Urban Forest Resource Analysis
Woodland, California

2018

WOODLAND
City of Trees
CALIFORNIA

DAVEY
Resource Group

Urban Forest Resource Analysis Woodland, California

2018

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Executive Summary

Public trees play a vital role in the City of Woodland, California. They provide numerous tangible and intangible benefits to residents, visitors, and neighboring communities. The City of Woodland recognizes that public trees are a valued resource, a vital component of the urban infrastructure, and part of the City's identity. As of 2018, the public tree inventory includes 14,166 trees.

To support the preservation and management of public trees, the City of Woodland contracted with Davey Resource Group (DRG) in 2009 to conduct a complete inventory of city-managed trees. Completed in 2010, the inventory collected data on 13,140 trees on streets, in parks, and at city facilities. Data collection included species, size, condition, maintenance needs, and geographic location. DRG used this data in conjunction with i-Tree *Streets* benefit-cost modeling software (itreetools.org) to develop a detailed and quantified analysis of the existing structure, function, and value of the public tree inventory (City of Woodland, California Urban Forest Resource Analysis and Community Canopy Study, 2010).

Since then, the public tree inventory has increased in population, individual trees have grown, new trees have been planted, and some older trees have been replaced. A follow-up inventory was completed in 2017. Throughout this time, the inventory data has been maintained by the City of Woodland. This resource analysis provides an update on the structure, conditions, and benefits of the public tree inventory, including key changes since 2010.

Structure

A structural analysis is the first step towards understanding the benefits provided by the public trees, as well as their management needs. As of 2018, Woodland's public tree inventory includes 14,166 trees and 85 available planting sites on streets and in parks. Considering species composition, diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes Woodland's public tree inventory:

- Since 2010, the inventory has increased by 1,026 trees (7.8%).

- 170 unique tree species were identified in the inventory. Since 2010, the number of unique species has increased by 30 species (21.4%).

- The predominant species are London planetree (*Platanus x acerifolia*) (10.3%), Chinese pistache (*Pistacia chinensis*) (10.0%), and crapemyrtle (*Lagerstroemia indica*) (7.3%).[1]

- 74.6% of trees are less than 12 inches DBH[2], indicating a young population that will greatly benefit from structural and training pruning. 6.4% of trees are larger than 24 inches DBH.

- 88.7% of trees are in fair or better condition.

- 80.0% of trees are deciduous broadleaf, evergreen conifers are the second most prevalent at 10.2%.

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[1] Industry standards recommend that no species represent more than 10% of the overall inventory. In 2010, London planetree exceeded this general rule. As of 2018, both London planetree and Chinese pistache are overrepresented in the inventory.
[2] DBH: Diameter at Breast Height. DBH represents the diameter of the tree when measured at 1.4 meters (4.5 feet) above ground (U.S.A. standard).

- Public trees provide an estimated 149.7 acres of canopy cover, about 1.5% of the total land area. The canopy cover from public trees has increased by 48.9 acres (11.2%) since 2010.

- The current stocking level for the public tree inventory is 99.4%, based on a total 14,251 planting sites, including 14,166 trees, 29 vacant sites, and 56 stumps.

- Replacement of the 14,166 public trees with trees of equivalent size, species, and condition, would cost nearly $30.5 million.

Benefits

Annually, Woodland's public trees provide cumulative benefits to the community at an average value of $116.95 per tree, for a total value of nearly $1.7 million. These benefits include:

- Reducing electricity (1,129 MWh) and natural gas (3,123 therms) use through shading and climate effects for a benefit of $264,269, an average of $18.66 per tree.

- Intercepting nearly 7.2 million gallons of stormwater, valued at $56,051, an average of $3.96 per tree.

- Reducing atmospheric carbon dioxide by 782 tons, valued at $11,723, an average of $0.83 per tree.

- Improving air quality by removing 6,381 pounds of particulates, valued at $118,626, an average of $8.37 per tree.

- Increasing property value through beautification for a benefit of $1.2 million, an average of $85.14 per tree.

- Since 2010, the annual benefits from the public tree inventory have increased by $607,424 (57.9%).

When the annual investment of $661,140 for the management of public trees is considered, the annual net benefit (benefits minus investment) to the community is $995,595. In other words, for every $1 invested in public trees, the community receives $2.51 in benefits. This is a significant increase over the net benefits provided by public trees in 2010, when the community was receiving $1.50 in benefits for every $1 invested.

Stormwater
$56,051
3.4%

Air Quality
$118,626
7.2%

CO_2
$11,723
<1%

Energy
$264,296
16.0%

Aesthetic/Other
$1,206,038
72.8%
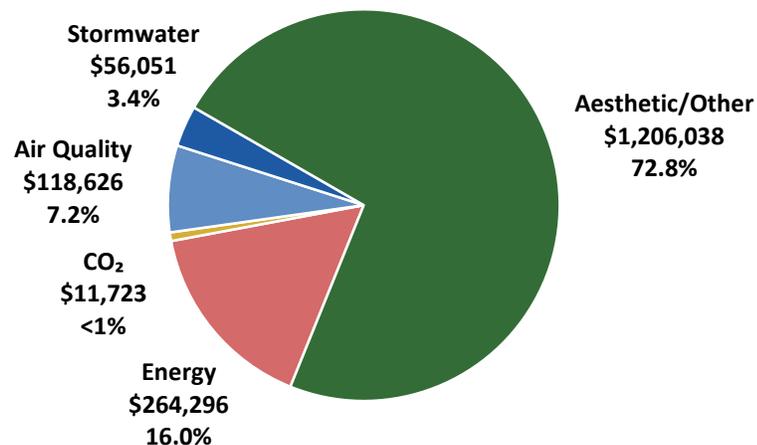
Figure 1: Benefits of the Public Tree Inventory for Woodland

Management

Woodland's public tree inventory is a dynamic resource that requires continued investment to maintain and realize its full benefit potential. Trees are one of the few community assets that have the potential to increase in value with time and proper management.

Appropriate and timely tree care can substantially increase lifespan. When trees live longer, they provide greater benefits. As individual trees mature, and aging trees are replaced, the overall value of the community forest and the amount of benefits provided grow as well. However, this vital living resource is vulnerable to a host of stressors and requires ecologically sound and sustainable best management practices to ensure a continued flow of benefits for future generations.

Overall, the public tree inventory in Woodland is a relatively young resource in fair to good condition. With proactive management, planning, and new and replacement tree planting, the benefits from this resource will continue to increase as young trees mature.

Based on this resource analysis, DRG recommends the following:

- Provide structural pruning for young trees and a regular pruning cycle for all trees.

- Protect existing trees and manage risk with regular inspection to identify and mitigate structural and age-related defects to manage risk and reduce the likelihood of tree and branch failure.

- Increase species diversity in new and replacement tree plantings to reduce reliance on the most prevalent species.

- Continue to maintain and update the inventory database, including tracking tree growth and condition during regular pruning cycles.

With adequate protection and planning, the value of the public tree inventory in Woodland will continue to increase over time. Proactive management and a tree replacement plan are critical to ensuring that residents continue to receive a high return on their investment. Along with new tree installations and replacement plantings, funding for tree maintenance and inspection is vital to preserving benefits, prolonging tree life, and managing risk. Existing mature trees should be maintained and protected whenever possible since the greatest benefits accrue from the continued growth and longevity of the existing canopy. Managers can take pride in knowing that public trees support the quality of life for residents and neighboring communities.

Historic Downtown Woodland

Introduction

Woodland is in Yolo County, California. The City, which encompasses 15.3 square miles, has a current population of 59,068, a 6.3% increase from 55,550 in 2010. The Yolo Bypass and the Sacramento River are to the east of Woodland and the Capay Valley and Coast Mountain Range are to the west. Located in the heart of California, Woodland enjoys a Mediterranean climate 69 feet above sea level, an average of 269 days of sunshine a year, and ample outdoor weather (Sperling's, 2018). Annual precipitation averages 21.4 inches, mostly occurring during the rainy season from October through April. Summers are typically hot and dry. Temperatures range from an average of 38°F in January to 96°F in July.

Woodland has a strong civic pride for the relationship between people and the land. The City is surrounded mainly by farmland. The community combines historic small-time charm with plentiful outdoor amenities. One such amenity is Velocity Island Park, a waterpark with wakeboarding, beach volleyball courts, and restaurants. Woodland also strongly supports bicycling, with a Bikeway Master Plan, which includes plentiful bike racks and bike loops.

The City of Woodland has a rich tree history, going back to their first celebration of Arbor Day in 1903. The community has endeavored to develop a robust tree canopy and there are many resources available to help citizens plant, protect, and learn about trees.

Individual trees and a healthy public tree inventory play an important role in the quality of life and the sustainability of every community. Research demonstrates that healthy urban trees can improve the local environment and diminish the impact resulting from urbanization and industry (Center for Urban Forest Research, 2017). Trees improve air quality by manufacturing oxygen and absorbing carbon dioxide (CO_2), as well as filtering and reducing airborne particulate matter such as smoke and dust. Urban trees reduce energy consumption by shading structures from solar energy and reducing the overall rise in temperature created through urban heat island effects (EPA). Trees slow and reduce stormwater runoff, helping to protect critical waterways from excess pollutants and particulates. In addition, urban trees provide critical habitat for wildlife and promote a connection to the natural world.

In addition to these direct improvements, healthy urban trees increase the overall attractiveness of a community and the value of local real estate by 7% to 10%. Trees also promote shopping, retail sales, and tourism (Wolf, 2007). Trees support a more livable community, fostering psychological health, and providing residents with a greater sense of place (Ulrich, 1986; Kaplan, 1989). Trees soften the urban hardscape by providing a green sanctuary, making Woodland a more enjoyable place to live, work, and play.

The tree inventory data was analyzed with i-Tree's *Streets*, a STRATUM Analysis Tool (*Streets* v5.1.5; i-Tree v6.1.19), to develop a resource analysis and report of the existing condition of the public tree inventory. This report, unique to Woodland, quantifies the value of the public tree resource regarding actual benefits. In addition, the report provides baseline values that can be used to develop and update a public tree resource management plan. Management plans help communities determine where to focus available resources and set benchmarks for measuring progress.

This analysis describes the structure, function, and value of Woodland's public tree resource. With this information, managers and citizens can make informed decisions about tree management strategies. This report provides the following information:

- A description of the current structure of Woodland's public tree resource and an established benchmark for future management decisions.

- The economic value of the benefits from the public tree resource, illustrating the relevance and relationship of trees to local quality of life issues such as air quality, environmental health, economic development, and psychological health.

- Data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-governmental organizations, air quality districts, federal and state agencies, legislative initiatives, or local assessment fees.

- Benchmark data for developing a long-term resource management plan.
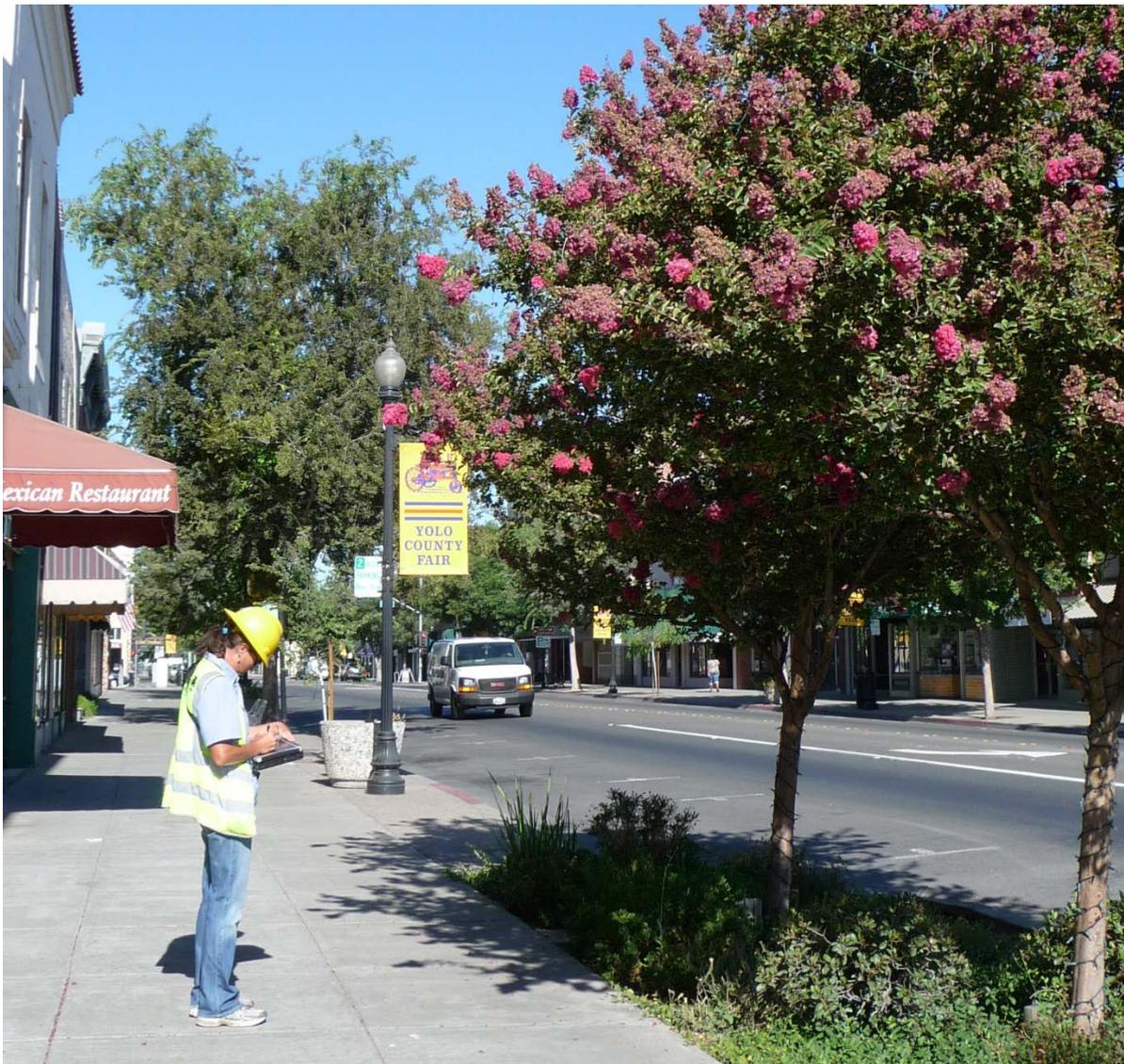
Beautiful Street Trees in Woodland

Public Tree Resource

A tree resource is more thoroughly understood through examination of composition and species richness of diversity (Figure 2). Consideration of stocking level, canopy cover, age distribution, condition, and performance, provide a foundation for planning and management strategies. Inferences based on this data can help managers understand the importance of individual tree species to the overall forest as it exists today and provide a basis to project the future potential of the resource.

Population Composition

Broadleaf species dominate Woodland's public tree resource, composing 80.0% of the total inventory. Broadleaf trees typically have larger canopies than coniferous trees of the same size. Since many of the measurable benefits derived from trees are directly related to leaf surface area, broadleaf trees generally provide the greatest level of benefits to a community. Larger-statured broadleaf tree species provide greater benefits than smaller-statured trees, independent of diameter. The broadleaf deciduous species is composed of three size categories; 30.3% large-stature, 30.3% medium-stature, and 19.4% small-stature trees. Coniferous evergreens comprise 10.2% of the population, with 9.4% large-stature and 0.8% medium-stature. Broadleaf evergreen trees comprise 8.6% of the population, with 4.5% large-stature, 1.5% medium-stature, and 2.6% small-stature trees. There are 61 (0.4%) large palms and 109 (0.8%) small palms, composing 1.2% of the population.

Broadleaf Deciduous Medium (BDM)
4,290
30.3%

Broadleaf Deciduous Small (BDS)
2,749
19.4%

Broadleaf Evergreen Large (BEL)
637
4.5%

Broadleaf Evergreen Medium (BEM)
215
1.5%

Broadleaf Evergreen Small (BES)
372
2.6%

Conifer Evergreen Large (CEL)
1,328
9.4%

Conifer Evergreen Medium (CEM)
118
0.8%

Palm Evergreen Large (PEL)
61
<1%

Palm Evergreen Small (PES)
109
<1%

Broadleaf Deciduous Large (BDL)
4,287
30.3%

Figure 2: Composition of Tree Type and Stature in Woodland

Species Richness and Composition

Woodland's public tree population includes a mix of 170 unique species (Appendix C), significantly more than that of the mean of 53 species reported by McPherson and Rowntree (1989) in their nationwide survey of street tree populations in 22 U. S. cities.

The top three prevalent species represent more than 27.6% of the overall population. These are London planetree (*Platanus x acerifolia* 10.3%), Chinese pistache (*Pistacia chinensis*, 10%), and crapemyrtle (*Lagerstroemia indica*, 7.3%). In general, no single species should represent greater than 10% of the total population and no single genus more than 20% (Clark et al, 1997). London planetree and Chinese pistache exceed this widely-accepted rule. Figure 3 shows the most prevalent species representing more than 1% of the overall tree population.

% of Inventory

Species	%
London planetree	10.3
Chinese pistache	10.0
crapemyrtle	7.3
flowering pear	5.1
Japanese zelkova	3.9
cherry plum	3.8
coast redwood	3.5
valley oak	2.9
little-leaf linden	2.8
holly oak	2.5
Chinese tallowtree	2.4
trident maple	2.4
northern red oak	2.4
flowering crabapple	2.2
Canary Island pine	1.9
velvet ash	1.6
red maple	1.4
Chinese hackberry	1.3
elm	1.3
deodar cedar	1.2
European hornbeam	1.1
ginkgo	1.1
goldenrain tree	1.1
Chinese elm	1.0
xylosma	1.0
All other trees	24.6

Figure 3: Most Prevalent Species in Woodland

Maintaining diversity in a public tree resource is important. Dominance of any single species or genus can have detrimental consequences in the event of storms, drought, disease, pests, or other stressors that can severely affect a public tree resource and the flow of benefits and costs over time. Catastrophic pathogens, such as Dutch elm disease (*Ophiostoma ulmi*), Emerald Ash Borer (*Agrilus planipennis*), Asian Longhorned Beetle (*Anoplophora glabripennis*), and Sudden Oak Death (*Phytophthora ramorum*) are some examples of unexpected, devastating, and costly pests and pathogens that highlight the importance of diversity and the balanced distribution of species and genera.

London planetree (*Platanus x acerifolia*) and Chinese pistache (*Pistacia chinensis*) were the most prevalent species in the 2010 tree inventory. Since 2010, crapemyrtle (*Lagerstroemia indica*) has overcome flowering pear (*Pyrus calleryana*) to become the third most prevalent tree species.

Table 1: Population Summary of Tree Species in Woodland

Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	% of Pop.
DBH Class (in)											
Broadleaf Deciduous Large (BDL)											
London planetree	93	217	355	260	237	140	110	38	8	1,458	10.3%
valley oak	74	102	82	47	42	20	13	11	26	417	2.9%
little-leaf linden	332	70	1	0	0	0	0	0	0	403	2.8%
northern red oak	298	26	9	0	0	0	0	0	0	333	2.4%
velvet ash	52	80	94	1	0	1	0	0	0	228	1.6%
Chinese hackberry	5	25	57	65	24	7	1	0	1	185	1.3%
elm	119	44	14	1	2	0	0	0	0	180	1.3%
Chinese elm	107	34	6	0	0	0	0	0	0	147	1.0%
All Other BDL	230	80	170	139	113	67	46	36	55	936	6.6%
Total	**1,310**	**678**	**788**	**513**	**418**	**235**	**170**	**85**	**90**	**4,287**	**30.3%**
Broadleaf Deciduous Medium (BDM)											
Chinese pistache	323	148	447	389	93	17	2	1	0	1,420	10.0%
flowering pear	74	207	272	127	40	4	1	0	0	725	5.1%
Japanese zelkova	229	159	127	12	10	10	1	1	0	549	3.9%
Chinese tallowtree	70	154	49	48	23	2	1	0	0	347	2.4%
red maple	183	11	0	0	0	0	0	0	0	194	1.4%
European hornbeam	146	9	0	2	4	1	0	0	0	162	1.1%
ginkgo	90	46	9	4	1	0	0	0	0	150	1.1%
goldenrain tree	21	68	47	10	4	0	0	0	0	150	1.1%
All Other BDM	110	137	61	58	31	13	1	0	0	593	5.2%
Total	**1,246**	**939**	**1,012**	**650**	**206**	**47**	**6**	**2**	**0**	**4,290**	**30.3%**
Broadleaf Deciduous Small (BDS)											
crapemyrtle	651	251	127	4	0	0	0	0	0	1,033	7.3%
cherry plum	123	279	126	8	0	0	0	0	0	536	3.8%
trident maple	303	18	5	9	4	0	0	0	0	339	2.4%
flowering crabapple	276	17	13	1	0	0	0	0	0	307	2.2%

Species	DBH Class (in)									Total	% of Pop.
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42		
All Other BDS	331	105	70	26	1	1	0	0	0	534	3.8%
Total	1,684	670	341	48	5	1	0	0	0	2,749	19.4%

Broadleaf Evergreen Large (BEL)											
holly oak	168	137	35	0	3	2	3	0	0	348	2.5%
All Other BEL	63	44	83	47	20	16	6	7	3	289	2.0%
Total	231	181	118	47	23	18	9	7	3	637	4.5%

Broadleaf Evergreen Medium (BEM)											
olive	0	16	21	31	35	24	8	0	2	137	1.0%
All Other BEM	18	13	10	10	14	10	3	0	0	78	0.6%
Total	18	29	31	41	49	34	11	0	2	215	1.5%

Broadleaf Evergreen Small (BES)											
xylosma	4	17	96	26	4	0	0	0	0	147	1.0%
All Other BES	41	52	72	40	15	4	1	0	0	225	1.6%
Total	45	69	168	66	19	4	1	0	0	372	2.6%

Conifer Evergreen Large (CEL)											
coast redwood	47	53	146	139	65	23	13	5	1	492	3.5%
Canary Island pine	48	119	92	2	3	0	0	0	0	264	1.9%
deodar cedar	47	20	39	21	26	13	4	1	1	172	1.2%
All Other CEL	55	36	85	69	74	43	23	10	5	400	2.8%
Total	197	228	362	231	168	79	40	16	7	1,328	9.4%

All Other Populations											
Conifer Evergreen Medium	57	11	22	24	4	0	0	0	0	118	0.8%
Palm Evergreen Medium	0	0	0	0	3	50	8	0	0	61	0.4%
Palm Evergreen Small	0	7	5	10	8	31	39	9	0	109	0.8%
Total	57	18	27	34	15	81	47	9	0	288	2.0%

| All trees | 4,860 | 2,785 | 2,923 | 1,633 | 930 | 517 | 296 | 120 | 102 | 14,166 | 100% |

Species Importance

To quantify the significance of any one species in Woodland's public tree resource, an importance value (IV) is derived for each of the most prevalent species. Importance values are particularly meaningful to public tree resource managers because they indicate a reliance on the functional capacity of a species. **i-Tree *Streets* calculates importance value based on the mean of three values: percentage of total population, percentage of total leaf area, and percentage of total canopy cover.** Importance value goes beyond tree numbers alone to suggest reliance on specific species based on the benefits they provide. The importance value can range from zero (which implies no reliance) to 100 (suggesting total reliance). A complete table, with importance values for all species, is included in Appendix C.

To reiterate, research strongly suggests that no single species should dominate the composition of a public tree resource. Because importance value goes beyond population numbers alone, it can help managers to better comprehend the resulting loss of benefits from a catastrophic loss of any one species. When importance values are comparatively equal among the 10 to 15 most prevalent species, the risk of significant reductions to benefits is reduced. Of course, suitability of the dominant species is another important consideration. Planting short-lived or poorly adapted species can result in short rotations and increased long-term management costs.

Table 2 lists the importance values of the most prevalent species. These 25 species represent 75.4% of the overall population, 64.3% of the total leaf area, and 68.4% of the total canopy cover for a combined importance value of 69.5. Of these, Woodland relies most on two species: London planetree (*Platanus x acerifolia*, IV = 17.6) and Chinese pistache (*Pistacia chinensis*, IV = 13.4). These species dominate the inventory, providing significant benefits and a sense of place. They are key to sustaining the benefits provided by the public tree resource, as well as preserving the essence of Woodland for years to come. However, because these two species are overrepresented in the inventory their prevalence should be reduced through future plantings.

Some species are more significant contributors to the urban forest than population numbers would suggest. For example, English elm (*Ulmus procera*) represents just 0.4% of the population, but 2.4% of canopy cover and 6.1% of leaf surface area. This large-stature species is represented by a significant portion (98.1%) of established trees (>12" DBH). English elm also had a high relative importance value in 2010 (2.97 IV; 0.4% of the inventory). The high IV indicates that this species has the greatest functional capacity to provide benefits compared to their representation in the inventory.

For some species, low importance values are primarily a function of tree type. Immature or small-stature species frequently have lower importance values than their representation in the inventory might suggest. This is largely due to relatively small leaf area and canopy coverage. For example, crapemyrtle (*Lagerstroemia indica*) represents 7.3% of the population, but the importance value is 3.16 and the crowns only contribute to 1.0% of the total leaf area and 1.2% of the canopy.

Table 2: Importance Value of Woodland's Prevalent Species

Species	Number of Trees	% of Pop.	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
London planetree	1,458	10.29	4,454,948	19.65	1,482,775	22.75	**17.56**
Chinese pistache	1,420	10.02	3,370,878	14.87	998,869	15.32	**13.40**
crapemyrtle	1,033	7.29	217,646	0.96	80,823	1.24	**3.16**
flowering pear	725	5.12	910,855	4.02	322,825	4.95	**4.70**
Japanese zelkova	549	3.88	523,328	2.31	191,212	2.93	**3.04**
cherry plum	536	3.78	193,928	0.86	71,712	1.10	**1.91**
coast redwood	492	3.47	1,058,698	4.67	253,130	3.88	**4.01**
valley oak	417	2.94	1,245,441	5.49	282,921	4.34	**4.26**
little-leaf linden	403	2.84	115,617	0.51	11,565	0.18	**1.18**
holly oak	348	2.46	152,926	0.67	38,652	0.59	**1.24**
Chinese tallowtree	347	2.45	362,208	1.60	122,020	1.87	**1.97**
trident maple	339	2.39	110,929	0.49	32,573	0.50	**1.13**
northern red oak	333	2.35	39,488	0.17	6,695	0.10	**0.88**
flowering crabapple	307	2.17	33,822	0.15	12,641	0.19	**0.84**
Canary Island pine	264	1.86	204,732	0.90	47,578	0.73	**1.17**
velvet ash	228	1.61	192,569	0.85	65,382	1.00	**1.15**
red maple	194	1.37	39,894	0.18	8,991	0.14	**0.56**
Chinese hackberry	185	1.31	552,355	2.44	165,656	2.54	**2.09**
elm	180	1.27	64,759	0.29	27,785	0.43	**0.66**
deodar cedar	172	1.21	319,081	1.41	80,677	1.24	**1.29**
European hornbeam	162	1.14	52,171	0.23	11,995	0.18	**0.52**
goldenrain tree	150	1.06	91,906	0.41	42,388	0.65	**0.70**
ginkgo	150	1.06	45,489	0.20	14,205	0.22	**0.49**
xylosma	147	1.04	188,809	0.83	71,986	1.10	**0.99**
Chinese elm	147	1.04	34,312	0.15	14,867	0.23	**0.47**
All other trees	3,480	24.57	8,099,115	35.72	2,058,645	31.58	**30.62**
All trees	**14,166**	**100%**	**22,675,905**	**100%**	**6,518,567**	**100%**	**100.00**

Leaf Surface Area

The amount and distribution of leaf surface area is the driving force behind the public tree resource's ability to produce benefits for the community (Clark et al., 1997). As canopy cover increases, so do the benefits afforded by leaf area. The City of Woodland covers an area of 15.31 square miles. i-Tree estimates that public trees are providing approximately 0.23 square miles (149.7 acres) of canopy cover which accounts for 1.5% of total land area.

Stocking Level

Woodland's public tree resource currently includes 85 available planting sites, including 29 vacant sites and 56 stumps. Considering the public tree inventory identified a total of 14,251 planting sites with 14,166 existing trees, the current stocking level of public trees is 99.4%.

Relative Age Distribution

Age distribution can be approximated by considering the DBH range of the overall inventory and of individual species. Trees with smaller diameters tend to be younger. It is important to note that palms do not increase in DBH over time, so they are not considered in this analysis. In palms, height more accurately correlates to age.

The distribution of individual tree ages within a tree population influences present and future costs as well as the flow of benefits. An ideally-aged population allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy coverage and associated benefits. A desirable distribution has a high proportion of young trees to offset establishment and age-related mortality as the percentage of older trees declines over time (Richards, 1982/83). This ideal, albeit uneven, distribution suggests a large fraction of trees (~40%) should be young, with a DBH less than eight (8) inches, while only 10% should be in the large diameter classes (>24 inches DBH).

The age distribution of Woodland's public tree resource (excluding palms) reveals that 75.4% of trees are 12 inches or less DBH and 6.4% of trees are larger than 24 inches DBH (Figure 4). In 2010, 72.7% of the tree inventory had a DBH of 12 inches or less.
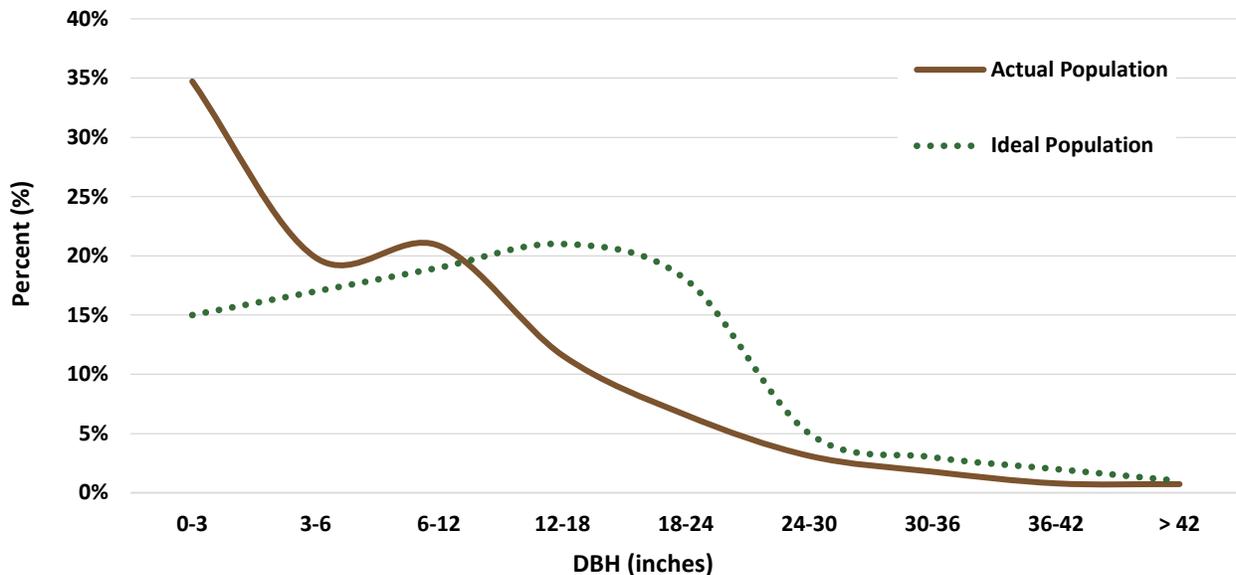
Figure 4: Public Tree Resource Age Distribution for Woodland

Relative age distribution can also be evaluated for each individual species. The 10 most prevalent species are compared against the ideal DBH distribution in Figures 5-6.
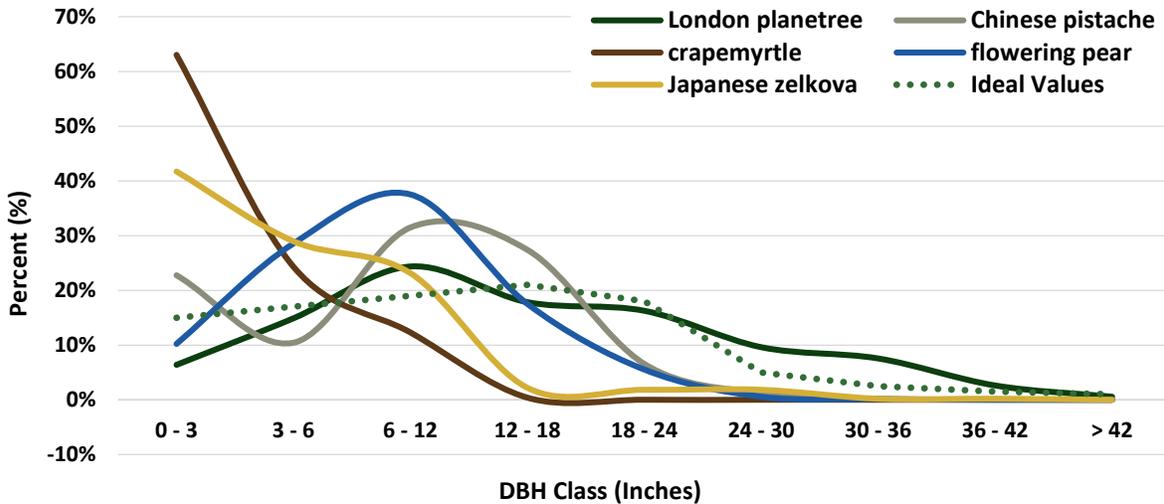
Figure 5: Relative Age Distribution of Top 10 Prevalent Non-Palm Species (Rankings 1-5)
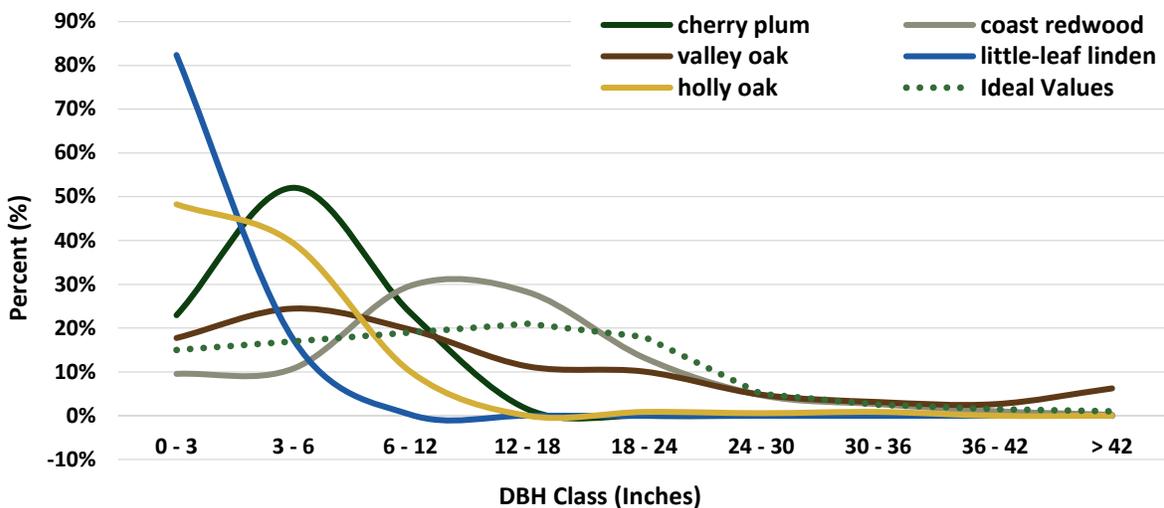
Figure 6: Relative Age Distribution of Top 10 Prevalent Non-Palm Species (Rankings 6-10)

The age distribution of prevalent species can help resource managers to understand and foresee maintenance activities and budgetary needs. In addition to informing managers of the economics of prevalent species, managers can use the age distribution to determine trends in plantings and adopt strategies for species selection in the years to come.

Of Woodland's top 10 most prevalent public tree species (Figures 5 and 6), all have significant representation in small stature, or young establishing trees (0 to 12-inch DBH). London planetree (*Platanus x acerifolia*) has a nearly ideal distribution. With regular inspection and management, the benefits provided by trees have a high potential to increase as trees grow and become established.

Tree Condition and Relative Performance

Tree condition is an indication of how well trees are managed and how well they are performing in each site-specific environment (e.g., street, median, parking lot, etc.). Condition ratings can help managers anticipate maintenance and funding needs. In addition, tree condition is an important factor for the calculation of public tree resource benefits. A condition rating of good assumes that a tree has no major structural problems, no significant mechanical damage, and may have only minor aesthetic, insect, disease, or structural problems, and is in good health. When trees are performing at their peak, as those rated as good or better, the benefits they provide are maximized.

Public trees in Woodland are in overall fair to good condition. 47.2% of trees are in fair condition and 41.6% are in good or better condition. Five percent (5.1%) of trees are in poor condition and 6% are in critical condition or dead/dying (Figure 7).

Figure 7: Tree Condition
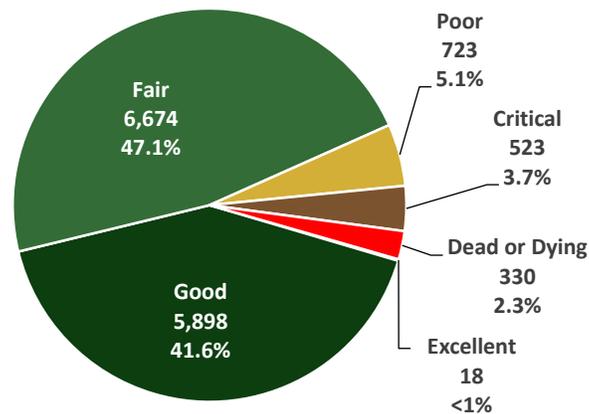
In 2010, 63.1% of trees were in good condition, compared to 41.6% today. The number of trees rated as fair increased from 30.5% in 2010 to 47.1% in 2018. Overall, 93.6% of trees were rated as fair or better in 2010.

Relative Performance Index

The *relative performance index* (RPI) is one way to further analyze the condition and suitability of a specific tree species. The RPI provides an urban forest manager with a detailed perspective on how different species perform compared to each other. The index compares the condition ratings of each tree species with the condition ratings of every other tree species within the inventory. An RPI of 1.0 or better indicates that the species is performing as well or better than average. An RPI value below 1.0 indicates that the species is not performing as well in comparison to the rest of the population.

Among the 25 most prevalent species, 13 have an RPI of 1.0 or greater (Table 3). Canary Island pine (*Pinus canariensis*) has the greatest RPI of 1.16. Xylosma (*Xylosma congestum*, 0.83 RPI) and European hornbeam (*Carpinus betulus*, 0.77 RPI) have the lowest RPI.

The RPI can be a useful tool for urban forest managers. For example, if a community has been planting two or more new species, the RPI can be used to compare their relative performance. If the RPI indicates that one is performing relatively poorly, managers may decide to reduce or even stop planting that species and subsequently save money on both planting stock and replacement costs. The RPI enables managers to look at the performance of long-standing

species as well. Established species with an RPI of 1.00 or greater have performed well over time. These top performers should be retained, and planted, as a healthy proportion of the overall population. It is important to keep in mind that, because RPI is based on condition at the time of the inventory, it may not reflect cosmetic or nuisance issues, especially seasonal issues that are not threatening the health or structure of the trees.

Table 3: Relative Performance Index of Most Prevalent Species

Species	Percent of Trees in Condition %						RPI	# of Trees	% of All Trees
	Excellent	Good	Fair	Poor	Critical	Dead / Dying			
London planetree	0.00	36.69	56.04	5.83	0.75	0.69	**1.02**	1,458	10.29
Chinese pistache	0.14	48.03	44.86	4.08	1.48	1.41	**1.05**	1,420	10.02
crapemyrtle	0.58	36.69	47.53	2.71	9.97	2.52	**0.95**	1,033	7.29
flowering pear	0.14	34.21	51.31	7.17	3.17	4.00	**0.96**	725	5.12
Japanese zelkova	0.00	40.80	51.18	5.10	1.64	1.28	**1.02**	549	3.88
cherry plum	0.00	54.48	44.78	0.37	0.00	0.37	**1.10**	536	3.78
coast redwood	0.41	51.02	45.12	0.81	1.02	1.63	**1.07**	492	3.47
valley oak	0.24	59.47	36.45	1.20	2.16	0.48	**1.09**	417	2.94
little-leaf linden	0.25	32.26	44.17	9.68	6.45	7.20	**0.89**	403	2.84
holly oak	0.00	65.80	30.17	0.86	1.44	1.72	**1.11**	348	2.46
Chinese tallowtree	0.00	49.57	46.40	3.75	0.00	0.29	**1.07**	347	2.45
trident maple	0.00	25.37	58.41	8.55	4.72	2.95	**0.93**	339	2.39
northern red oak	0.00	33.33	47.75	3.00	10.81	5.11	**0.91**	333	2.35
flowering crabapple	0.00	42.35	34.53	6.19	14.66	2.28	**0.93**	307	2.17
Canary Island pine	0.00	84.47	10.23	0.38	3.79	1.14	**1.16**	264	1.86
velvet ash	0.00	64.47	35.09	0.44	0.00	0.00	**1.13**	228	1.61
red maple	0.00	30.93	54.64	3.61	6.70	4.12	**0.94**	194	1.37
Chinese hackberry	0.00	17.30	78.92	3.78	0.00	0.00	**0.97**	185	1.31
elm	0.00	23.89	63.33	3.33	6.11	3.33	**0.93**	180	1.27
deodar cedar	0.00	72.09	25.58	0.58	0.00	1.74	**1.14**	172	1.21
European hornbeam	0.00	24.69	39.51	1.23	28.40	6.17	**0.77**	162	1.14
goldenrain tree	0.00	64.00	34.00	0.67	0.00	1.33	**1.11**	150	1.06
ginkgo	0.00	44.67	49.33	2.00	1.33	2.67	**1.03**	150	1.06
Chinese elm	0.00	29.93	59.86	2.72	4.76	2.72	**0.96**	147	1.04
xylosma	0.00	12.93	42.86	42.86	0.68	0.68	**0.83**	147	1.04
All trees	0.13%	41.63%	47.11%	5.10%	3.69%	2.33%	1.00	14,166	100%

An RPI value less than 1.00 may be indicative of a species that is not well adapted to local conditions. Poorly adapted species are more likely to present increased safety and maintenance issues. Species with an RPI less than 1.00 should receive careful consideration before being selected for future planting choices. However, prior to selecting or deselecting trees based on RPI alone, managers should consider the age distribution of the species, among other factors. A species that has an RPI of less than 1.00 but has a significant number of trees in larger DBH classes, may simply be exhibiting signs of population senescence. A complete table, with RPI values for all species, is included in Appendix C.

RPI is also helpful for identifying underused species that are demonstrating reliable performance. Species with an RPI value greater than 1.00 and an established age distribution may be indicating their suitability for the local environment. These species should receive consideration for additional planting (Table 4).

Table 4: Species That May Be Underused (based on RPI and age distribution)

Species	RPI	# of Trees	% of All Trees
Canary Island date palm	**1.19**	61	0.43
goldenrain tree	**1.11**	150	1.06
European plum	**1.11**	63	0.44
western sycamore	**1.10**	96	0.68
interior live oak	**1.09**	103	0.73
Japanese red pine	**1.08**	75	0.53
cork oak	**1.07**	121	0.85
hind walnut	**1.01**	78	0.55
Idaho locust	**1.01**	91	0.64

RPI is most relevant when there is a moderately high representation of the species. In other words, if there is a single individual that has a high RPI (greater than 1.00) but is the only representative of the species at the site, additional trial plantings of the species can help test the accuracy of the RPI. It is important to use RPI as one of many factors for species selection. Species that have historically experienced major issues in Woodland should be avoided. Prioritize species with a high RPI value that are found on the community's tree planting list.

Replacement Value

The current replacement value of Woodland's public tree resource is $30.5 million (Table 5). The replacement value accounts for the historical investment in trees over their lifetime. The replacement value is also a way of describing the value of a tree population (and/or average value per tree) at a given time. The replacement value reflects current population numbers, stature, placement, and condition. There are several methods available for obtaining a fair and reasonable perception of a tree's value (CTLA, 1992; Watson, 2002). The trunk formula method used in this analysis assumes the value of a tree is equal to the cost of replacing the tree in its current state (Cullen, 2002).

More than 33.3% of the overall replacement value is attributable to London planetree (*Platanus x acerifolia*) and Chinese pistache (*Pistacia chinensis*), for a total of nearly $10.2 million. These species represent 20.3% of the total tree population. London planetree has the highest replacement value of $5.5 million or $ 3,604 per tree (Table 5). The average per tree replacement value is $2,149.

The replacement value for Woodland's public tree resource reflects the vital importance of these assets to the community. With proper care and maintenance, the value will continue to increase over time. It is important to recognize that replacement values are separate and distinct from the value of annual benefits produced by this public tree resource and in some instances the replacement value of a tree may be greater than or less than the benefits that that tree may provide.

In 2010 the replacement value for Woodlands public trees was $29.3 million. Since then, the replacement value has increased 4.2%.

Table 5: Replacement Value for Woodland's Most Prevalent Species

Species	Replacement Value ($) by DBH Class (in)					Total ($)	% of Total Replac. Value	% of Pop.
	0-6	6-18	18-30	30-42	> 42			
London planetree	92,989	1,102,006	2,120,011	1,789,678	150,170	**5,254,855**	17.26	10.27
Chinese pistache	135,642	3,293,534	1,381,189	81,090	0	**4,891,455**	16.07	10.00
valley oak	145,593	485,335	829,444	775,017	1,127,353	**3,298,934**	10.84	7.28
English elm	82,282	0	7,939	424,221	1,008,273	**1,440,568**	4.73	5.11
coast redwood	90,098	447,835	415,435	187,861	15,822	**1,089,891**	3.58	3.87
flowering pear	103,388	676,833	248,924	18,159	0	**1,036,797**	3.41	3.78
cork oak	19,661	222,411	142,378	291,588	162,525	**836,091**	2.75	3.47
olive	70,773	123,197	445,845	115,438	46,663	**738,206**	2.42	2.94
Japanese zelkova	58,915	277,829	203,019	35,775	0	**632,721**	2.08	2.84
river-she oak	80,169	9,559	437,365	80,129	30,742	**559,321**	1.84	2.45
hind walnut	50,547	42,192	99,320	132,956	253,698	**531,031**	1.74	2.44
pine	12,267	28,198	267,322	182,589	44,001	**526,965**	1.73	2.39
western sycamore	13,620	212,225	263,966	38,018	0	**517,222**	1.70	2.35
crapemyrtle	100,505	266,456	0	0	0	**492,150**	1.62	2.16
deodar cedar	41,968	109,891	262,628	68,611	18,179	**473,848**	1.56	1.86
Chinese hackberry	19,843	222,243	178,045	11,255	13,172	**433,551**	1.42	1.61
northern hackberry	3,376	111,966	128,035	106,539	0	**354,312**	1.16	1.37
interior live oak	10,858	206,369	132,402	0	0	**352,566**	1.16	1.30
Chinese tallowtree	24,049	137,844	98,070	8,230	0	**306,055**	1.01	1.27
xylosma	8,334	248,150	31,268	0	0	**287,501**	0.94	1.21
holly oak	29,862	68,064	49,943	57,026	0	**280,508**	0.92	1.14
cypress	20,017	22,508	115,497	102,490	29,334	**269,829**	0.89	1.06
white mulberry	38,590	16,448	206,616	16,459	0	**239,850**	0.79	1.06
cherry plum	38,220	122,998	0	0	0	**235,915**	0.77	1.04
camphor tree	7,626	36,015	131,305	57,026	0	**224,346**	0.74	1.04
All other trees	575,952	1,770,049	1,720,233	699,111	215,451	**5,141,938**	16.89	35.14
All trees	**$1,875,421**	**$10,260,155**	**$9,916,201**	**$5,279,265**	**$3,115,384**	**$30,446,427**	**100%**	**100%**

Woodland Tree Benefits

Public trees are important to Woodland. They help lessen energy use, reduce global carbon dioxide (CO_2) levels, improve air quality, and mitigate stormwater runoff. Additionally, trees provide a wealth of well-documented psychological, social, and economic benefits related primarily to their aesthetic effects. Environmentally, trees make good sense, providing quantifiable benefits to the community; however, the question remains, are the collective benefits worth the cost of management? In other words, are these trees a worthwhile investment for the community? To answer this question, the benefits must be quantified in financial terms.

The i-Tree *Streets* analysis model allows benefits to be quantified based on regional reference cities and local attributes, such as median home values and local energy prices. This analysis provides a snapshot of the annual benefits (along with the value of those benefits) produced by Woodland's tree population. While the annual benefits produced by these trees can be substantial, it is important to recognize that the greatest benefits are derived from the benefit stream that results over time, from a mature population where trees are well managed, healthy, and long-lived.

This analysis used current inventory data on Woodland's trees with i-Tree's *Streets* software to assess and quantify the beneficial functions of this resource and to place a dollar value on the annual environmental benefits these trees provide. The benefits calculated by i-Tree *Streets* are estimations based on the best available and current scientific research with an accepted degree of uncertainty. The data returned from i-Tree *Streets* can provide a platform from which informed management decisions can be made (Maco and McPherson, 2003). A discussion on the methods used to calculate and assign a monetary value to these benefits is included in Appendix C.

Woodland Community & Senior Center

Tree-Lined Streets in Downtown Woodland

Atmospheric Carbon Dioxide Reduction

As environmental awareness continues to increase, governments are paying attention to global warming and the effects of greenhouse gas (GHG) emissions. As energy from the sun (sunlight) strikes the Earth's surface it is reflected into space as infrared radiation (heat). GHGs absorb some of this infrared radiation and trap heat in the atmosphere, modifying the temperature of the Earth's surface. Many chemical compounds in the Earth's atmosphere act as GHGs, including carbon dioxide (CO_2), water vapor, and human-made (gases/aerosols). As GHGs increase, the amount of energy radiated back into space is reduced, and more heat is trapped in the atmosphere. An increase in the average temperature of the Earth may result in changes in weather, sea levels, and land-use patterns, commonly referred to as "climate change."

The Center for Public Urban Forest Research (CUFR) recently led the development of Public Urban Forest Project Reporting Protocol. The protocol, which incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard (VCS), establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides public tree resource managers in developing tree planting and stewardship projects that could be registered for GHG reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, campuses, and utility service areas anywhere in the United States.

While the public tree resource in Woodland may or may not qualify for carbon-offset credits or be traded in the open market, the City's trees are nonetheless providing a significant reduction in atmospheric carbon dioxide (CO_2) for a positive environmental and financial benefit to the community.

Urban trees reduce atmospheric CO_2 in two ways:

- Directly, through growth and the sequestration of CO_2 in wood, foliar biomass, and soil.

- Indirectly, by lowering the demand for heating and air conditioning, thereby reducing the emissions associated with electric power generation and natural gas consumption.

Sequestered Carbon Dioxide

To date, Woodland trees in the public tree resource have stored 9,011 tons of carbon (CO_2) in woody and foliar biomass valued at $135,158. This is a 5.4% increase over the stored carbon in 2010 (8,551 tons).

Annually, all public trees directly sequester an additional 362 tons of CO_2, valued at $5,424. Accounting for estimated CO_2 emissions from tree decomposition (-103 tons), tree related maintenance activity (-110 tons), and avoided CO_2 (530 tons), Woodland's public trees provide an annual net reduction in atmospheric CO_2 of 782 tons, valued at $11,723, with an average value of $0.83 per tree (Table 6).

Among prevalent species, Chinese hackberry (*Celtis sinensis*, $1.68/tree), coast redwood (*Sequoia sempervirens,* $1.49/tree) and valley oak (*Quercus lobata,* $1.49/tree) provide the greatest annual per-tree benefits to carbon sequestration (Figure 8). Due to their prevalence, London planetree (*Platanus x acerifolia)* provides the greatest carbon benefits by population, valued at $2,002, accounting for 17.1% of the total benefit.
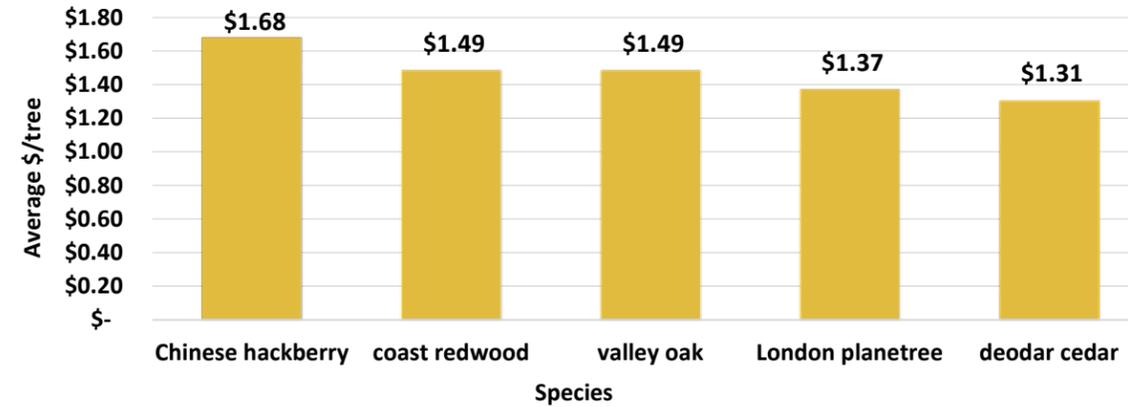
Figure 8: Top Five Species for Carbon Benefits

Table 6: Annual Carbon Benefits from Woodland's Most Prevalent Species

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
London planetree	91,535	687	- 50,584	- 2,875	- 400.95	228,872	1,716.54	266,947	2,002	10.29	17.08	**1.37**
Chinese pistache	51,061	383	- 14,055	- 1,758	- 118.59	172,515	1,293.86	207,764	1,558	10.02	13.29	**1.10**
crapemyrtle	3,032	23	- 644	- 430	- 8.06	11,112	83.34	13,069	98	7.29	0.84	**0.09**
flowering pear	28,559	214	- 5,906	- 829	- 50.51	56,368	422.76	78,193	586	5.12	5.00	**0.81**
Japanese zelkova	21,522	161	- 2,579	- 381	- 22.21	31,705	237.78	50,266	377	3.88	3.22	**0.69**
cherry plum	2,201	17	- 666	- 350	- 7.62	10,286	77.15	11,471	86	3.78	0.73	**0.16**
coast redwood	58,782	441	- 7,939	- 827	- 65.74	47,464	355.98	97,481	731	3.47	6.24	**1.49**
valley oak	64,726	485	- 27,989	- 710	- 215.25	46,569	349.26	82,595	619	2.94	5.28	**1.49**
little-leaf linden	4,073	31	- 22	- 107	- 0.97	1,664	12.48	5,608	42	2.84	0.36	**0.10**
holly oak	18,431	138	- 2,117	- 182	- 17.24	5,903	44.27	22,035	165	2.46	1.41	**0.47**
Chinese tallowtree	10,904	82	- 2,385	- 329	- 20.35	21,057	157.93	29,247	219	2.45	1.87	**0.63**
trident maple	6,015	45	- 394	- 104	- 3.73	5,512	41.34	11,030	83	2.39	0.71	**0.24**
northern red oak	5,433	41	- 101	- 84	- 1.38	951	7.13	6,200	47	2.35	0.40	**0.14**
flowering crabapple	649	5	- 65	- 81	- 1.09	1,575	11.81	2,078	16	2.17	0.13	**0.05**
Canary Island pine	8,018	60	- 448	- 199	- 4.85	8,507	63.80	15,879	119	1.86	1.02	**0.45**
velvet ash	14,190	106	- 480	- 172	- 4.89	9,804	73.53	23,341	175	1.61	1.49	**0.77**
red maple	1,175	9	- 11	- 42	- 0.40	1,335	10.01	2,457	18	1.37	0.16	**0.09**
Chinese hackberry	19,301	145	- 3,710	- 308	- 30.14	26,244	196.83	41,526	311	1.31	2.66	**1.68**
elm	3,817	29	- 196	- 73	- 2.02	4,549	34.11	8,097	61	1.27	0.52	**0.34**
deodar cedar	18,606	140	- 2,770	- 252	- 22.67	14,377	107.82	29,961	225	1.21	1.92	**1.31**
European hornbeam	1,558	12	- 269	- 52	- 2.41	1,895	14.21	3,132	23	1.14	0.20	**0.14**
goldenrain tree	5,996	45	- 734	- 129	- 6.47	7,185	53.89	12,319	92	1.06	0.79	**0.62**
ginkgo	3,126	23	- 219	- 66	- 2.14	2,599	19.50	5,440	41	1.06	0.35	**0.27**
xylosma	8,208	62	- 889	- 185	- 8.05	12,130	90.98	19,264	144	1.04	1.23	**0.98**
Chinese elm	2,361	18	- 40	- 48	- 0.66	2,387	17.90	4,660	35	1.04	0.30	**0.24**
All other trees	269,932	2,024	- 79,959	- 4,928	- 636.65	328,024	2,460.18	513,069	3,848	24.57	32.82	**1.02**
All trees	**723,211**	**$5,424**	**- 205,170**	**- 15,501**	**-$1,655**	**1,060,588**	**$7,954**	**1,563,128**	**$11,723**	**100%**	**100%**	**$0.83**

The Chinese hackberry is one of the best performing, most important, and greatest benefits producing species of trees in Woodland, with an average of $1.68 per tree in carbon benefits. Trees manage carbon through several modes, including storing carbon in the woody mass.

Air Quality Impacts

Urban trees improve air quality in five (5) fundamental ways:

- Absorption of gaseous pollutants such as ozone (O_3), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) through leaf surfaces

- Interception of particulate matter (PM_{10}), such as dust, ash, dirt, pollen, and smoke

- Increase of oxygen levels through photosynthesis

- Transpiration of water and shade provision, resulting in lower local air temperatures, thereby reducing ozone (O_3) levels

PM_{10} is particulate matter in the air that measures less than ten (10) micrometers, smaller than the width of a single human hair. These small particles or liquid droplets include smoke, soot, dust, and secondary reactions from gaseous pollutants. PM_{10} pollution is detrimental to health.

Ozone (O_3) is another air pollutant that is harmful to human health. Ozone forms when nitrogen oxide from fuel combustion and volatile organic gases from evaporated petroleum products react in the presence of sunshine. In the absence of cooling effects provided by trees, higher temperatures contribute to ozone (O_3) formation. Additionally, short-term increases in ozone concentrations are statistically associated with increased tree mortality for 95 large US cities (Bell et al., 2004). However, it should be noted that while trees do a great deal to absorb air pollutants (especially ozone and particulate matter); they also negatively contribute to air pollution. Trees emit biogenic volatile organic compounds (BVOCs), which also contribute to ozone formation. i-Tree *Streets* analysis accounts for these BVOC emissions in the air quality cumulative benefit.

Deposition, Interception, and Avoided Pollutants

Each year, 11,084 pounds of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), small particulate matter (PM_{10}), and ozone (O_3) are intercepted or absorbed by Woodland trees, for a value of $129,952 (Table 7). As a population, London planetree (*Platanus x acerifolia*) is the greatest contributor to pollutant deposition and interception, accounting for 22% of these benefits.

Energy savings provided by trees have the additional indirect benefit of reducing air pollutant emissions (NO_2, PM_{10}, SO_2, and VOCs) that result from energy production. Altogether 2,129 pounds of pollutants, valued at $20,715, are avoided annually through the shading effects of trees.

More than 6,800 pounds of BVOCs are emitted annually from Woodland's public trees, reducing annual benefits to air quality by -$32,042. Of prevalent species, the heaviest emitters by population are London planetree (*Platanus x acerifolia*) and valley oak (*Quercus lobata*) which together emit 51.7% of all BVOCs.

The cumulative value of air pollutants removed by public trees in Woodland is $118,492 an average of $8.38 per tree. Chinese hackberry (*Celtis sinensis*, $19.63/tree) and London planetree ($15.10/tree) are the greatest contributors to air quality benefits (Figure9).
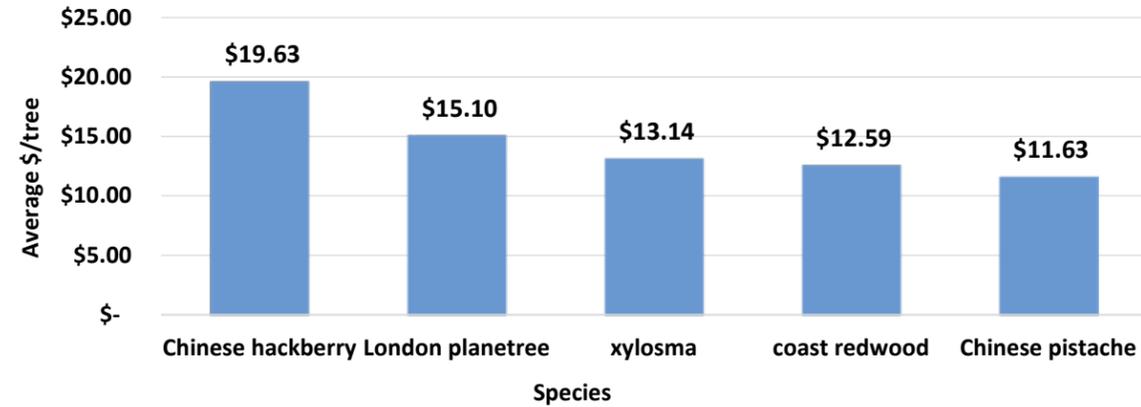
Figure 9: Top Five Species for Air Quality Benefits

Table 7: Annual Air Quality Benefits from Woodland's Most Prevalent Species

Species	Deposition O₃ (lb)	Deposition NO₂ (lb)	Deposition PM₁₀ (lb)	Deposition SO₂ (lb)	Total Deposition ($)	Avoided NO₂ (lb)	Avoided PM₁₀ (lb)	Avoided VOC (lb)	Avoided SO₂ (lb)	Total Avoided ($)	BVOC Emiss. (lb)	BVOC Emiss. ($)	Total (lb)	Total ($)	% of Total Tree Numbers	Avg. $/tree
London planetree	1,320	337	765	0	28,396	279	52	14	124	4,586	- 2,339	- 10,970	552	22,013	10.31	**15.10**
Chinese pistache	915	220	458	0	18,832	197	39	10	94	3,278	- 1,192	- 5,592	740	16,518	10.04	**11.63**
crapemyrtle	67	16	32	0	1,368	13	2	1	6	216	0	0	138	1,584	7.30	**1.53**
flowering pear	298	77	174	0	6,438	71	13	3	31	1,155	0	0	667	7,593	5.13	**10.47**
Japanese zelkova	169	40	83	0	3,454	35	7	2	17	591	0	0	353	4,045	3.88	**7.37**
cherry plum	60	14	29	0	1,214	12	2	1	5	197	0	0	123	1,411	3.79	**2.63**
coast redwood	257	73	183	0	5,947	55	11	3	26	919	- 143	- 670	465	6,196	3.48	**12.59**
valley oak	287	82	205	0	6,647	53	10	3	25	882	- 1,429	- 6,703	- 764	826	2.95	**1.98**
little-leaf linden	11	3	5	0	218	2	0	0	1	32	0	0	22	250	2.85	**0.62**
holly oak	39	11	28	0	908	7	1	0	3	112	- 175	- 823	- 86	197	2.46	**0.57**
Chinese tallowtree	113	29	66	0	2,434	26	5	1	11	431	0	0	252	2,864	2.45	**8.25**
trident maple	29	7	14	0	588	6	1	0	3	103	- 10	- 45	51	646	2.40	**1.91**
northern red oak	7	2	5	0	157	1	0	0	1	19	- 45	- 213	- 30	- 37	2.35	**-0.11**
flowering crabapple	11	2	5	0	214	2	0	0	1	32	0	0	21	246	2.17	**0.80**
Canary Island pine	48	14	34	0	1,118	9	2	0	5	153	- 28	- 130	85	1,141	1.87	**4.32**
velvet ash	56	13	25	0	1,118	12	2	1	5	199	0	0	114	1,316	1.61	**5.77**
red maple	8	2	4	0	162	1	0	0	1	24	- 3	- 16	13	171	1.37	**0.88**
Chinese hackberry	152	37	76	0	3,123	31	6	2	14	508	0	0	317	3,631	1.31	**19.63**
elm	25	6	12	0	502	5	1	0	2	85	0	0	51	587	1.27	**3.26**
deodar cedar	82	23	58	0	1,896	17	3	1	8	283	- 43	- 202	150	1,976	1.22	**11.49**
European hornbeam	11	3	6	0	239	2	0	0	1	39	0	0	24	278	1.15	**1.72**
goldenrain tree	37	9	18	0	766	9	2	0	4	149	- 117	- 550	- 37	365	1.06	**2.43**
ginkgo	13	3	6	0	257	3	1	0	1	53	- 8	- 37	19	272	1.06	**1.82**
xylosma	73	21	52	0	1,691	15	3	1	7	241	0	0	171	1,932	1.04	**13.14**
Chinese elm	13	3	6	0	269	3	1	0	1	45	0	0	27	313	1.04	**2.13**
All Other Trees	1,940	502	1,144	0	41,995	386	74	19	177	6,384	- 1,299	- 6,091	2,943	42,288	24.57	**11.56**
All trees	6,041	1,549	3,495	0	$129,952	1,254	239	62	574	$20,715	- 6,832	-$32,042	6,381	$118,626	100%	**$8.37**

Chinese hackberry is one of the best performing species in Woodland for air quality benefits. Each tree provides an average of $19.63 in annual air quality benefits. Trees filter particulates from the air which improves quality. Trees also remove carbon dioxide from the air through photosynthesis. However, due to overplanting and potential aphid issues, they are no longer planted by the city.

Stormwater Runoff Reductions

Rainfall interception by trees reduces the amount of stormwater that enters collection and treatment facilities during large storm events. Trees intercept rainfall in their canopy, acting as mini-reservoirs, controlling runoff at the source. Healthy urban trees reduce the amount of runoff and pollutant loading in receiving waters in three primary ways:

- Leaves and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
- Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.
- Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on bare soil.

Trees in Woodland intercept more than 7,186,036 gallons of stormwater annually for an average of 507 gallons per tree (Table 8). The total value of this benefit to Woodland is $56,051, an average of $3.96 per tree.

Among the most prevalent species, valley oak (*Quercus lobata*) provides the greatest per tree benefit of $10.69 (Figure 10). London planetree (*Platanus x acerifolia*) provides the largest portion of stormwater benefit at 11.9%, which aligns with the fact that they represent 10.3% of the total population. Combined with the age distribution and stature of these trees, this explains the larger benefit that they provide by comparison to other species.

As trees grow, the benefits that they provide tend to grow as well. Admittedly, some species incur more benefits than others will, and a component of that reality is biology. Some trees have characteristics that hinder their ability to be strong contributors to stormwater runoff reduction, possibly due to a tree having smaller leaves and thinner canopies.
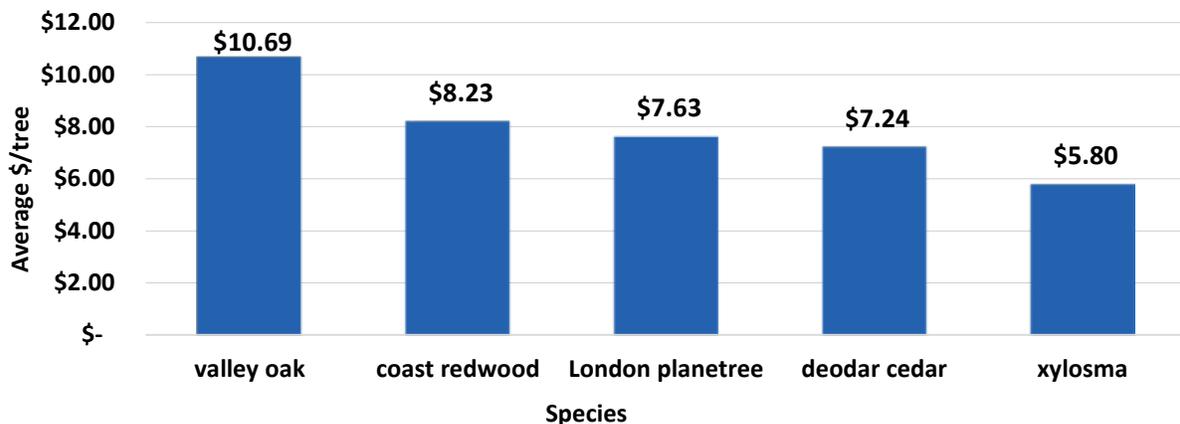
Figure 10: Top Five Species for Stormwater Benefits

Table 8: Annual Stormwater Benefits from Woodland's Most Prevalent Species

Species	Total Rainfall Interception (Gal)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
London planetree	1,426,781	11,129	10.29	19.85	**7.63**
Chinese pistache	741,624	5,785	10.02	10.32	**4.07**
crapemyrtle	57,045	445	7.29	0.79	**0.43**
flowering pear	302,805	2,362	5.12	4.21	**3.26**
Japanese zelkova	131,076	1,022	3.88	1.82	**1.86**
cherry plum	50,619	395	3.78	0.70	**0.74**
coast redwood	519,138	4,049	3.47	7.22	**8.23**
valley oak	571,482	4,458	2.94	7.95	**10.69**
little-leaf linden	9,767	76	2.84	0.14	**0.19**
holly oak	71,987	561	2.46	1.00	**1.61**
Chinese tallowtree	116,559	909	2.45	1.62	**2.62**
trident maple	24,263	189	2.39	0.34	**0.56**
northern red oak	13,681	107	2.35	0.19	**0.32**
flowering crabapple	8,927	70	2.17	0.12	**0.23**
Canary Island pine	98,091	765	1.86	1.37	**2.90**
velvet ash	47,383	370	1.61	0.66	**1.62**
red maple	7,125	56	1.37	0.10	**0.29**
Chinese hackberry	129,319	1,009	1.31	1.80	**5.45**
elm	18,690	146	1.27	0.26	**0.81**
deodar cedar	159,728	1,246	1.21	2.22	**7.24**
European hornbeam	12,363	96	1.14	0.17	**0.60**
goldenrain tree	28,875	225	1.06	0.40	**1.50**
ginkgo	10,475	82	1.06	0.15	**0.54**
xylosma	109,370	853	1.04	1.52	**5.80**
Chinese elm	9,951	78	1.04	0.14	**0.53**
All Other Trees	2,508,913	19,570	24.57	34.91	**5.13**
All trees	**7,186,036**	**$56,051**	**100%**	**100%**	**$3.96**

Energy Savings

Trees modify climate and conserve energy in three principal ways:

- Shading reduces the amount of radiant energy absorbed and stored by hardscape surfaces, thereby reducing the heat island effect.

- Transpiration converts moisture to water vapor, thereby cooling the air by using solar energy that would otherwise result in heating of the air.

- Reduction of wind speed plus the movement of outside air into interior spaces, and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows) (Simpson, 1998).

The *heat island effect* describes the increase in urban temperatures in relation to surrounding suburban and rural areas. Heat islands are associated with an increase in hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger scale, temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy coverage and more vegetated suburban areas (Akbari et al., 1992). The relative importance of these effects depends upon the size and configuration of trees and other landscape elements (McPherson, 1993). Tree spacing, crown spread, and vertical distribution of leaf area each influence the transport of warm air and pollutants along streets and out of urban canyons. Trees reduce conductive heat loss from buildings by reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding). Trees can reduce wind speed and the resulting air infiltration by up to 50%, translating into potential annual heating savings of 25% (Heisler, 1986).

Electricity and Natural Gas Reduction

Electricity and natural gas saved annually Woodland from both the shading and climate effects of trees is equal to 1,129 MWh (valued at $260,397) and 3,123 therms ($3,899), for a total retail savings of approximately $264,296 and an average of $18.66 per tree (Table 9). The species that contribute most to energy benefits on a per-tree basis are London planetree (*Platanus x acerifolia*), with an average value of $39.95 and Chinese hackberry (*Celtis sinensis*) with an average value of $35.15 per tree (Figure 11).

On a per-tree basis, northern red oak (*Quercus rubra*) provides $0.72 in average energy benefits, just 0.1% of the total energy benefits. This is the least amount of energy benefits provided per tree, among prevalent tree species. This low energy benefit is because 89.5% of the northern red oak population is very young (less than 3" DBH). Northern red oaks are large stature trees, and the per tree energy benefits should increase significantly as the tree mature.
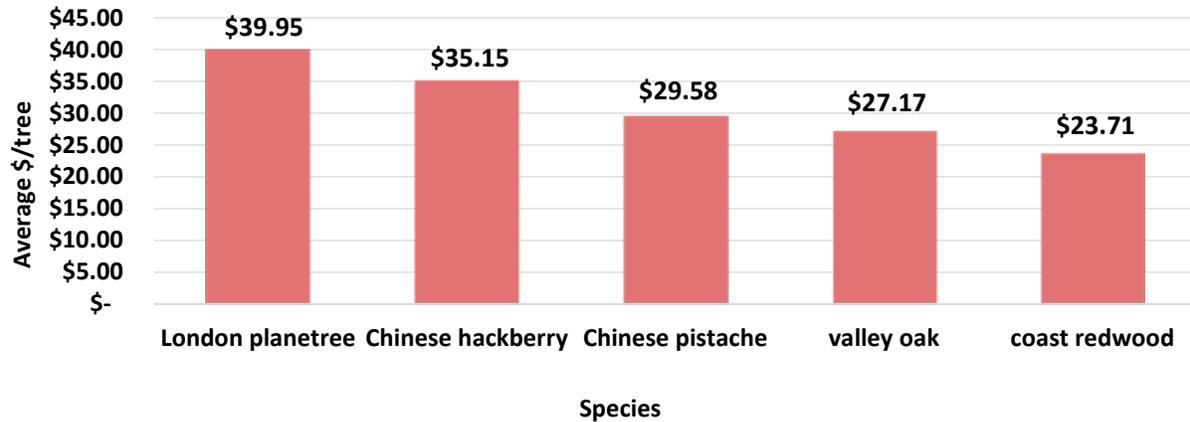
Figure 11: Top Five Species for Energy Benefits

Table 9: Annual Energy Benefits from Woodland's Most Prevalent Species

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
London planetree	244	56,193	1,650	2,061	58,254	10.29	22.04	**39.95**
Chinese pistache	184	42,356	- 286	- 357	41,999	10.02	15.89	**29.58**
crapemyrtle	12	2,728	60	74	2,802	7.29	1.06	**2.71**
flowering pear	60	13,840	541	676	14,515	5.12	5.49	**20.02**
Japanese zelkova	34	7,784	- 121	- 151	7,633	3.88	2.89	**13.90**
cherry plum	11	2,525	30	38	2,563	3.78	0.97	**4.78**
coast redwood	51	11,653	10	12	11,665	3.47	4.41	**23.71**
valley oak	50	11,434	- 84	- 105	11,329	2.94	4.29	**27.17**
little-leaf linden	2	409	4	5	413	2.84	0.16	**1.03**
holly oak	6	1,449	0	0	1,449	2.46	0.55	**4.16**
Chinese tallowtree	22	5,170	199	249	5,419	2.45	2.05	**15.62**
trident maple	6	1,353	- 23	- 29	1,324	2.39	0.50	**3.91**
northern red oak	1	234	6	7	240	2.35	0.09	**0.72**
flowering crabapple	2	387	18	22	409	2.17	0.15	**1.33**
Canary Island pine	9	2,089	- 77	- 96	1,993	1.86	0.75	**7.55**
velvet ash	10	2,407	101	126	2,533	1.61	0.96	**11.11**
red maple	1	328	- 9	- 12	316	1.37	0.12	**1.63**
Chinese hackberry	28	6,444	47	59	6,502	1.31	2.46	**35.15**
elm	5	1,117	- 13	- 16	1,101	1.27	0.42	**6.11**
deodar cedar	15	3,530	42	52	3,582	1.21	1.36	**20.83**
European hornbeam	2	465	20	26	491	1.14	0.19	**3.03**
goldenrain tree	8	1,764	90	112	1,877	1.06	0.71	**12.51**
ginkgo	3	638	19	23	661	1.06	0.25	**4.41**
xylosma	13	2,978	62	77	3,056	1.04	1.16	**20.79**
Chinese elm	3	586	- 5	- 6	580	1.04	0.22	**3.95**
All other trees	349	80,537	843	1,053	81,590	24.57	30.87	**21.95**
All trees	**1,129**	**$260,397**	**3,123**	**$3,899**	**$264,296**	**100%**	**100%**	**$18.66**

Aesthetic, Property Value, and Socioeconomic Benefits

Trees provide beauty in the urban landscape, privacy to homeowners, improved human health, a sense of comfort and place, and habitat for urban wildlife. Research shows that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 1999). Some of these benefits are captured as a percentage of the value of the property on which a tree stands. To determine the value of these less tangible benefits, i-Tree *Streets* uses research that compares differences in sales prices of homes to estimate the contribution associated with trees. Differences in housing prices in relation to the presence (or lack) of a street tree help define the aesthetic value of street trees in the urban environment.

The calculation of annual aesthetic and other benefits corresponds with a tree's annual increase in leaf area. When a tree is actively growing, leaf area may increase dramatically. Once a tree is mature, there may be little or no net increase in leaf area from one year to the next; thus, there is little or no incremental annual aesthetic benefit for that year, although the cumulative benefit over the course of the entire life of the tree may be large. Since this report represents a one-year sample snapshot of the inventoried tree population, **aesthetic benefits reflect the increase in leaf area for each species population over the course of a single year.**

The total annual benefit from Woodland trees associated with property value increases and other less tangible benefits is over $1.2 million, an average of $85.14 per tree (Table 10). Among prevalent species, little-leaf linden (*Tilia cordata*, $216.62) and velvet ash (*Fraxinus velutina*, $212.18) provide the greatest per-tree aesthetic value annually (Figure 12).
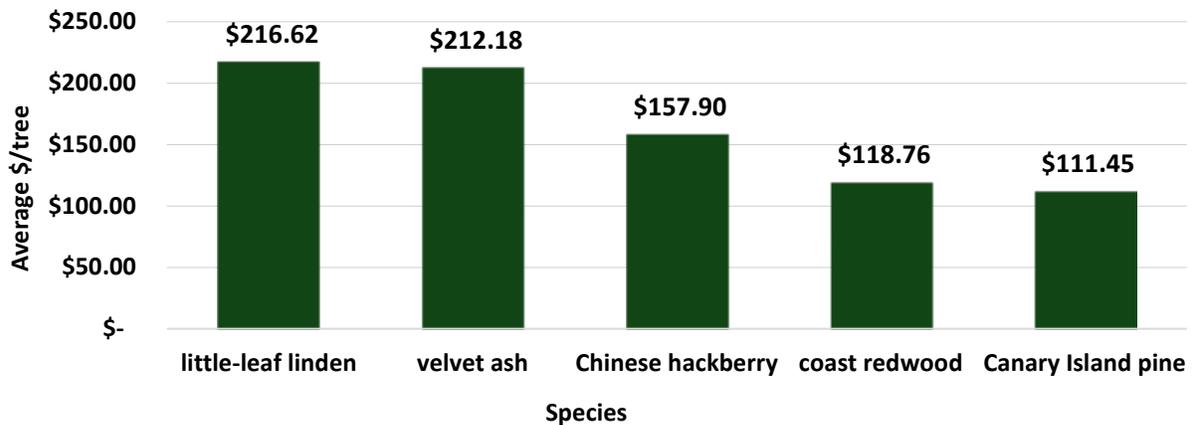
Figure 12: Top Five Species for Aesthetic Benefits

Table 10: Annual Aesthetic Benefits from Woodland's Most Prevalent Species

Species	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
London planetree	130,627	10.29	10.83	89.59
Chinese pistache	143,830	10.02	11.93	101.29
crapemyrtle	12,889	7.29	1.07	12.48
flowering pear	51,163	5.12	4.24	70.57
Japanese zelkova	56,050	3.88	4.65	102.09
cherry plum	6,517	3.78	0.54	12.16
coast redwood	58,432	3.47	4.84	118.76
valley oak	36,513	2.94	3.03	87.56
little-leaf linden	87,299	2.84	7.24	216.62
holly oak	22,400	2.46	1.86	64.37
Chinese tallowtree	28,171	2.45	2.34	81.19
trident maple	31,421	2.39	2.61	92.69
northern red oak	18,295	2.35	1.52	54.94
flowering crabapple	3,870	2.17	0.32	12.61
Canary Island pine	29,422	1.86	2.44	111.45
velvet ash	48,376	1.61	4.01	212.18
red maple	17,071	1.37	1.42	88.00
Chinese hackberry	29,211	1.31	2.42	157.90
elm	15,731	1.27	1.30	87.39
deodar cedar	18,698	1.21	1.55	108.71
European hornbeam	17,980	1.14	1.49	110.99
goldenrain tree	7,451	1.06	0.62	49.68
ginkgo	6,517	1.06	0.54	43.45
xylosma	10,589	1.04	0.88	72.03
Chinese elm	12,283	1.04	1.02	83.56
All other trees	305,232	24.57	25.31	87.01
All trees	**$1,206,038**	**100%**	**100%**	**$85.14**

Annual Per Tree Benefits of Most Prevalent Species
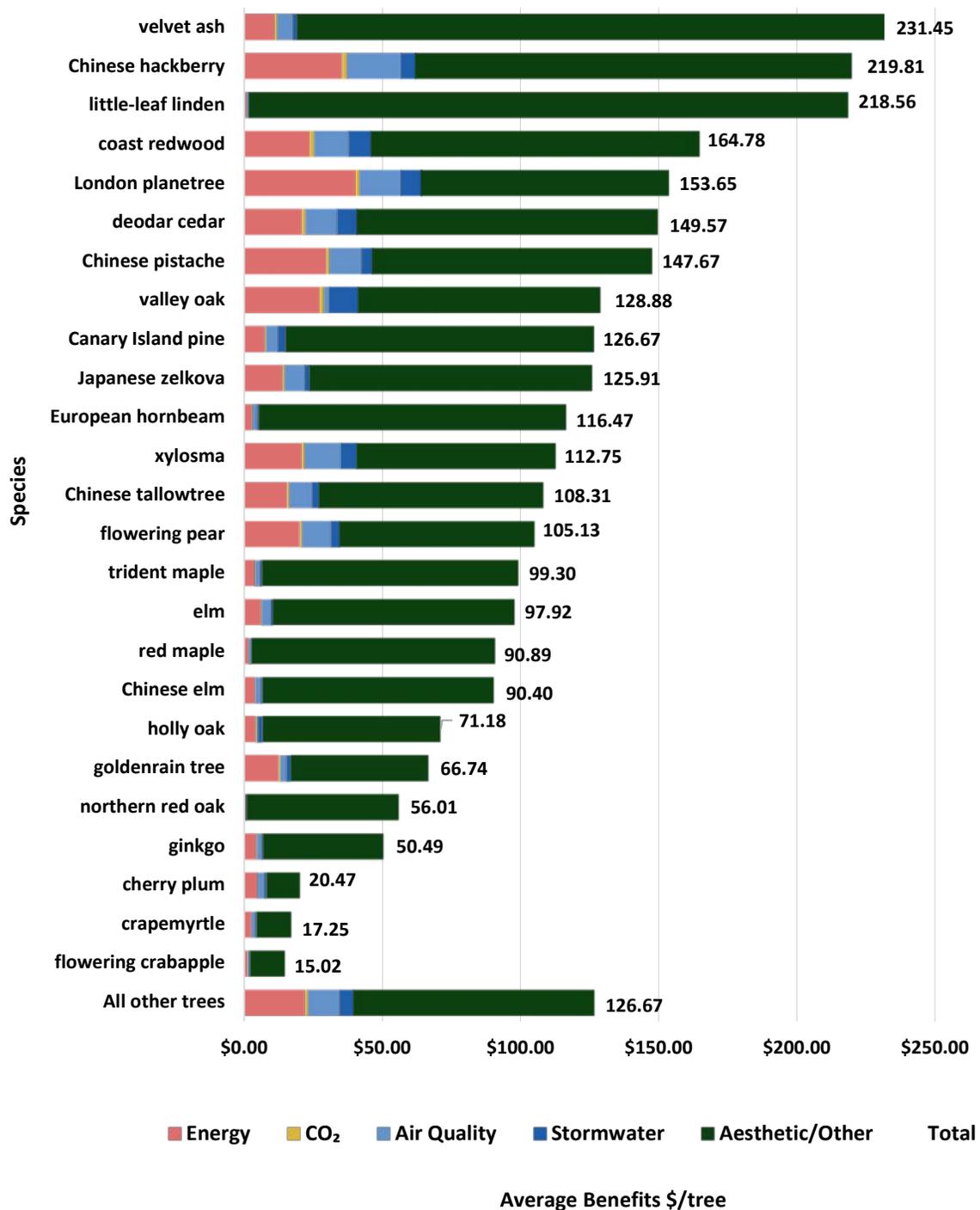
Figure 13: Summary of Annual per Tree Benefits for Most Prevalent Species

Table 11: Summary of Annual Per-Tree Benefits of Prevalent Species

Species	Energy	CO₂	Air Quality	Stormwater	Aesthetic/Other	Total
London planetree	39.95	1.37	15.10	7.63	89.59	153.65
Chinese pistache	29.58	1.10	11.63	4.07	101.29	147.67
crapemyrtle	2.71	0.09	1.53	0.43	12.48	17.25
flowering pear	20.02	0.81	10.47	3.26	70.57	105.13
Japanese zelkova	13.90	0.69	7.37	1.86	102.09	125.91
cherry plum	4.78	0.16	2.63	0.74	12.16	20.47
coast redwood	23.71	1.49	12.59	8.23	118.76	164.78
valley oak	27.17	1.49	1.98	10.69	87.56	128.88
little-leaf linden	1.03	0.10	0.62	0.19	216.62	218.56
holly oak	4.16	0.47	0.57	1.61	64.37	71.18
Chinese tallowtree	15.62	0.63	8.25	2.62	81.19	108.31
trident maple	3.91	0.24	1.91	0.56	92.69	99.30
northern red oak	0.72	0.14	-0.11	0.32	54.94	56.01
flowering crabapple	1.33	0.05	0.80	0.23	12.61	15.02
Canary Island pine	7.55	0.45	4.32	2.90	111.45	126.67
velvet ash	11.11	0.77	5.77	1.62	212.18	231.45
red maple	1.63	0.09	0.88	0.29	88.00	90.89
Chinese hackberry	35.15	1.68	19.63	5.45	157.90	219.81
elm	6.11	0.34	3.26	0.81	87.39	97.92
deodar cedar	20.83	1.31	11.49	7.24	108.71	149.57
European hornbeam	3.03	0.14	1.72	0.60	110.99	116.47
goldenrain tree	12.51	0.62	2.43	1.50	49.68	66.74
ginkgo	4.41	0.27	1.82	0.54	43.45	50.49
xylosma	20.79	0.98	13.14	5.80	72.03	112.75
Chinese elm	3.95	0.24	2.13	0.53	83.56	90.40
All other trees	21.95	1.02	11.56	5.13	87.01	126.67
Average	**$18.66**	**$0.83**	**$8.37**	**$3.96**	**$85.14**	**$116.95**

Net Benefits and Benefit versus Investment Ratio (BIR)

Woodland receives substantial benefits from their public tree resource (Figure 14); however, managers should examine the investments involved in preserving the public tree resource and the benefits that it provides.

A *benefit-investment ratio* (BIR) is an indicator used to summarize the overall value created compared to the investments of a given resource. For this analysis, BIR is the ratio of the total value of benefits provided by all Woodland trees, compared to the cost associated with their management.

Benefits

Woodland's public tree resource has beneficial effects on the environment. Approximately $450,697 of the total annual benefits (over $1.6 million) quantified in this study are environmental services (Figure 14). Annually, Woodland trees provide a total benefit of nearly $1.7 million, a value of $116.95 per tree and $27.79 per capita. Individual components of the environmental benefits include: stormwater management for $56,051 (3.4%), improved air quality $118,626 (7.2%), carbon reductions of $11,723 (0.7%), and energy savings of $264,296 (16.0%) (Table 12). The remainder of the total annual benefits, over $1.2 million (72.8%), are related to aesthetic and socioeconomic benefits including increased property values.

The total estimated benefits provided by Woodland's public tree resource is nearly $1.7 million, a value of $116.95 per tree and $27.79 per capita. These benefits are realized on an annual basis.

Woodland from the Air
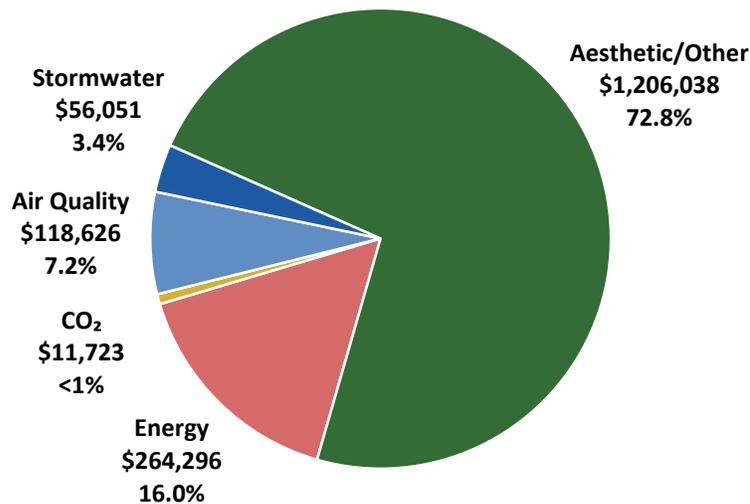
Figure 14: Annual Benefits from Woodland's Public Trees

Total Annual Benefits: $1,656,735

Average Annual Per Tree Benefit: $116.95

A limitation of the annual benefits summary is that it does not fully account for all benefits provided by the public tree resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence.

Empirical evidence of these benefits does exist (Wolf, 2007; Kaplan, 1989; Ulrich, 1986), but there is limited knowledge about the physical processes at work and the complex nature of interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and investments must consider variability among sites (e.g., tree species, growing conditions, maintenance practices) throughout the City, as well as variability in tree growth. In other words, trees are worth far more than what one can ever quantify!

Investment

Investment costs were provided by Woodland (Table 13). The total annual cost of managing the public tree resource in Woodland is $661,140, the bulk of that cost is associated with contract pruning (28.26%) and the remaining balance is attributable to irrigation and planting costs.

Benefit versus Investment Ratio

When Woodland's annual estimated expenditure (or investment) of $661,140 in this resource is considered, the net annual benefit (benefits minus investment) to the City is $995,595. The average net benefit for an individual tree in Woodland is $16.70. Therefore, Woodland is currently receiving $2.51 in benefits for every $1 invested in public trees.

Table 12: Benefits and Investments in the Public tree resource of Woodland

Benefits	Total ($)	$/Tree	$/Capita
Energy	264,296	18.66	4.43
CO_2	11,723	0.83	0.20
Air Quality	118,626	8.37	1.99
Stormwater	56,051	3.96	0.94
Aesthetic/Other	1,206,038	85.14	20.23
Total Benefits	$1,656,735	$116.95	$27.79

Investments	Total	$/Tree	$/Capita
Purchasing Trees and Planting	10,449	0.74	0.18
Contract Pruning	212,872	15.03	3.57
Pest Management	2,572	0.18	0.04
Irrigation	2,443	0.17	0.04
Removal	51,211	3.62	0.86
Administration	346,623	24.47	5.81
Inspection/Service	2,354	0.17	0.04
Litter Clean-up	24,497	1.73	0.41
Liability/Claim	8,119	0.57	0.14
Total Investments	$661,140	$46.67	$11.09

Net Benefits	$995,595	$70.28	$16.70

Benefit-Investment Ratio	2.51		

Table 13: Summary of Annual Tree Benefits 2010 and Now

Category	2010	2017	% Change
Air Benefits	$108,104	$118,492	9.6%
Water Benefits	$50,943	$56,009	9.9%
Carbon Benefits	$10,244	$11,714	14.3%
Energy Benefits	$122,007	$264,045	116.4%
Aesthetic/Property Benefits	$758,033	$1,204,590	58.9%
Total Benefits	$1,049,311	$1,654,850	57.7%

Woodland has seen a 57.7% increase of annual benefits from 2010 to 2018 (Table 12). Energy benefits experienced the greatest increase, from $122,007 to $264,056, a 116.4% change. As the many young trees of the Woodland public tree resource grow, these benefits should continue to increase.

Street Trees along Main Street Provide Many Environmental and Economic Benefits

Conclusion

This analysis describes the current structural characteristics of Woodland's public tree resource, using established numerical modeling and statistical methods to provide a general accounting of the benefits. The analysis provides a "snapshot" of this resource at its current population, structure, and condition. Trees are providing quantifiable impacts on air quality, reduction in atmospheric CO_2, stormwater runoff, and aesthetic benefits. Woodland's 14,166 public trees provide cumulative annual benefits worth $1.7 million, a value of $116.95 per tree and $27.79 per capita.

As a living resource, Woodland's public tree inventory has grown in both size and value since 2010. These changes are reflected in Table 14.

Table 14: Changes in the Public Tree Resource of Woodland (2010-2017)

Category	2010	2017	% Change
Human Population	55,550	59,068	6.33%
Public Trees	13,140	14,166	7.81%
Unique Species	140	170	21.43%
Replacement Cost	$29,225,592	$30,446,427	4.18%
Canopy (Acres)	134.52	149.65	11.24%
Leaf Area (Acres)	471.67	520.57	10.37%
Air Quality Benefit	$108,104	$118,626	9.73%
Stormwater Benefit	$50,943	$56,051	10.03%
Carbon Benefit	$10,244	$11,723	14.44%
Energy Benefit	$122,007	$264,296	116.62%
Aesthetic/Property Benefit	$758,033	$1,206,038	59.10%
Total Annual Benefit	$1,049,311	$1,656,735	57.89%
Annual Investment	$698,397	$661,140	-5.33%
BIR	1.50	2.51	67.06%
Species representing >10%	1	2	100.00%
Deciduous Species	77.00%	80.00%	3.90%
Evergreen Species	22.00%	18.80%	-14.55%
Palm Species	1.00%	1.20%	20.00%
DBH < 12 Inches	74.50%	74.60%	0.13%

Since 2010, Woodland has added 1,026 trees to the public tree resource, an increase of 7.8%. The replacement value of the public tree resource has also increased from $29.2 million to $30.4 million and total annual benefits have increased by $607,424 (57.9%). This increase in benefits occurred despite a 5.3% decrease in the annual investment. Correspondingly, the benefit versus investment ratio increased from $1.50 to $2.51.

Industry standards suggest that no one tree species should represent more than 10% of the urban forest. The number of species comprising over 10% of Woodland's public tree resource has increased from one (London planetree, *Platanus x acerifolia*) in 2010, to two (London planetree and Chinese pistache, *Pistacia chinensis*) as of 2018. Future new and replacement tree

plantings should focus on increasing species diversity and reducing reliance on both London planetree and Chinese pistache.

Woodland's public tree resource has an overall young and established age distribution in fair to good condition with 170 distinct species. The City should continue to focus resources on preserving existing and mature trees to promote health, strong structure, and tree longevity. Structural and training pruning for young trees will maximize the value of this resource, reduce long-term maintenance costs, reduce risk, and ensure that as trees mature they provide the greatest possible benefits over time.

Based on this resource analysis, DRG recommends the following:

- Provide structural pruning for young trees and a regular pruning cycle for all trees.

- Protect existing trees and manage risk with regular inspection to identify and mitigate structural and age-related defects to manage risk and reduce the likelihood of tree and branch failure.

- Increase species diversity in new and replacement tree plantings to reduce reliance on the most prevalent species.

- Continue to maintain and update the inventory database, including tracking tree growth and condition during regular pruning cycles.

Urban forest managers can better anticipate future trends with an understanding of the status of the tree population. Managers can also anticipate challenges and devise plans to increase the current level of benefits. Performance data from this analysis can be used to make determinations regarding species selection, distribution, and maintenance policies. Documenting current structure is necessary for establishing goals and performance objectives and can serve as a benchmark for measuring future success. Information from the public tree resource analysis can be referenced in development of a public tree resource management or master plan. An urban forest master plan is a critical tool for successful public tree resource management, inspiring commitment and providing vision for communication with key decision-makers both inside and outside the organization.

Woodland's trees are of vital importance to the environmental, social, and economic well-being of the community. City leadership has demonstrated that trees are a valued community resource, a vital component of the City infrastructure, and an important part of the community's identity. The inventory data can be used to plan a proactive and forward-looking approach to the future care of public trees. Updates should continue to be incorporated into the inventory a regular maintenance is performed, including updating the DBH and condition of existing trees. Current and complete inventory data will help staff to more efficiently track maintenance activities and tree health and will provide a strong basis for making informed management decisions. A continued commitment to planting, maintaining, and preserving these trees, will support the health and welfare of the city and community at large.

Appendix A: Methodology

In 2017, the City of Woodland provided public tree inventory data to Davey Resource Group. This inventory included details about each tree, including species, size, and condition. DRG formatted the data for use in i-Tree *Streets*, a STRATUM Analysis Tool (Streets v 5.1.5; i-Tree v 6.1.15). i-Tree *Streets* assesses tree population structure and the function of those trees, such as their role in energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. To analyze the economic benefits of Woodland's public trees, i-Tree *Streets* calculates the dollar value of annual resource functionality. This analysis combines the results of the tree inventory with benefit modeling data to produce information regarding resource structure, function, and value for use in determining management recommendations. i-Tree *Streets* regionalizes the calculations of its output by incorporating detailed reference city project information for 17 climate zones across the United States. Woodland is in the Inland Valleys Climate Zone. The reference city is Modesto, California.

An annual resource unit was determined on a per tree basis for each of the modeled benefits. Resource units are measured as MWh of electricity saved per tree; MBtu of natural gas conserved per tree; pounds of atmospheric CO_2 reduced per tree; pounds of NO_2, SO_2, O_3, PM_{10}, and VOCs reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values. Price values assigned to each resource unit (tree) were generated based on economic indicators of society's willingness to pay for the environmental benefits trees provide. The City of Woodland provided the estimated investment costs.

Estimates of benefits are initial approximations as some benefits are difficult to quantify (e.g. impacts on psychological health, crime, and violence). In addition, limited knowledge about the physical processes at work and their interactions makes estimates imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Therefore, this method of quantification provides first-order approximations based on current research. It is intended to be a general accounting of the benefits produced by urban trees.

i-Tree *Streets* default values (Table 15) from the South Climate Zone were used for all benefit prices except for the median home value, and electrical and natural gas rates. Using these rates, the magnitude of the benefits provided by the public tree resource was calculated using i-Tree *Streets*. Electrical and gas rates, and program investment costs were supplied by public tree resource managers for Woodland.

Table 15: Benefit Prices Used in This Analysis

Benefits	Price	Unit	Source
Electricity	0.23073	$/Kwh	Pacific Gas and Electric Company
Natural Gas	1.2486	$/Therm	Pacific Gas and Electric Company
CO_2	0.0075	$/lb	i-Tree Default
PM_{10}	9.41	$/lb	i-Tree Default
NO_2	12.79	$/lb	i-Tree Default
SO_2	3.72	$/lb	i-Tree Default
VOC	4.69	$/lb	i-Tree Default
Stormwater Interception	0.0078	$/gallon	i-Tree Default
Median Home Price	383,094	$	Zillow

Appendix B: References

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Appendix C: Tables

Table 16: Common and Botanical Species Names

Common Species Name	Botanical Species Name	Number of Trees
'prairifire' crabapple	*Malus ioensis 'Prairifire'*	66
African sumac	*Rhus lancea*	7
Aleppo pine	*Pinus halepensis*	15
almond	*Prunus dulcis*	7
American elm	*Ulmus americana*	7
American hornbeam	*Carpinus caroliniana*	31
American linden	*Tilia americana*	4
Amur maple	*Acer tataricum ginnala*	16
apricot	*Prunus armeniaca*	1
Arizona cypress	*Cupressus arizonica*	35
Arizona smooth cypress	*Cupressus glabra*	2
Ash species	*Fraxinus species*	76
atlas cedar	*Cedrus atlantica*	9
Austrian pine	*Pinus nigra*	54
baldcypress	*Taxodium distichum*	8
Bechtel crabapple	*Malus ioensis 'Plena'*	1
birch	*Betula species*	1
black locust	*Robinia pseudoacacia*	55
black tupelo	*Nyssa sylvatica*	34
black walnut	*Juglans nigra*	10
blue oak	*Quercus douglasii*	3
bottle tree	*Brachychiton populneus*	2
burr oak	*Quercus macrocarpa*	2
California laurel	*Umbellularia californica*	18
California palm	*Washingtonia filifera*	97
callery pear 'Chanticleer'	*Pyrus calleryana 'Chanticleer'*	2
callery pear 'Redspire'	*Pyrus calleryana 'Red Spire'*	2
camphor tree	*Cinnamomum camphora*	28
Canary Island date palm	*Phoenix canariensis*	61
Canary Island pine	*Pinus canariensis*	264
Canyon live oak	*Quercus chrysolepis*	4
cape pittosporum	*Pittosporum viridiflorum*	2
Carob	*Ceratonia siliqua*	2
cherry laurel	*Prunus caroliniana*	63
cherry plum	*Prunus cerasifera*	536
chestnut-leaved oak	*Quercus castaneafolia*	10
chinaberry	*Melia azedarach*	9
Chinese elm	*Ulmus parvifolia*	147
Chinese fringe tree	*Chionanthus retusus*	10
Chinese hackberry	*Celtis sinensis*	185

Common Species Name	Botanical Species Name	Number of Trees
Chinese pistache	*Pistacia chinensis*	1,420
Chinese privet	*Ligustrum lucidum*	29
Chinese tallowtree	*Sapium sebiferum*	347
chitalpa	*Chitalpa tashkentensis*	60
citrus	*Citrus species*	7
coast redwood	*Sequoia sempervirens*	492
coastal live oak	*Quercus agrifolia*	33
common fig	*Ficus carica*	4
cork oak	*Quercus suber*	121
cottonwood	*Populus species*	2
crapemyrtle	*Lagerstroemia indica*	1,033
cypress	*Cupressus species*	29
dawn redwood	*Metasequoia glyptostroboi*	11
deodar cedar	*Cedrus deodara*	172
eastern redbud	*Cercis canadensis*	61
eastern redcedar	*Juniperus virginiana*	5
edible apple	*Malus sylvestris*	1
edible pear	*Pyrus communis*	4
elm	*Ulmus species*	180
English elm	*Ulmus procera*	54
English walnut	*Juglans regia*	10
European hackberry	*Celtis australis*	11
European hornbeam	*Carpinus betulus*	162
European plum	*Prunus domestica*	63
European white birch	*Betula pendula*	10
evergreen pear	*Pyrus kawakamii*	49
fastigiata' oak	*Quercus robur 'fastigiata'*	47
fern pine	*Podocarpus gracilior*	1
flowering crabapple	*Malus species*	307
flowering pear	*Pyrus calleryana*	725
flowering plum	*Prunus blireana*	13
fraser photinia	*Photinia x fraseri*	21
Freeman maple	*Acer x freemanii*	7
Fremont cottonwood	*Populus fremontii*	47
ginkgo	*Ginkgo biloba*	150
goldenrain tree	*Koelreuteria paniculata*	150
green ash	*Fraxinus pennsylvanica*	8
gum	*Eucalyptus species*	8
hedge maple	*Acer campestre*	1
hind walnut	*Juglans hindsii*	78
holly oak	*Quercus ilex*	348
honeylocust	*Gleditsia triacanthos*	33
horsetail tree	*Casuarina equisetifolia*	16
Idaho locust	*Robinia ambigua idahoensis*	91
incense cedar	*Calocedrus decurrens*	8

Common Species Name	Botanical Species Name	Number of Trees
interior live oak	*Quercus wislizeni*	103
Italian alder	*Alnus cordata*	3
Italian cypress	*Cupressus sempervirens*	42
Italian stone pine	*Pinus pinea*	2
Japanese black pine	*Pinus thunbergiana*	6
Japanese cryptomeria	*Cryptomeria japonica*	1
Japanese flowering cherry	*Prunus serrulata*	2
Japanese maple	*Acer palmatum*	23
Japanese pagoda tree	*Sophora japonica*	9
Japanese red pine	*Pinus densiflora*	75
Japanese zelkova	*Zelkova serrata*	549
juniper	*Juniperus species*	5
Kentucky coffeetree	*Gymnocadus dioicus*	10
laurel de olor	*Laurus nobilis*	27
lemon	*Citrus limon*	2
Leyland cypress	*Cupressocyparis x leylandii*	5
little-leaf linden	*Tilia cordata*	403
Lombardy poplar	*Populus nigra italica*	5
London planetree	*Platanus x acerifolia*	1,458
maple	*Acer species*	26
mayten tree	*Maytenus boaria*	2
Mediterranean fan palm	*Chamaerops humilis*	1
Mexican fan palm	*Washingtonia robusta*	9
Modesto ash	*Fraxinus velutina 'Modesto'*	97
Mondell pine	*Pinus eldarica*	49
Monterey cypress	*Cupressus macrocarpa*	2
mulberry	*Morus species*	4
northern hackberry	*Celtis occidentalis*	80
northern red oak	*Quercus rubra*	333
Norway maple	*Acer platanoides*	42
oak	*Quercus species*	67
oleander	*Nerium oleander*	2
olive	*Olea europaea*	137
orange	*Citrus sinensis*	2
orchid tree	*Bauhinia species*	1
oriental arborvitae	*Platycladus orientalis*	4
Other species	*Other species*	9
peach	*Prunus persica*	4
pecan	*Carya illinoensis*	4
pin oak	*Quercus palustris*	4
pine	*Pinus species*	93
plum	*Prunus species*	17
pomegranate	*Punica granatum*	2
Ponderosa pine	*Pinus ponderosa*	2
purple smoke tree	*Cotinus coggygria*	6

Common Species Name	Botanical Species Name	Number of Trees
queen palm	*Arecastrum romanzoffianum*	2
raywood ash	*Fraxinus angustifolia 'Raywood'*	24
red maple	*Acer rubrum*	194
redbud	*Cercis species*	51
red-flowering gum	*Eucalyptus ficifolia*	2
river-she oak	*Casuarina cunninghamiana*	46
saucer magnolia	*Magnolia x soulangiana*	2
saw-leaf zelkova	*Zelkova serrata 'Wireless'*	33
scarlet oak	*Quercus coccinea*	43
Siberian elm	*Ulmus pumila*	1
silver maple	*Acer saccharinum*	30
smooth hawthorn	*Crataegus laevigata*	61
southern live oak	*Quercus virginiana*	36
southern magnolia	*Magnolia grandiflora*	15
star magnolia	*Magnolia stellata*	2
strawberry tree	*Arbutus unedo*	23
sweetgum	*Liquidambar styraciflua*	17
tarata	*Pittosporum eugenioides*	10
toyon	*Heteromeles arbutifolia*	4
tree of heaven	*Ailanthus altissima*	10
trident maple	*Acer buergerianum*	339
tulip tree	*Liriodendron tulipifera*	39
Turkish pine	*Pinus brutia*	13
Unknown shrub	*Unknown shrub*	7
Unknown species	*Unknown species*	16
valley oak	*Quercus lobata*	417
velvet ash	*Fraxinus velutina*	228
walnut	*Juglans species*	26
Washington hawthorn	*Crataegus phaenopyrum*	27
weeping willow	*Salix babylonica*	8
western catalpa	*Catalpa speciosa*	5
western hackberry	*Celtis reticulata*	27
western sycamore	*Platanus racemosa*	96
white alder	*Alnus rhombifolia*	13
white ash	*Fraxinus americana*	25
white mulberry	*Morus alba*	58
willow	*Salix species*	10
willow oak	*Quercus phellos*	11
xylosma	*Xylosma congestum*	147
yew pine	*Podocarpus macrophyllus*	4
All trees		**14,166**

Table 17: Importance Value for All Tree Species

Species	Number of Trees	% of Total Trees	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
London planetree	1,458	10.29	4,454,948	19.65	1,482,775	22.75	**17.56**
Chinese pistache	1,420	10.02	3,370,878	14.87	998,869	15.32	**13.40**
crapemyrtle	1,033	7.29	217,646	0.96	80,823	1.24	**3.16**
flowering pear	725	5.12	910,855	4.02	322,825	4.95	**4.70**
Japanese zelkova	549	3.88	523,328	2.31	191,212	2.93	**3.04**
cherry plum	536	3.78	193,928	0.86	71,712	1.10	**1.91**
coast redwood	492	3.47	1,058,698	4.67	253,130	3.88	**4.01**
valley oak	417	2.94	1,245,441	5.49	282,921	4.34	**4.26**
little-leaf linden	403	2.84	115,617	0.51	11,565	0.18	**1.18**
holly oak	348	2.46	152,926	0.67	38,652	0.59	**1.24**
Chinese tallowtree	347	2.45	362,208	1.60	122,020	1.87	**1.97**
trident maple	339	2.39	110,929	0.49	32,573	0.50	**1.13**
northern red oak	333	2.35	39,488	0.17	6,695	0.10	**0.88**
flowering crabapple	307	2.17	33,822	0.15	12,641	0.19	**0.84**
Canary Island pine	264	1.86	204,732	0.90	47,578	0.73	**1.17**
velvet ash	228	1.61	192,569	0.85	65,382	1.00	**1.15**
red maple	194	1.37	39,894	0.18	8,991	0.14	**0.56**
Chinese hackberry	185	1.31	552,355	2.44	165,656	2.54	**2.09**
elm	180	1.27	64,759	0.29	27,785	0.43	**0.66**
deodar cedar	172	1.21	319,081	1.41	80,677	1.24	**1.29**
European hornbeam	162	1.14	52,171	0.23	11,995	0.18	**0.52**
goldenrain tree	150	1.06	91,906	0.41	42,388	0.65	**0.70**
ginkgo	150	1.06	45,489	0.20	14,205	0.22	**0.49**
xylosma	147	1.04	188,809	0.83	71,986	1.10	**0.99**
Chinese elm	147	1.04	34,312	0.15	14,867	0.23	**0.47**
olive	137	0.97	646,611	2.85	136,769	2.10	**1.97**
cork oak	121	0.85	307,680	1.36	72,922	1.12	**1.11**
interior live oak	103	0.73	120,712	0.53	42,225	0.65	**0.64**
Modesto ash	97	0.68	440,548	1.94	131,611	2.02	**1.55**
California palm	97	0.68	34,941	0.15	17,226	0.26	**0.37**
western sycamore	96	0.68	242,648	1.07	82,249	1.26	**1.00**
pine	93	0.66	270,813	1.19	74,599	1.14	**1.00**
Idaho locust	91	0.64	48,866	0.22	26,045	0.40	**0.42**
northern hackberry	80	0.56	285,143	1.26	76,934	1.18	**1.00**
hind walnut	78	0.55	522,452	2.30	127,305	1.95	**1.60**
Ash species	76	0.54	139,032	0.61	49,158	0.75	**0.63**
Japanese red pine	75	0.53	146,333	0.65	31,898	0.49	**0.55**
oak	67	0.47	71,165	0.31	22,084	0.34	**0.38**
'prairifire' crabapple	66	0.47	4,187	0.02	1,660	0.03	**0.17**
European plum	63	0.44	23,582	0.10	9,238	0.14	**0.23**
cherry laurel	63	0.44	49,543	0.22	16,825	0.26	**0.31**

Species	Number of Trees	% of Total Trees	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
smooth hawthorn	61	0.43	6,214	0.03	2,535	0.04	**0.17**
Canary Island date palm	61	0.43	69,323	0.31	67,375	1.03	**0.59**
eastern redbud	61	0.43	6,408	0.03	2,631	0.04	**0.17**
chitalpa	60	0.42	45,775	0.20	14,365	0.22	**0.28**
white mulberry	58	0.41	197,434	0.87	67,373	1.03	**0.77**
black locust	55	0.39	30,893	0.14	16,373	0.25	**0.26**
Austrian pine	54	0.38	6,387	0.03	1,480	0.02	**0.14**
English elm	54	0.38	1,383,820	6.10	157,683	2.42	**2.97**
redbud	51	0.36	5,590	0.02	2,136	0.03	**0.14**
Mondell pine	49	0.35	67,978	0.30	14,753	0.23	**0.29**
evergreen pear	49	0.35	91,549	0.40	36,157	0.55	**0.43**
fastigiata' oak	47	0.33	9,501	0.04	368	0.01	**0.13**
Fremont cottonwood	47	0.33	130,818	0.58	39,458	0.61	**0.50**
river-she oak	46	0.32	184,374	0.81	48,984	0.75	**0.63**
scarlet oak	43	0.30	5,370	0.02	991	0.02	**0.11**
Norway maple	42	0.30	10,404	0.05	2,798	0.04	**0.13**
Italian cypress	42	0.30	102,764	0.45	26,160	0.40	**0.38**
tulip tree	39	0.28	66,070	0.29	13,072	0.20	**0.26**
southern live oak	36	0.25	12,675	0.06	3,329	0.05	**0.12**
Arizona cypress	35	0.25	66,600	0.29	12,054	0.18	**0.24**
black tupelo	34	0.24	6,795	0.03	1,094	0.02	**0.10**
honeylocust	33	0.23	48,938	0.22	22,889	0.35	**0.27**
coastal live oak	33	0.23	98,757	0.44	23,604	0.36	**0.34**
saw-leaf zelkova	33	0.23	22,326	0.10	11,799	0.18	**0.17**
American hornbeam	31	0.22	5,301	0.02	621	0.01	**0.08**
silver maple	30	0.21	37,187	0.16	14,395	0.22	**0.20**
cypress	29	0.20	113,453	0.50	31,029	0.48	**0.39**
Chinese privet	29	0.20	58,651	0.26	21,429	0.33	**0.26**
camphor tree	28	0.20	160,574	0.71	33,496	0.51	**0.47**
laurel de olor	27	0.19	24,092	0.11	7,729	0.12	**0.14**
western hackberry	27	0.19	19,246	0.08	6,097	0.09	**0.12**
Washington hawthorn	27	0.19	2,102	0.01	870	0.01	**0.07**
walnut	26	0.18	194,825	0.86	49,062	0.75	**0.60**
maple	26	0.18	7,076	0.03	2,038	0.03	**0.08**
white ash	25	0.18	106,414	0.47	32,433	0.50	**0.38**
raywood ash	24	0.17	91,663	0.40	23,917	0.37	**0.31**
Japanese maple	23	0.16	7,737	0.03	2,515	0.04	**0.08**
strawberry tree	23	0.16	13,596	0.06	4,531	0.07	**0.10**
fraser photinia	21	0.15	21,968	0.10	8,052	0.12	**0.12**
California laurel	18	0.13	17,169	0.08	6,202	0.10	**0.10**
plum	17	0.12	1,078	0.00	427	0.01	**0.04**
sweetgum	17	0.12	57,246	0.25	9,122	0.14	**0.17**
horsetail tree	16	0.11	31,619	0.14	7,714	0.12	**0.12**

Species	Number of Trees	% of Total Trees	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
Unknown species	16	0.11	16,224	0.07	5,553	0.09	**0.09**
Amur maple	16	0.11	1,209	0.01	498	0.01	**0.04**
Aleppo pine	15	0.11	70,984	0.31	20,440	0.31	**0.24**
southern magnolia	15	0.11	11,723	0.05	3,063	0.05	**0.07**
flowering plum	13	0.09	825	0.00	327	0.01	**0.03**
white alder	13	0.09	24,787	0.11	8,824	0.14	**0.11**
Turkish pine	13	0.09	5,705	0.03	1,363	0.02	**0.05**
European hackberry	11	0.08	46,135	0.20	13,401	0.21	**0.16**
willow oak	11	0.08	4,527	0.02	768	0.01	**0.04**
dawn redwood	11	0.08	19,340	0.09	5,794	0.09	**0.08**
willow	10	0.07	9,265	0.04	3,252	0.05	**0.05**
European white birch	10	0.07	9,928	0.04	2,714	0.04	**0.05**
Chinese fringe tree	10	0.07	1,617	0.01	582	0.01	**0.03**
chestnut-leaved oak	10	0.07	3,856	0.02	647	0.01	**0.03**
tree of heaven	10	0.07	20,037	0.09	7,189	0.11	**0.09**
Kentucky coffeetree	10	0.07	47,681	0.21	13,806	0.21	**0.16**
English walnut	10	0.07	30,491	0.13	10,563	0.16	**0.12**
tarata	10	0.07	9,514	0.04	3,366	0.05	**0.05**
black walnut	10	0.07	94,546	0.42	23,152	0.36	**0.28**
chinaberry	9	0.06	18,274	0.08	6,328	0.10	**0.08**
Other species	9	0.06	10,688	0.05	3,679	0.06	**0.06**
Mexican fan palm	9	0.06	1,781	0.01	868	0.01	**0.03**
atlas cedar	9	0.06	18,649	0.08	5,860	0.09	**0.08**
Japanese pagoda tree	9	0.06	84,649	0.37	14,323	0.22	**0.22**
weeping willow	8	0.06	26,558	0.12	9,237	0.14	**0.11**
gum	8	0.06	49,728	0.22	11,759	0.18	**0.15**
baldcypress	8	0.06	43,146	0.19	12,549	0.19	**0.15**
incense cedar	8	0.06	14,426	0.06	3,697	0.06	**0.06**
green ash	8	0.06	25,354	0.11	9,036	0.14	**0.10**
Freeman maple	7	0.05	1,280	0.01	247	0.00	**0.02**
Unknown shrub	7	0.05	444	0.00	176	0.00	**0.02**
citrus	7	0.05	8,776	0.04	3,348	0.05	**0.05**
American elm	7	0.05	138,887	0.61	16,869	0.26	**0.31**
almond	7	0.05	3,588	0.02	1,265	0.02	**0.03**
African sumac	7	0.05	7,994	0.04	3,066	0.05	**0.04**
purple smoke tree	6	0.04	381	0.00	151	0.00	**0.02**
Japanese black pine	6	0.04	890	0.00	64	0.00	**0.02**
western catalpa	5	0.04	10,319	0.05	3,192	0.05	**0.04**
juniper	5	0.04	6,594	0.03	1,327	0.02	**0.03**
Lombardy poplar	5	0.04	26,924	0.12	7,620	0.12	**0.09**
Leyland cypress	5	0.04	1,216	0.01	440	0.01	**0.02**
eastern redcedar	5	0.04	328	0.00	71	0.00	**0.01**
oriental arborvitae	4	0.03	763	0.00	207	0.00	**0.01**

Species	Number of Trees	% of Total Trees	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
mulberry	4	0.03	6,423	0.03	2,219	0.03	**0.03**
edible pear	4	0.03	3,028	0.01	1,047	0.02	**0.02**
yew pine	4	0.03	708	0.00	120	0.00	**0.01**
pin oak	4	0.03	334	0.00	21	0.00	**0.01**
peach	4	0.03	1,032	0.00	484	0.01	**0.01**
Canyon live oak	4	0.03	11,103	0.05	3,263	0.05	**0.04**
pecan	4	0.03	12,460	0.05	3,920	0.06	**0.05**
American linden	4	0.03	11,897	0.05	3,551	0.05	**0.05**
toyon	4	0.03	4,356	0.02	1,606	0.02	**0.02**
common fig	4	0.03	643	0.00	292	0.00	**0.01**
blue oak	3	0.02	9,673	0.04	2,962	0.05	**0.04**
Italian alder	3	0.02	4,681	0.02	1,761	0.03	**0.02**
star magnolia	2	0.01	923	0.00	341	0.01	**0.01**
lemon	2	0.01	354	0.00	60	0.00	**0.01**
Monterey cypress	2	0.01	6,289	0.03	1,450	0.02	**0.02**
orange	2	0.01	354	0.00	60	0.00	**0.01**
callery pear 'Chanticleer'	2	0.01	1,694	0.01	590	0.01	**0.01**
red-flowering gum	2	0.01	2,628	0.01	1,102	0.02	**0.01**
Japanese flowering cherry	2	0.01	1,110	0.00	381	0.01	**0.01**
oleander	2	0.01	1,719	0.01	587	0.01	**0.01**
Ponderosa pine	2	0.01	7,463	0.03	1,800	0.03	**0.02**
Carob	2	0.01	15,168	0.07	4,274	0.07	**0.05**
bottle tree	2	0.01	12,830	0.06	2,854	0.04	**0.04**
pomegranate	2	0.01	915	0.00	285	0.00	**0.01**
callery pear 'Redspire'	2	0.01	2,350	0.01	883	0.01	**0.01**
cottonwood	2	0.01	3,458	0.02	1,080	0.02	**0.02**
Arizona smooth cypress	2	0.01	4,320	0.02	639	0.01	**0.01**
cape pittosporum	2	0.01	2,334	0.01	872	0.01	**0.01**
mayten tree	2	0.01	4,850	0.02	1,568	0.02	**0.02**
burr oak	2	0.01	6,417	0.03	1,889	0.03	**0.02**
saucer magnolia	2	0.01	444	0.00	141	0.00	**0.01**
Italian stone pine	2	0.01	8,593	0.04	2,217	0.03	**0.03**
queen palm	2	0.01	419	0.00	211	0.00	**0.01**
apricot	1	0.01	1,175	0.01	441	0.01	**0.01**
edible apple	1	0.01	63	0.00	25	0.00	**0.00**
hedge maple	1	0.01	852	0.00	260	0.00	**0.00**
birch	1	0.01	209	0.00	66	0.00	**0.00**
Bechtel crabapple	1	0.01	63	0.00	25	0.00	**0.00**
Siberian elm	1	0.01	13,110	0.06	2,439	0.04	**0.03**
Japanese cryptomeria	1	0.01	69	0.00	61	0.00	**0.00**
fern pine	1	0.01	75	0.00	9	0.00	**0.00**
Mediterranean fan palm	1	0.01	406	0.00	208	0.00	**0.00**
orchid tree	1	0.01	75	0.00	9	0.00	**0.00**
All trees	**14,166**	**100%**	**22,675,905**	**100%**	**6,518,567**	**100%**	**100**

Table 18: DBH Distribution and RPI for All Tree Species

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48	# of Trees	% of Pop.	RPI
Broadleaf Deciduous Large (BDL)													
London planetree	93	217	355	260	237	140	110	38	5	3	1,458	10.3%	**1.02**
valley oak	74	102	82	47	42	20	13	11	20	6	417	2.9%	**4.26**
little-leaf linden	332	70	1	0	0	0	0	0	0	0	403	2.8%	**1.18**
northern red oak	298	26	9	0	0	0	0	0	0	0	333	2.4%	**0.88**
velvet ash	52	80	94	1	0	1	0	0	0	0	228	1.6%	**1.16**
Chinese hackberry	5	25	57	65	24	7	1	0	0	1	185	1.3%	**2.10**
elm	119	44	14	1	2	0	0	0	0	0	180	1.3%	**0.66**
Chinese elm	107	34	6	0	0	0	0	0	0	0	147	1.0%	**0.47**
Modesto ash	5	5	2	4	28	24	21	6	2	0	97	0.7%	**1.55**
western sycamore	1	6	31	31	21	4	2	0	0	0	96	0.7%	**1.00**
northern hackberry	2	17	27	15	8	5	5	1	0	0	80	0.6%	**1.00**
hind walnut	0	7	27	5	9	7	3	7	2	11	78	0.6%	**1.60**
oak	29	8	15	9	4	1	1	0	0	0	67	0.5%	**0.38**
English elm	1	0	0	0	1	0	6	13	27	6	54	0.4%	**2.97**
Fremont cottonwood	9	3	8	20	6	0	1	0	0	0	47	0.3%	**0.51**
fastigiata' oak	47	0	0	0	0	0	0	0	0	0	47	0.3%	**0.13**
scarlet oak	42	0	0	1	0	0	0	0	0	0	43	0.3%	**0.11**
Norway maple	37	4	1	0	0	0	0	0	0	0	42	0.3%	**0.13**
tulip tree	3	5	22	8	0	1	0	0	0	0	39	0.3%	**0.26**
honeylocust	3	9	8	10	3	0	0	0	0	0	33	0.2%	**0.27**
silver maple	12	2	8	7	0	1	0	0	0	0	30	0.2%	**0.20**
walnut	0	3	2	3	9	1	2	3	2	1	26	0.2%	**0.60**
white ash	1	1	1	3	8	10	0	1	0	0	25	0.2%	**0.38**
sweetgum	0	4	4	5	3	0	1	0	0	0	17	0.1%	**0.17**
willow oak	8	2	1	0	0	0	0	0	0	0	11	0.1%	**0.04**
European hackberry	2	0	2	2	3	2	0	0	0	0	11	0.1%	**0.16**
dawn redwood	4	0	4	2	1	0	0	0	0	0	11	0.1%	**0.08**
Kentucky coffeetree	0	0	2	5	0	3	0	0	0	0	10	0.1%	**0.16**
black walnut	0	0	1	1	2	2	1	3	0	0	10	0.1%	**0.28**
chestnut-leaved oak	8	1	1	0	0	0	0	0	0	0	10	0.1%	**0.03**
baldcypress	0	0	0	0	1	3	3	1	0	0	8	0.1%	**0.15**
American elm	1	0	0	0	1	0	0	1	0	4	7	0.0%	**0.31**
Freeman maple	7	0	0	0	0	0	0	0	0	0	7	0.0%	**0.02**
western catalpa	0	1	2	2	0	0	0	0	0	0	5	0.0%	**0.04**
Lombardy poplar	0	0	1	2	0	2	0	0	0	0	5	0.0%	**0.09**
pecan	1	0	0	2	1	0	0	0	0	0	4	0.0%	**0.05**
American linden	2	0	0	0	2	0	0	0	0	0	4	0.0%	**0.05**

Species	DBH Class (in)										# of Trees	% of Pop.	RPI
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48			
pin oak	4	0	0	0	0	0	0	0	0	0	4	0.0%	**0.01**
blue oak	0	1	0	1	1	0	0	0	0	0	3	0.0%	**0.04**
burr oak	0	1	0	0	1	0	0	0	0	0	2	0.0%	**0.02**
cottonwood	1	0	0	1	0	0	0	0	0	0	2	0.0%	**0.02**
Siberian elm	0	0	0	0	0	1	0	0	0	0	1	0.0%	**0.03**
Total	**1,310**	**678**	**788**	**513**	**418**	**235**	**170**	**85**	**58**	**32**	**4,287**	**30.3%**	

Broadleaf Deciduous Medium (BDM)													
Chinese pistache	323	148	447	389	93	17	2	1	0	0	1,420	10.0%	**13.42**
flowering pear	74	207	272	127	40	4	1	0	0	0	725	5.1%	**4.70**
Japanese zelkova	229	159	127	12	10	10	1	1	0	0	549	3.9%	**3.04**
Chinese tallowtree	70	154	49	48	23	2	1	0	0	0	347	2.5%	**1.98**
red maple	183	11	0	0	0	0	0	0	0	0	194	1.4%	**0.56**
European hornbeam	146	9	0	2	4	1	0	0	0	0	162	1.1%	**0.52**
ginkgo	90	46	9	4	1	0	0	0	0	0	150	1.1%	**0.49**
goldenrain tree	21	68	47	10	4	0	0	0	0	0	150	1.1%	**0.71**
Idaho locust	19	35	37	0	0	0	0	0	0	0	91	0.6%	**0.42**
Ash species	11	23	9	23	4	2	3	1	0	0	76	0.5%	**0.64**
white mulberry	2	0	4	7	21	22	2	0	0	0	58	0.4%	**0.77**
black locust	13	19	22	1	0	0	0	0	0	0	55	0.4%	**0.26**
southern live oak	24	8	4	0	0	0	0	0	0	0	36	0.3%	**0.12**
black tupelo	32	1	1	0	0	0	0	0	0	0	34	0.2%	**0.10**
saw-leaf zelkova	14	4	14	1	0	0	0	0	0	0	33	0.2%	**0.17**
American hornbeam	30	1	0	0	0	0	0	0	0	0	31	0.2%	**0.08**
maple	22	3	1	0	0	0	0	0	0	0	26	0.2%	**0.08**
raywood ash	0	0	2	5	10	1	6	0	0	0	24	0.2%	**0.31**
Unknown species	8	1	3	3	1	0	0	0	0	0	16	0.1%	**0.11**
white alder	1	0	7	2	3	0	0	0	0	0	13	0.1%	**0.09**
willow	1	4	4	1	0	0	0	0	0	0	10	0.1%	**0.05**
tree of heaven	0	1	4	3	1	0	1	0	0	0	10	0.1%	**0.05**
European white birch	1	3	6	0	0	0	0	0	0	0	10	0.1%	**0.12**
English walnut	0	0	2	2	4	1	1	0	0	0	10	0.1%	**0.08**
Japanese pagoda tree	0	0	0	2	5	2	0	0	0	0	9	0.1%	**0.06**
chinaberry	1	1	3	1	3	0	0	0	0	0	9	0.1%	**0.22**
Other species	0	4	4	0	1	0	0	0	0	0	9	0.1%	**0.11**
weeping willow	0	0	0	3	2	3	0	0	0	0	8	0.1%	**0.10**
green ash	0	0	0	6	2	0	0	0	0	0	8	0.1%	**0.03**
edible pear	1	1	2	0	0	0	0	0	0	0	4	0.0%	**0.02**
mulberry	1	0	2	0	1	0	0	0	0	0	4	0.0%	**0.02**

Species	DBH Class (in)										# of Trees	% of Pop.	RPI
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48			
Italian alder	0	0	2	1	0	0	0	0	0	0	3	0.0%	**0.01**
callery pear 'Redspire'	0	0	2	0	0	0	0	0	0	0	2	0.0%	**0.01**
callery pear 'Chanticleer'	0	1	1	0	0	0	0	0	0	0	2	0.0%	**0.00**
birch	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.01**
apricot	0	0	1	0	0	0	0	0	0	0	1	0.0%	**0.01**
Total	**1,318**	**912**	**1,088**	**653**	**233**	**65**	**18**	**3**	**0**	**0**	**4,290**	**30.3%**	

Broadleaf Deciduous Small (BDS)													
crapemyrtle	651	251	127	4	0	0	0	0	0	0	1,033	7.3%	**3.16**
cherry plum	123	279	126	8	0	0	0	0	0	0	536	3.8%	**1.91**
trident maple	303	18	5	9	4	0	0	0	0	0	339	2.4%	**1.13**
flowering crabapple	276	17	13	1	0	0	0	0	0	0	307	2.2%	**0.84**
'prairifire' crabapple	66	0	0	0	0	0	0	0	0	0	66	0.5%	**0.17**
European plum	2	48	11	2	0	0	0	0	0	0	63	0.4%	**0.23**
smooth hawthorn	52	8	1	0	0	0	0	0	0	0	61	0.4%	**0.17**
eastern redbud	51	9	1	0	0	0	0	0	0	0	61	0.4%	**0.17**
chitalpa	0	9	39	12	0	0	0	0	0	0	60	0.4%	**0.28**
redbud	45	4	1	1	0	0	0	0	0	0	51	0.4%	**0.14**
western hackberry	1	5	10	10	1	0	0	0	0	0	27	0.2%	**0.12**
Washington hawthorn	25	2	0	0	0	0	0	0	0	0	27	0.2%	**0.07**
Japanese maple	16	6	1	0	0	0	0	0	0	0	23	0.2%	**0.08**
plum	17	0	0	0	0	0	0	0	0	0	17	0.1%	**0.04**
Amur maple	15	1	0	0	0	0	0	0	0	0	16	0.1%	**0.04**
flowering plum	13	0	0	0	0	0	0	0	0	0	13	0.1%	**0.03**
Chinese fringe tree	8	1	1	0	0	0	0	0	0	0	10	0.1%	**0.03**
almond	0	4	2	0	0	1	0	0	0	0	7	0.0%	**0.03**
Unknown shrub	7	0	0	0	0	0	0	0	0	0	7	0.0%	**0.02**
purple smoke tree	6	0	0	0	0	0	0	0	0	0	6	0.0%	**0.02**
peach	0	4	0	0	0	0	0	0	0	0	4	0.0%	**0.01**
common fig	2	2	0	0	0	0	0	0	0	0	4	0.0%	**0.01**
pomegranate	1	0	0	1	0	0	0	0	0	0	2	0.0%	**0.01**
saucer magnolia	1	1	0	0	0	0	0	0	0	0	2	0.0%	**0.01**
Japanese flowering cherry	0	1	1	0	0	0	0	0	0	0	2	0.0%	**0.01**
star magnolia	1	0	1	0	0	0	0	0	0	0	2	0.0%	**0.01**
Bechtel crabapple	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.00**
edible apple	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.00**
hedge maple	0	0	1	0	0	0	0	0	0	0	1	0.0%	**0.00**
Total	**1,684**	**670**	**341**	**48**	**5**	**1**	**0**	**0**	**0**	**0**	**2,749**	**19.4%**	**8.74**

Species	DBH Class (in)										# of Trees	% of Pop.	RPI
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48			
Broadleaf Evergreen Large (BEL)													
holly oak	168	137	35	0	3	2	3	0	0	0	348	2.5%	**1.24**
cork oak	26	22	29	22	5	5	5	4	2	1	121	0.9%	**1.11**
interior live oak	18	17	42	17	5	4	0	0	0	0	103	0.7%	**0.64**
coastal live oak	14	0	4	4	5	3	0	3	0	0	33	0.2%	**0.34**
California laurel	4	5	5	2	2	0	0	0	0	0	18	0.1%	**0.10**
gum	1	0	0	0	3	3	1	0	0	0	8	0.1%	**0.15**
Canyon live oak	0	0	2	1	0	1	0	0	0	0	4	0.0%	**0.04**
red-flowering gum	0	0	1	1	0	0	0	0	0	0	2	0.0%	**0.01**
Total	**231**	**181**	**118**	**47**	**23**	**18**	**9**	**7**	**2**	**1**	**637**	**4.5%**	**3.64**
Broadleaf Evergreen Medium (BEM)													
olive	0	16	21	31	35	24	8	0	2	0	137	1.0%	**1.97**
camphor tree	0	0	3	8	7	7	3	0	0	0	28	0.2%	**0.47**
laurel de olor	7	10	6	2	1	1	0	0	0	0	27	0.2%	**0.14**
southern magnolia	9	3	0	0	3	0	0	0	0	0	15	0.1%	**0.07**
Carob	0	0	0	0	1	1	0	0	0	0	2	0.0%	**0.05**
bottle tree	0	0	0	0	1	1	0	0	0	0	2	0.0%	**0.04**
mayten tree	0	0	1	0	1	0	0	0	0	0	2	0.0%	**0.02**
fern pine	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.00**
orchid tree	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.00**
Total	**18**	**29**	**31**	**41**	**49**	**34**	**11**	**0**	**2**	**0**	**215**	**1.5%**	**2.77**
Broadleaf Evergreen Small (BES)													
xylosma	4	17	96	26	4	0	0	0	0	0	147	1.0%	**0.99**
cherry laurel	9	26	27	1	0	0	0	0	0	0	63	0.4%	**0.31**
evergreen pear	0	1	19	22	6	1	0	0	0	0	49	0.3%	**0.44**
Chinese privet	2	6	4	7	6	3	1	0	0	0	29	0.2%	**0.26**
strawberry tree	17	2	1	1	2	0	0	0	0	0	23	0.2%	**0.10**
fraser photinia	1	7	10	3	0	0	0	0	0	0	21	0.1%	**0.12**
tarata	0	5	4	1	0	0	0	0	0	0	10	0.1%	**0.05**
African sumac	4	0	0	2	1	0	0	0	0	0	7	0.0%	**0.04**
citrus	0	2	3	2	0	0	0	0	0	0	7	0.0%	**0.05**
yew pine	4	0	0	0	0	0	0	0	0	0	4	0.0%	**0.01**
toyon	0	2	1	1	0	0	0	0	0	0	4	0.0%	**0.02**
lemon	2	0	0	0	0	0	0	0	0	0	2	0.0%	**0.01**
orange	2	0	0	0	0	0	0	0	0	0	2	0.0%	**0.01**
cape pittosporum	0	0	2	0	0	0	0	0	0	0	2	0.0%	**0.01**
oleander	0	1	1	0	0	0	0	0	0	0	2	0.0%	**0.01**

Species	DBH Class (in)										# of Trees	% of Pop.	RPI
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48			
Total	**45**	**69**	**168**	**66**	**19**	**4**	**1**	**0**	**0**	**0**	**372**	**2.6%**	**2.43**

Conifer Evergreen Large (CEL)													
coast redwood	47	53	146	139	65	23	13	5	0	1	492	3.5%	**4.01**
Canary Island pine	48	119	92	2	3	0	0	0	0	0	264	1.9%	**1.17**
deodar cedar	47	20	39	21	26	13	4	1	1	0	172	1.2%	**1.29**
pine	20	7	13	5	18	16	9	3	2	0	93	0.7%	**1.00**
Japanese red pine	2	8	26	33	6	0	0	0	0	0	75	0.5%	**0.56**
Mondell pine	4	12	19	14	0	0	0	0	0	0	49	0.3%	**0.29**
river-she oak	2	2	0	2	22	13	3	1	1	0	46	0.3%	**0.63**
Italian cypress	11	0	8	4	13	4	1	1	0	0	42	0.3%	**0.38**
cypress	0	0	6	5	5	7	3	2	1	0	29	0.2%	**0.39**
horsetail tree	0	2	10	2	0	0	2	0	0	0	16	0.1%	**0.12**
Aleppo pine	0	0	1	1	6	1	3	2	0	1	15	0.1%	**0.24**
atlas cedar	5	1	0	0	0	1	1	1	0	0	9	0.1%	**0.08**
incense cedar	2	1	2	2	0	0	1	0	0	0	8	0.1%	**0.06**
Japanese black pine	5	1	0	0	0	0	0	0	0	0	6	0.0%	**0.02**
Leyland cypress	3	2	0	0	0	0	0	0	0	0	5	0.0%	**0.02**
Italian stone pine	0	0	0	0	1	1	0	0	0	0	2	0.0%	**0.03**
Monterey cypress	0	0	0	1	1	0	0	0	0	0	2	0.0%	**0.02**
Ponderosa pine	0	0	0	0	2	0	0	0	0	0	2	0.0%	**0.02**
Japanese cryptomeria	1	0	0	0	0	0	0	0	0	0	1	0.0%	**0.00**
Total	**197**	**228**	**362**	**231**	**168**	**79**	**40**	**16**	**5**	**2**	**1,328**	**9.4%**	

Conifer Evergreen Medium (CEM)													
Austrian pine	47	4	3	0	0	0	0	0	0	0	54	0.4%	**0.14**
Arizona cypress	0	0	10	22	3	0	0	0	0	0	35	0.2%	**0.24**
Turkish pine	4	3	6	0	0	0	0	0	0	0	13	0.1%	**0.05**
eastern redcedar	5	0	0	0	0	0	0	0	0	0	5	0.0%	**0.01**
juniper	0	0	3	2	0	0	0	0	0	0	5	0.0%	**0.03**
oriental arborvitae	1	3	0	0	0	0	0	0	0	0	4	0.0%	**0.01**
Arizona smooth cypress	0	1	0	0	1	0	0	0	0	0	2	0.0%	**0.01**
Total	**57**	**11**	**22**	**24**	**4**	**0**	**0**	**0**	**0**	**0**	**118**	**0.8%**	**0.50**

Palm Evergreen Large (PEL)													
Canary Island date palm	0	0	0	0	3	50	8	0	0	0	61	0.4%	**0.59**
Total	**0**	**0**	**0**	**0**	**3**	**50**	**8**	**0**	**0**	**0**	**61**	**0.4%**	**0.59**

Palm Evergreen Small (PES)													

Species	DBH Class (in)										# of Trees	% of Pop.	RPI
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	> 48			
California palm	0	5	3	6	6	30	38	9	0	0	97	0.7%	**0.37**
Mexican fan palm	0	2	2	2	2	1	0	0	0	0	9	0.1%	**0.03**
queen palm	0	0	0	2	0	0	0	0	0	0	2	0.0%	**0.01**
Mediterranean fan palm	0	0	0	0	0	0	1	0	0	0	1	0.0%	**0.00**
Total	0	7	5	10	8	31	39	9	0	0	109	0.8%	0.41
All trees	4,860	2,784	2.920	1,630	930	517	296	120	67	35	14,166	100%	100