBAN FOREST, 2018

Table A2—Tree statistics by Forest Inventory and Analysis (FIA) land-use class, extrapolated to sampling area scale from plot inventory in San Antonio, 2018 (continued)

FIA land-use class	Common name	Woodland species	Invasive species	City			Extraterritorial jurisdiction (ETJ)			Combined city and ETJ		
				Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter	Total number of trees	Basal area	Average diameter
					<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>		<i>square feet per acre</i>	<i>inches</i>
Residential (continued)	Green ash			13,633.6	7.2	14.8	0.0	0.0	—	13,633.6	7.2	14.8
	Hackberry			9,960.1	0.9	5.2	0.0	0.0	—	9,960.1	0.9	5.2
	Honey mesquite	X		33,553.7	32.4	17.7	519,797.4	120.2	11.7	553,351.1	152.6	12.4
	Japanese privet	X	X	678,841.2	96.7	5.6	0.0	0.0	—	678,841.2	96.7	5.6
	Live oak			852,358.0	590.4	14.7	1,238,783.3	239.2	9.5	2,091,141.3	829.5	12.5
	Loquat			1,272,370.9	22.2	2.1	0.0	0.0	—	1,272,370.9	22.2	2.1
	Mescal bean			124,069.9	3.2	2.8	0.0	0.0	—	124,069.9	3.2	2.8
	Mexican white oak			23,593.6	4.2	7.7	0.0	0.0	—	23,593.6	4.2	7.7
	Oriental arborvitae			23,565.1	3.6	7.4	0.0	0.0	—	23,565.1	3.6	7.4
	Peach			0.0	0.0	—	42,688.5	2.9	6.6	42,688.5	2.9	6.6
	Pecan			187,574.3	206.1	17.3	0.0	0.0	—	187,574.3	206.1	17.3
	Post oak			0.0	0.0	—	19,407.0	17.1	22.8	19,407.0	17.1	22.8
	Queen sago			0.0	0.0	—	27,566.3	8.7	16.3	27,566.3	8.7	16.3
	Red mulberry			9,960.1	16.8	22.6	0.0	0.0	—	9,960.1	16.8	22.6
	Shumard oak			11,782.5	0.9	5.1	0.0	0.0	—	11,782.5	0.9	5.1
	Southern magnolia			25,416.1	8.2	10.6	0.0	0.0	—	25,416.1	8.2	10.6
	Sugarberry			3,497,099.0	193.7	3.5	185,452.3	23.1	8.9	3,682,551.2	216.8	3.7
	Sweet acacia	X		13,633.6	2.4	8.6	0.0	0.0	—	13,633.6	2.4	8.6
	Velvet ash			250,017.6	207.3	12.1	27,566.3	4.3	11.4	277,583.8	211.6	12.0
	White mulberry			0.0	0.0	—	27,566.3	1.1	5.9	27,566.3	1.1	5.9
Rights-of-way	Cedar elm			25,416.1	7.5	9.7	0.0	0.0	—	25,416.1	7.5	9.7
	Crapemyrtle	X		0.0	0.0	—	55,132.5	4.5	8.0	55,132.5	4.5	8.0
	Honey mesquite	X		37,227.2	19.2	13.3	0.0	0.0	—	37,227.2	19.2	13.3
	Live oak			27,267.2	9.6	11.9	0.0	0.0	—	27,267.2	9.6	11.9
	Other palms			0.0	0.0	—	27,566.3	2.6	8.9	27,566.3	2.6	8.9
	Sugarberry			964,882.1	85.7	4.0	0.0	0.0	—	964,882.1	85.7	4.0
	Washington fan palm			29,880.2	11.8	11.0	0.0	0.0	—	29,880.2	11.8	11.0
	Western soapberry			11,782.5	1.8	7.5	0.0	0.0	—	11,782.5	1.8	7.5

— = no data.

Table A3—Species composition in maintained areas, San Antonio, 2018

	Common name	Total number of trees	Percent
City	Sugarberry	4,014,370.9	36.9
	Loquat	1,282,330.9	11.8
	Crapemyrtle	924,447.8	8.5
	Live oak	917,614.4	8.4
	Ailanthus	717,279.8	6.6
	Japanese privet	597,039.7	5.5
	Honey mesquite	354,662.2	3.3
	Velvet ash	259,977.6	2.4
	Pecan	217,454.5	2.0
	Chinaberry	208,484.4	1.9
	Cedar elm	191,219.3	1.8
	Texas persimmon	171,139.1	1.6
	Citrus species	146,772.1	1.4
	Callery pear	129,607.9	1.2
	Mescal bean	124,069.9	1.1
	Ashe juniper	113,447.0	1.0
	Shumard oak	71,542.9	0.7
	Buckley oak	47,158.7	0.4
	Chinese tallowtree	45,336.2	0.4
	Bur oak	43,485.2	0.4
	Oriental arborvitae	33,525.1	0.3
	Washington fan palm	29,880.2	0.3
	Southern magnolia	25,416.1	0.2
	Mexican white oak	23,593.6	0.2
	Goldenrain tree	23,565.1	0.2
	Chinese pistache	21,742.6	0.2
	Anacua knockaway	19,920.1	0.2
	Durand oak	13,633.6	0.1
	Green ash	13,633.6	0.1
	Western soapberry	13,633.6	0.1
	Apple species	11,782.5	0.1
	Chinese elm	11,782.5	0.1
	Chinese parasol tree	11,782.5	0.1

SAN ANTONIO'S URBAN FOREST, 2018

Table A3—Species composition in maintained areas, San Antonio, 2018 (continued)

	Common name	Total number of trees	Percent
City (continued)	Chinese privet	9,960.1	0.1
	White mulberry	9,960.1	0.1
	Red mulberry	9,960.1	0.1
	Hackberry	9,960.1	0.1
Extraterritorial jurisdiction (ETJ)	Live oak	1,053,007.4	41.6
	Ashe juniper	463,365.0	18.3
	Honey mesquite	437,098.6	17.3
	Sugarberry	157,886.0	6.2
	Blackjack oak	56,390.4	2.2
	Crapemyrtle	55,132.5	2.2
	Cedar elm	48,910.5	1.9
	Peach	42,688.5	1.7
	Other palms	27,566.3	1.1
	White mulberry	27,566.3	1.1
	Velvet ash	27,566.3	1.1
	Pecan	27,566.3	1.1
	Queen sago	27,566.3	1.1
	Glossy privet	19,407.0	0.8
	Post oak	19,407.0	0.8
	Texas live oak	18,796.8	0.7
	Black hickory	18,796.8	0.7
Combined city and ETJ	Sugarberry	4,172,256.9	31.1
	Live oak	1,970,621.8	14.7
	Loquat	1,282,330.9	9.6
	Crapemyrtle	979,580.3	7.3
	Honey mesquite	791,760.8	5.9
	Ailanthus	717,279.8	5.4
	Japanese privet	597,039.7	4.5
	Ashe juniper	576,812.0	4.3
	Velvet ash	287,543.9	2.1
	Pecan	245,020.7	1.8
	Cedar elm	240,129.8	1.8
	Chinaberry	208,484.4	1.6

Table A3—Species composition in maintained areas, San Antonio, 2018 (continued)

	Common name	Total number of trees	Percent
Combined city and ETJ (continued)	Texas persimmon	171,139.1	1.3
	Citrus species	146,772.1	1.1
	Callery pear	129,607.9	1.0
	Mescal bean	124,069.9	0.9
	Shumard oak	71,542.9	0.5
	Blackjack oak	56,390.4	0.4
	Buckley oak	47,158.7	0.4
	Chinese tallowtree	45,336.2	0.3
	Bur oak	43,485.2	0.3
	Peach	42,688.5	0.3
	White mulberry	37,526.3	0.3
	Oriental arborvitae	33,525.1	0.3
	Washington fan palm	29,880.2	0.2
	Other palms	27,566.3	0.2
	Queen sago	27,566.3	0.2
	Southern magnolia	25,416.1	0.2
	Mexican white oak	23,593.6	0.2
	Goldenrain tree	23,565.1	0.2
	Chinese pistache	21,742.6	0.2
	Anacua knockaway	19,920.1	0.1
	Glossy privet	19,407.0	0.1
	Post oak	19,407.0	0.1
	Black hickory	18,796.8	0.1
	Texas live oak	18,796.8	0.1
	Green ash	13,633.6	0.1
	Durand oak	13,633.6	0.1
	Western soapberry	13,633.6	0.1
	Apple species	11,782.5	0.1
	Chinese elm	11,782.5	0.1
	Chinese parasol tree	11,782.5	0.1
	Red mulberry	9,960.1	0.1
	Chinese privet	9,960.1	0.1
	Hackberry	9,960.1	0.1

Table A4—Percentage of live trees identified with damage, maintenance, and site issues in San Antonio, 2018

	Common name	Percent
City	Callery pear	54.5
	Chinaberry	36.6
	Velvet ash	28.2
	Crapemyrtle	27.3
	Pecan	25.4
	Live oak	15.7
	Sugarberry	12.2
	Japanese privet	11.9
	Goldenrain tree	10.4
	Loquat	4.6
	Cedar elm	4.0
	Honey mesquite	3.7
Extraterritorial jurisdiction (ETJ)	Honey mesquite	9.2
	Live oak	7.2
	Sugarberry	4.5
	Mescal bean	2.7
	Bluewood	1.7
	Ashe juniper	0.9
	Cedar elm	0.7
	Texas persimmon	0.1
Combined city and ETJ	Callery pear	54.5
	Velvet ash	32.0
	Crapemyrtle	31.4
	Chinaberry	29.1
	Pecan	20.7
	Japanese privet	11.9
	Goldenrain tree	10.4
	Live oak	10.1
	Sugarberry	10.1
	Honey mesquite	7.6
	Loquat	4.6
	Texas live oak	2.8
	Cedar elm	2.1
	Mescal bean	1.8
	Bluewood	0.9
	Ashe juniper	0.7
	Texas persimmon	0.1

Includes only the live tree population.

Table A5—List of invasive plant species in San Antonio, 2018

Species symbol	Scientific name	Common name	Presence	
			City	ETJ
AIAL	<i>Ailanthus altissima</i>	Ailanthus	X	
ALJU	<i>Albizia julibrissin</i>	Mimosa, silktree	X	X
ELAEA	<i>Elaeagnus</i> spp.	Oleaster	X	
FISI2	<i>Firmiana simplex</i>	Chinese parasoltree	X	
HEDER	<i>Hedera</i> spp.	Ivy	X	
LIJA	<i>Ligustrum japonicum</i>	Japanese privet	X	X
LIGUS2	<i>Ligustrum</i> spp.	Privet	X	X
LOJA	<i>Lonicera japonica</i>	Japanese honeysuckle		X
MEAZ	<i>Melia azedarach</i>	Chinaberry	X	X
NADO	<i>Nandina domestica</i>	Sacred bamboo	X	X
PHSE17	<i>Photinia serratifolia</i>	Taiwanese photinia	X	
PHFR9	<i>Photinia xfraseri</i>	Fraser's photinia	X	X
PICH4	<i>Pistacia chinensis</i>	Chinese pistache	X	
PYCA80	<i>Pyrus calleryana</i>	Callery pear	X	
TRSE6	<i>Triadica sebifera</i>	Chinese tallowtree	X	X
2VH	Vine, herbaceous	Vine, herbaceous	X	

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An analysis of the urban forest in the city and extraterritorial jurisdiction (ETJ) of San Antonio, TX revealed that this area had an estimated 137.8 million live trees across all ownerships. The most common tree species were Ashe juniper (*Juniperus ashei*), Texas persimmon (*Diospyros texana*), mesquite (*Prosopis glandulosa*), sugarberry (*Celtis laevigata*), and honey mesquite (*Prosopis glandulosa*). Trees in San Antonio were estimated to store about 3.5 million tons of carbon (12.8 million tons of carbon dioxide [CO₂]), valued at \$594.4 million. In addition, these trees were estimated to remove about 320,059 tons of carbon from the atmosphere per year (1.2 million tons of CO₂ per year, valued at \$54.5 million per year, which is roughly equivalent to the annual emissions of 253,383 passenger vehicles or energy usage by 138,837 homes). San Antonio's trees also removed about 6,565 tons of air pollution per year (valued at \$61.9 million per year). San Antonio's urban forest was estimated to reduce annual energy costs of residential buildings by \$22.4 million per year. These trees also provided an estimated 382 million cubic feet of avoided stormwater runoff, valued at \$25.5 million per year. The overall compensatory value (the replacement value of trees as a structural asset, which tends to increase with tree size and health) of the urban forest was estimated at \$33.1 billion. The information presented in this bulletin can be used to support urban forest management programs and inform policy and planning to improve environmental quality and human health in San Antonio. The analysis also provides a basis for monitoring changes in the urban forest over time.

Keywords: Urban forests, ecosystem services, carbon, FIA, forest health monitoring, forest inventory, Texas.



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