City of Woodland, California Urban Forest Resource Analysis and Community Canopy Study

February 2010

DAVEY RESOURCE GROUP

A Division of The Davey Tree Expert Company

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Executive Summary

Woodland, California, by its own declaration, is the "City of Trees." The community recognizes that trees are of vital importance to the environmental, social, and economic well-being of the City. They provide numerous benefits both tangible and intangible, to residents, visitors, and neighboring communities. Recognized since 2000 by the National Arbor Day Foundation as a Tree City, USA, Woodland has demonstrated that public trees are a highly valued community resource, a vital component of the urban infrastructure, and an important part of the City's history and identity.

The Urban Forestry Group is responsible for the care and management of Woodland's public trees, providing inspections, small tree maintenance, tree replacement, and contract monitoring for large tree care. Assuming a proactive approach to managing this vital public resource, the City of Woodland contracted with Davey Resource Group (DRG) in 2009 to conduct a complete inventory of City-managed trees, including 14,155 trees and available planting sites in parks, cemeteries, City facilities, and public rights of way (ROWs). The inventory will be used by staff to more efficiently track maintenance activities and tree health and as a basis for making informed management decisions.

In addition, DRG developed a detailed and quantified analysis of the current structure, function, and value of Woodland's public tree resource using inventory data in conjunction with i-Tree benefit-cost modeling software. The analysis determined that Woodland's public tree population is a cost-effective resource, providing annual benefits of $1,049,311 ($19.23 per capita) to the community through energy savings, air quality improvements, stormwater interception, atmospheric CO_2 reductions, and aesthetic contributions. Considering the annual investment of $698,397 ($12.80 per capita) to care for this critical resource, the community realizes an overall net benefit of $350,914. The bottom line is that for every $1 spent on public trees, Woodland receives $1.50 in benefits.

Woodland's public trees are currently storing 8,551 tons CO_2 and continue to reduce atmospheric CO_2 by 682 tons annually. While Woodland's urban forest may not qualify as a carbon offset credit, it is nonetheless providing a significant reduction in atmospheric CO_2, contributing quantifiable environmental benefits and significantly reducing Woodland's carbon footprint.

Trees are one community asset that has the potential to increase in value over time and with proper maintenance. Fortunately, Woodland's public tree resource is a relatively young population in overall good condition. And, although it is critical to maintain an adequate level of resources to protect this investment, with more than 140 different species and an estimated 93% stocking rate, Woodland is well positioned to realize a significant increase in benefit flow as this vital resource continues to mature.

A separate community canopy study, which considered both publicly- and privately-owned trees, revealed that the current overall tree canopy coverage in Woodland is approximately 8.4% (665 acres). While this is well below the recommended goal of a 25% average, community outreach and education can encourage additional private tree planting and appropriate maintenance. In addition, as the public tree population matures in parks and rights of way, it too will provide a significant contribution to overall canopy coverage. With a demonstrated commitment to maintaining and maximizing the benefits from its community forest, Woodland clearly intends to remain the City of Trees.

Introduction

Woodland, California, incorporated in 1871, serves as the County Seat for Yolo County. It is located in the Sacramento Valley Region, 20 miles northwest of the State Capital of Sacramento and eight miles from the Sacramento International Airport. Woodland, which began as a farming community, has evolved as a major manufacturing and distribution hub in addition to maintaining its agricultural spirit.

Woodland, officially declared "The City of Trees" and named for the expansive native oak forests that surrounded the original settlement, is a community that takes great pride in its history and heritage. With a vital and thriving downtown historic district, it's no surprise that the City of Woodland's values include a dedication to "history and connection to the land." Determined to be a premier place to live, work, and conduct business, the primary goals of the City's Strategic Plan are focused on quality of life and community vitality (City of Woodland Strategic Plan).

True to their vision and stated strategy, the City of Woodland has taken positive steps to ensure the continued vitality, growth, and sustainability of the community. Named a Climate Action Leader in 2009 by the California Climate Action Registry, Woodland has demonstrated recognition of the impact a community can have on the environment at a local, state, and global level. Identifying and establishing a benchmark for Woodland's carbon footprint is the huge step in accepting community responsibility for improving and preserving the quality of life in the community. While Woodland's community forest may not qualify as a carbon offset with the state, the community can be assured that their urban forest makes a very positive contribution to reducing their carbon footprint.

A healthy urban forest plays an important role in the quality of life and the sustainability of a community. Research has demonstrated that healthy City trees can improve the local environment and lessen the impact resulting from urbanization and industry (CUFR). Urban trees slow and reduce stormwater runoff, helping to protect our waterways from excess pollutants and particulate matter. Trees improve air quality by manufacturing oxygen and absorbing carbon dioxide (CO_2), as well as filtering and reducing airborne particulate matter. Urban trees reduce energy consumption by shading structures from solar energy and reducing the overall rise in temperature created through urban heat island effects. Urban trees also 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 have been proven to increase the value of local real estate and promote shopping, retail sales, and tourism. Trees promote a more livable community, fostering psychological health and providing residents with a greater sense of place. Community trees, both public and private, soften the urban hardscape by providing a green sanctuary and making Woodland a more enjoyable place to live, work, and play. The City's 13,140 public trees play a prominent role in the benefits afforded to the community and the citizens rely on the City of Woodland to protect and maintain this vital resource.

Recognized by The National Arbor Day Foundation as a Tree City, USA since 2000, ample evidence exists throughout the community that Woodland takes great pride in being the "City of Trees." Demonstrating appreciation, concern, and a proactive stance on the management of the community's urban forest resource, the City contracted with Davey Resource Group

(DRG) in the fall of 2009 to conduct a comprehensive inventory and analysis of the public tree resource. Collecting the inventory, a team of DRG Certified Arborists mapped the location of publicly-owned trees using global positioning system technology, which can be incorporated into the City's Geographic Information System (GIS), allowing the City to manage trees along with other vital public assets. Besides location, DRG arborists collected information about the species, age, condition, and current maintenance needs of each tree. In addition to generating an inventory database, the data collected was used in conjunction with i-Tree's *Streets*, a STRATUM Analysis Tool (*Streets* v3.0.4; STRATUM v3.0.5), to develop a resource analysis and report of the current condition of the urban forest. This report, unique to Woodland, effectively quantifies the value of the community's public trees in regards to actual benefits derived from the tree resource. In addition, the report provides baseline values that can be used when developing and updating an urban forest management plan. This helps in determining where to focus available resources and setting benchmarks for measuring progress.

The purpose of the urban forest resource analysis and report is to provide information on the structure, function, and value of the public tree resource. From this information, managers and citizens alike can make informed decisions about budgetary support and management priorities. 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.
- Current, detailed management expenditures for Woodland's publicly-managed trees and critical baseline information for evaluating program efficiency.
- A quantified value of the environmental benefits provided by Woodland's public trees. This also illustrates the relevance and relationship of the resource to local quality of life issues such as air quality and environmental health, economic development, and psychological health.
- Quantified 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 that can be used in the development of a long-term community forest management plan.

Woodland's urban forest inventory included all publicly-managed trees in parks and cemeteries, at City facilities, and along streets in public rights of way.

Chapter 1: Summary of the Public Tree Resource

Tree Resource Structure

The City of Woodland's urban forest includes 13,140 publicly-managed trees. A structural analysis is the first step towards understanding the benefits provided by these trees and their management needs. Upon examination of species composition, diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes Woodland's public tree resource:

- More than 140 distinct tree species were identified in the inventory. The predominant tree species are London planetree (*Platanus X. acerifolia*, 12%), Chinese pistache (*Pistacia chinensis*, 9%), flowering pear (*Pyrus calleryana*, 8%) and crapemyrtle (*Lagerstroemia indica*, 6%).
- The age structure of Woodland's public tree population is predominantly young to intermediate, with 74.5% of trees measuring a DBH (Diameter of the trunk at 4'6" above the ground) of less than 12 inches.
- The majority of Woodland's public trees were determined to be in good condition. Maintaining the condition of existing trees for as long as possible will increase their useful lifespan and maintain a steady flow of benefits to the community.
- A separate community canopy study, which considered both publicly- and privately-owned trees, revealed that the combined community forest is providing 665 acres of canopy coverage, or 8.4% of the total land within 25 tree service areas.

Replacement of Woodland's 13,140 public trees with trees of similar size, species, and condition would cost more than $29 million.

- Woodland's public tree population has sequestered over 8,551 tons of carbon (CO_2), valued at $128,267.
- Replacement of Woodland's 13,140 public trees with trees of similar size, species, and condition would cost more than $29 million.
- Woodland's current stocking level for public trees is estimated to be 92.8%, based on a total 14,155 planting sites, including 13,140 trees, 871 vacant sites, and 144 sites requiring stump removal prior to replanting.

Tree Resource Benefits

Annually, Woodland's public trees provide cumulative benefits to the community at an average value of $79.86 per tree, for a gross total value of $1,049,311 per year. The City's public trees are providing the following substantial annual benefits:

- Public trees reduce electricity and natural gas use in Woodland through shading and climate effects, totaling $122,007, an average of $9.29 per tree.

- The public trees in Woodland sequester 682 tons of atmospheric CO_2 per year, valued at $10,244, an average of $0.78 per tree.
- Net air quality improvements provided by the public tree population through the removal and avoidance of air pollutants are valued at $108,104, an average per tree benefit of $8.23.
- Woodland's public trees intercept an estimated 6.5 million gallons of stormwater annually for a total value of $50,943 per year, an average of $3.88 per tree.
- The total annual benefits contributed by Woodland's publicly-owned trees to property value increases, aesthetics, and other less tangible improvements is $758,033, an average of $57.69 per tree.
- When the City's annual investment of $698,397 for tree maintenance is considered, the net annual benefit (benefits minus investment) to the City is $350,914. The average net benefit for an individual public tree in Woodland is $26.71 per year. **Woodland receives $1.50 in benefits for every $1 spent on the ROW tree population.**

Tree Resource Management

Woodland's street and park tree population is a dynamic resource that is worth continued investment to ensure its full potential. **The community forest is one of the few assets that has the potential to increase in value with time and proper management.** Trees improve the quality of life in the community and help lessen the environmental impact of urbanization. However, this critical resource is vulnerable to a host of stressors, requiring sound and sustainable management practices to ensure a continued flow of benefits. With the benefit of a relatively young urban forest in good condition, Woodland can focus resources on maximizing the flow of benefits from the current tree population and maintaining a forward thinking approach by continuing to:

- *Maximize the benefits of the existing tree resource through comprehensive tree maintenance and a cyclical pruning schedule.*
- *Maintain an appropriate age distribution by planting new trees to improve long-term resource sustainability and greater canopy coverage. Focus on large-stature trees where conditions are sustainable to maximize benefits.*
- *Continue to plant new trees with the goal of establishing replacement trees for the City's most mature trees (and top benefit producers) with trees of similar stature, before they must be removed, thereby ensuring a consistent benefit flow.*
- *Implement a structural pruning program for young and establishing trees to promote healthy structure, extend life expectancy, and reduce future costs and liability.*

The value of Woodland's public tree resource should continue to increase as existing trees mature and new trees are planted. As the resource grows, continued investment in management is critical to ensuring that residents will continue receiving a high return on investment in the future. It is not as simple as planting more trees to increase canopy cover and benefits. Planning and funding for care and management must complement planting efforts in order to ensure the long-term success and health of new plantings. Existing trees

must also be maintained and protected since the greatest benefits will accrue from continued growth of the existing canopy. Woodland's trees are a dynamic resource requiring constant care to maximize and sustain production of benefits into the future. However, Woodland can take pride in knowing that street trees do improve the quality of life in the City and, perhaps just as importantly, trees are well worth the investment.

Recognizing that stewardship of the urban forest is critical to sustainability and to preserving a healthy urban climate, the City of Woodland contracted with Davey Resource Group (DRG) in fall 2009 to conduct a complete inventory of publicly-managed trees and to produce a detailed analysis of that resource. This urban forest resource analysis and report, based on the current tree inventory status, defines the population and structure of Woodland's public urban forest as well as quantifying the benefits. The analysis focuses solely on publicly-owned, City-managed trees on streets and in parks and utilized i-Tree *Streets*, a STRATUM Analysis Tool (*Streets* v3.0.4; STRATUM v3.0.5), in order to establish baseline information on the value of that public resource to the community. This report and the included analysis, which is unique to Woodland, effectively estimates and quantifies the value of the public tree resource in regards to actual benefits derived from this resource. In addition, the report provides a baseline analysis that can be used when implementing and updating an urban forest management plan, determining where best to focus available resources and setting benchmarks for measuring progress. A municipal forest resource analysis provides information on the structure, function, and value of a tree resource so that managers and citizens alike can make informed decisions about budgetary support and management priorities. This report is intended to provide the following information:

- *A description of the current structure of Woodland's public tree resource and an established benchmark for future management decisions.*
- *Current, detailed management expenditures for Woodland's public trees and critical baseline information for evaluating program efficiency.*
- *A quantified value of the environmental benefits provided by Woodland's public trees, illustrating the relevance and relationship of the resource to local quality of life issues, such as air quality and environmental health, economic development, and psychological health.*
- *Quantified data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-profit organizations, air quality districts, federal and state agencies, legislative initiatives, and/or establishing or updating local assessment fees.*
- *Benchmark data that can be used in the development of a long-term urban and community forest management plan.*

For every $1 invested in city-owned trees, Woodland receives
$1.50
in benefits

Chapter 2: Woodland's Urban Forest Resource

Population Composition

Broadleaf species dominate Woodland's public tree population, composing 87% 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 highest level of benefits to a community. Large-growing broadleaf trees provide greater benefits than smaller-statured trees. Deciduous broadleaf species make up 77% of Woodland's public tree population, including 32% medium-stature, 29% large-stature, and 16% small-stature deciduous broadleaf trees. Evergreen broadleaf trees make up 10% of the population, including 5% large-stature, 3% small-stature, and 2% medium-stature evergreen broadleaf trees. Twelve percent of the population is comprised of large conifers. Small and medium conifers are represented by less than 1% of the overall population. Small-canopied palms make up the final 1%, with large-canopied palms representing less than 1% (Figure 1).

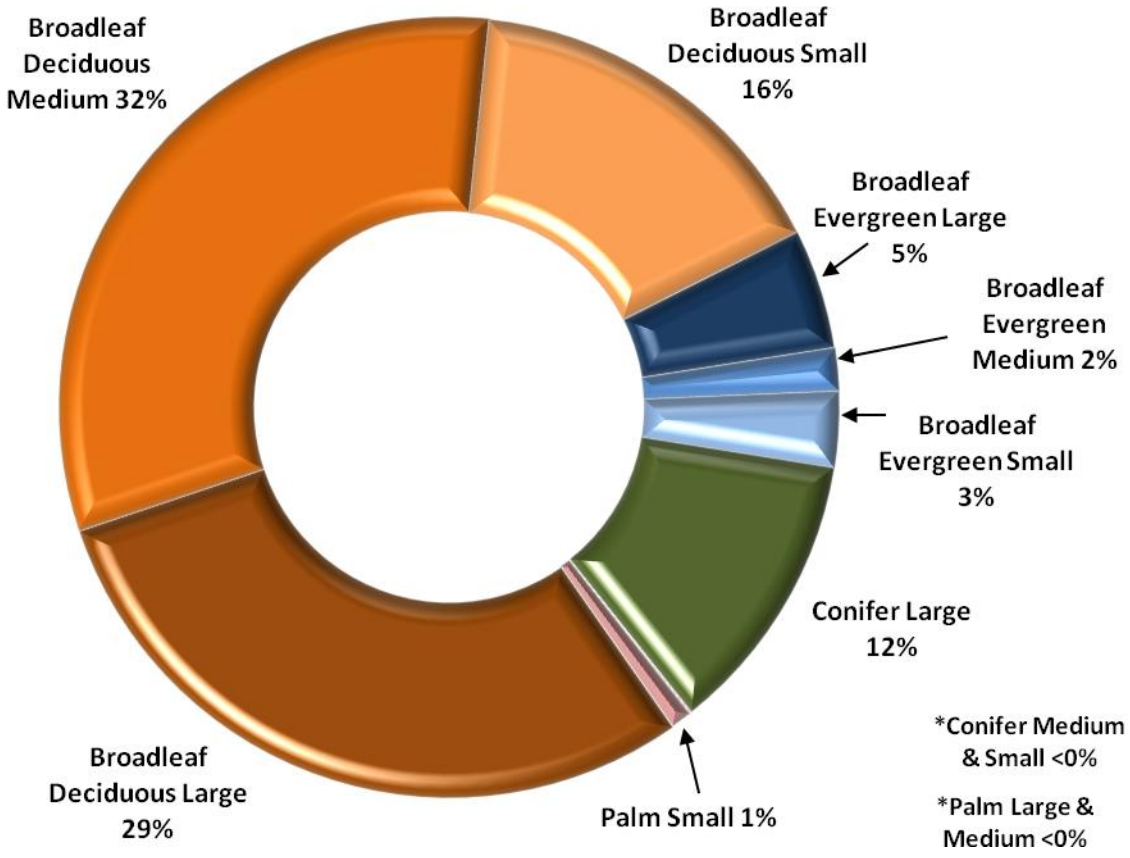


Figure 1. Composition of Woodland's Public Tree Population.

Species Richness and Composition

Woodland's public tree population includes a mix of more than 140 unique species, 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 ten species represent 55% of the total population (Figure 2 and Table 1, see also Appendix C). The predominant tree species are London planetree (*Platanus X. acerifolia*, 12%), Chinese pistache (*Pistacia chinensis*, 9%), flowering pear (*Pyrus calleryana*, 8%) and crapemyrtle (*Lagerstroemia indica*, 6%). Three genera represent 30% of the population, comprised of *Platanus* (12.4%), *Quercus* (9.25%) and *Pyrus* (8.63%). London planetree is the only species that exceeds the widely accepted rule that no single species should represent greater than 10% of the total population, while no single genus more than 20% (Clark Et al, 1997). This suggests adequate diversification within Woodland's public tree canopy

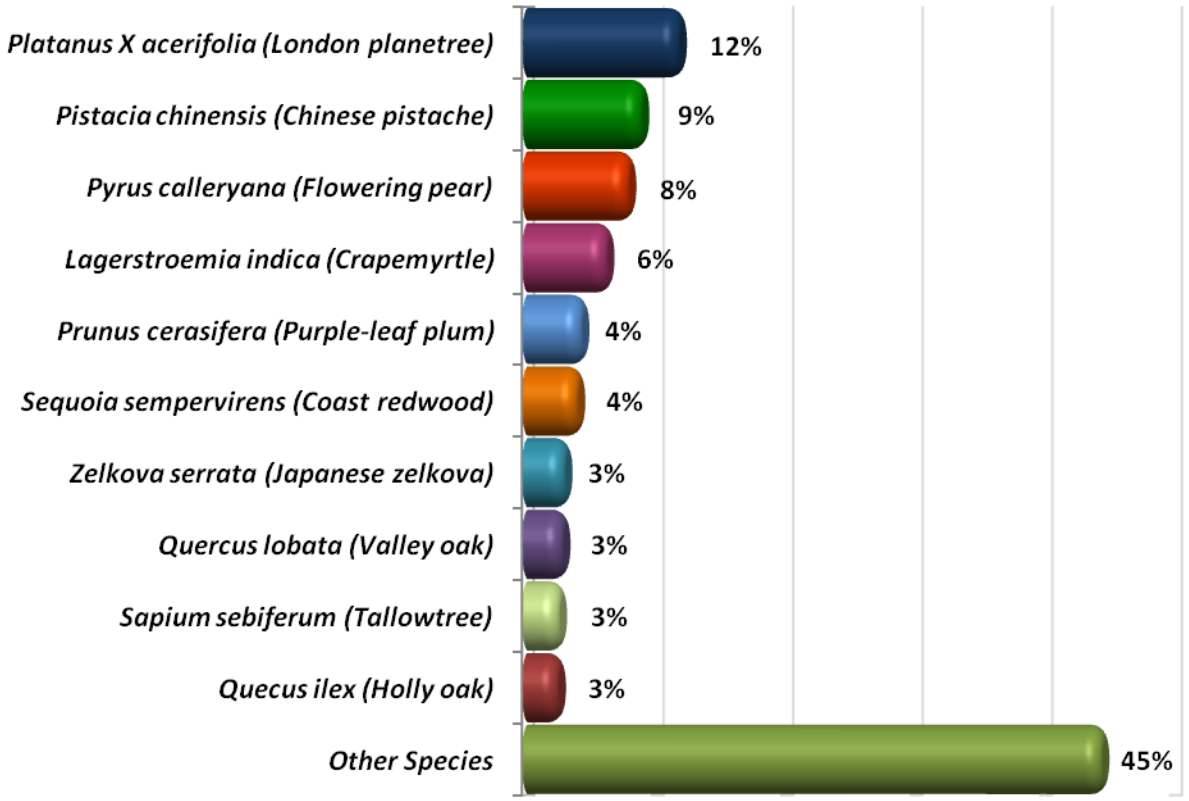


Figure 2. Species Frequency of Woodland's Public Tree Population.

Maintaining a diverse population within an urban forest is important. Dominance of any single species or genus can have catastrophic consequences in the event of storms, drought, disease, pests, or other stressors, which can severely affect an urban forest 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 (SOD) (*Phytophthora ramorum*) are some examples of unexpected, devastating, and costly pest and pathogen problems that highlight the importance of a balanced distribution of species and genera.

Table 1. Population Summary of Woodland's Public Tree Inventory.

		DBH Class (in)									
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	**Total**
Broadleaf Deciduous Large (BDL)											
Platanus X acerifolia	**London planetree**	289	248	270	183	257	145	94	31	3	**1,520**
Quercus lobata	**Valley oak**	151	50	57	42	26	16	12	14	28	**396**
Fraxinus velutina	**Velvet ash**	242	34	0	1	1	0	0	0	0	**278**
Ulmus parvifolia	**Chinese elm**	211	9	0	0	0	0	0	0	0	**220**
Celtis sinensis	**Chinese hackberry**	36	21	55	64	18	7	0	0	1	**202**
Ulmus species	**English & American Elm**	95	9	0	0	2	3	7	24	36	**176**
Fraxinus Velutina "Modesto	**Modesto ash**	4	0	1	3	47	62	28	4	1	**150**
Quercus rubra	**Northern red oak**	**134**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**134**
BDL OTHER	**BDL OTHER**	162	116	184	155	73	50	20	16	17	**793**
Total		**1,324**	**487**	**567**	**448**	**424**	**283**	**161**	**89**	**86**	**3,869**
Broadleaf Deciduous Medium (BDM)											
Pistacia chinensis	**Chinese pistache**	178	180	469	338	21	9	0	1	0	**1,196**
Pyrus calleryana	**Flowering pear**	391	307	195	135	34	2	0	0	0	**1,064**
Zelkova serrata	**Japanese zelkova**	265	115	8	8	10	10	1	0	0	**417**
Triadica sebifera	**Tallowtree**	211	39	36	56	17	1	1	0	0	**361**
Koelreuteria paniculata	**Goldenrain tree**	111	52	27	8	2	0	0	0	0	**200**
Tilia species	**Basswood**	185	0	0	0	2	0	0	0	0	**187**
Ginkgo biloba	**Ginkgo**	134	7	10	1	0	0	0	0	0	**152**
BDM OTHER	**BDM OTHER**	296	35	60	74	80	29	8	0	1	**583**
Total		**1,771**	**735**	**805**	**620**	**166**	**51**	**10**	**1**	**1**	**4,160**
Broadleaf Deciduous Small (BDS)											
Lagerstroemia indica	**Crapemyrtle**	581	188	71	2	0	0	0	0	0	**842**
Prunus cerasifera	**Cherry plum**	388	156	41	3	0	0	0	0	0	**588**

Malus species	**Crabapple, flowering**	253	12	11	0	0	0	0	0	0	**276**
BDS OTHER	**BDS OTHER**	221	88	53	11	7	0	0	0	0	**380**
Total		**1,443**	**444**	**176**	**16**	**7**	**0**	**0**	**0**	**0**	**2,086**

Broadleaf Evergreen Large (BEL)											
Quercus ilex	**Holly oak**	338	3	0	1	3	5	0	0	0	**350**
BEL OTHER	**BEL OTHER**	110	70	48	21	20	17	7	5	2	**300**
Total		**448**	**73**	**48**	**22**	**23**	**22**	**7**	**5**	**2**	**650**

Broadleaf Evergreen Medium (BEM)											
Olea europaea	**Olive**	12	16	19	42	33	23	6	1	0	**152**
BEM OTHER	**BEM OTHER**	21	11	13	15	15	6	1	0	0	**82**
Total		**33**	**27**	**32**	**57**	**48**	**29**	**7**	**1**	**0**	**234**

Broadleaf Evergreen Small (BES)											
Xylosma congestum	**Xylosma**	13	10	103	21	1	0	0	0	0	**148**
BES OTHER	**BES OTHER**	31	79	92	46	16	3	1	0	0	**268**
Total		**44**	**89**	**195**	**67**	**17**	**3**	**1**	**0**	**0**	**416**

Conifer Evergreen Large (CEL)											
Sequoia sempervirens	**Coast redwood**	91	91	160	99	61	25	15	3	1	**546**
Pinus canariensis	**Canary Island Pine**	245	41	3	19	7	0	0	0	0	**315**
Cedrus deodara	**Deodar cedar**	69	19	37	20	39	17	1	1	1	**204**
Pinus species	**Pine**	45	28	14	11	30	21	12	3	1	**165**
CEL OTHER	**CEL OTHER**	43	35	103	35	54	25	13	3	2	**313**
Total		**493**	**214**	**317**	**184**	**191**	**88**	**41**	**10**	**5**	**1,543**

Conifer Evergreen Medium (CEM)											
CEM OTHER	**CEM OTHER**	0	0	3	2	0	0	0	0	0	**5**
Total		**0**	**0**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**5**

Conifer Evergreen Small (CES)											
CES OTHER	CES OTHER	1	1	0	0	0	0	0	0	0	**2**
Total		**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Palm Evergreen Large (PEL)											
PEL OTHER	PEL OTHER	0	0	0	0	3	52	7	0	0	**62**
Total		**0**	**0**	**0**	**0**	**3**	**52**	**7**	**0**	**0**	**62**
Palm Evergreen Medium (PEM)											
PEM OTHER	PEM OTHER	0	0	0	0	0	0	0	0	0	**0**
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm Evergreen Small (PES)											
PES OTHER	PES OTHER	5	4	8	8	8	19	53	8	0	**113**
Total		**5**	**4**	**8**	**8**	**8**	**19**	**53**	**8**	**0**	**113**
Citywide Total		**5,562**	**2,074**	**2,151**	**1,424**	**887**	**547**	**287**	**114**	**94**	**13,140**

Species Importance

To quantify the significance of any one particular species found in Woodland's public tree population, an *importance value* (IV) is derived for each of the most common species in the inventory. Importance values are particularly meaningful to urban forest managers because they indicate a community's reliance on the functional capacity of particular species. **i-Tree *Streets*** calculates IV based on the mean of three important 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 IV can range from zero (which implies no reliance) to 100 (suggesting total reliance). No single species should dominate the composition in the City's urban forest population. Because IV 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 IVs are comparatively equal among the 10 to 15 most abundant species, the risk of significant reductions to benefits is significantly 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.

The 25 most abundant species identified in Woodland's public tree inventory represent 78% of the total population, 75% of the total leaf area, and 75% of the total canopy cover from street trees for a combined IV of 75.9 (Table 2). Of these species, Woodland relies most on the functional capacity of the London planetree (*Platanus X acerifolia,* IV=18.2), Chinese pistache (*Pistacia chinensis*, IV=11.4) and flowering pear (*Pyrus calleryana*, IV=5.9). The analysis further indicates that redwood (*Sequoia sempervirens*, IV=4.4) comprising 4.2% of the population, valley oak (*Quercus lobata*, IV=4.3) comprising 3.0% of the population, elms (*Ulmus procera* and *U. americana*, IV=4.7) comprising 1.3% of the population, and Modesto ash (*Fraxinus velutina 'Modesto'*, IV=2.9) comprising 1.1% of the population, are each more important in terms of capacity to produce benefits than the fourth most common tree species, crapemyrtle (*Lagerstroemia indica*, IV=2.7), which comprises 6.4% of the total population. This is attributable to each of these species' relative maturity, greater size, and greater leaf area.

Woodland's American and English elms (*Ulmus procera and U. americana*), accounting for less than 2% of the population, have an IV of 4.67 and are providing the greatest per tree functional capacity to provide benefits compared to their representation in the population. Modesto ash (*Fraxinus velutina 'Modesto',* population of 1.1% and an IV of 2.89) and valley oak (*Quercus lobata*, population 3% and an IV of 4.32) are also performing at a higher functional capacity comparatively.

London planetree (*Platanus X acerifolia*), valley oak (*Quercus lobata*), and redwood (*Sequoia sempervirens*) are among the largest street trees identified in Woodland's public tree inventory, having a significant percentage of individuals (in relation to their specific population) in intermediate and mature size classes (>24 inches DBH), 18%, 18%, and 8%, respectively.

Due to their relatively small leaf area and canopy coverage, immature and small-stature trees tend to have lower importance values than their population numbers might suggest. Therefore, consideration of tree type along with age distribution can provide additional significance to the importance value For instance, in Woodland, Japanese zelkova (*Zelkova*

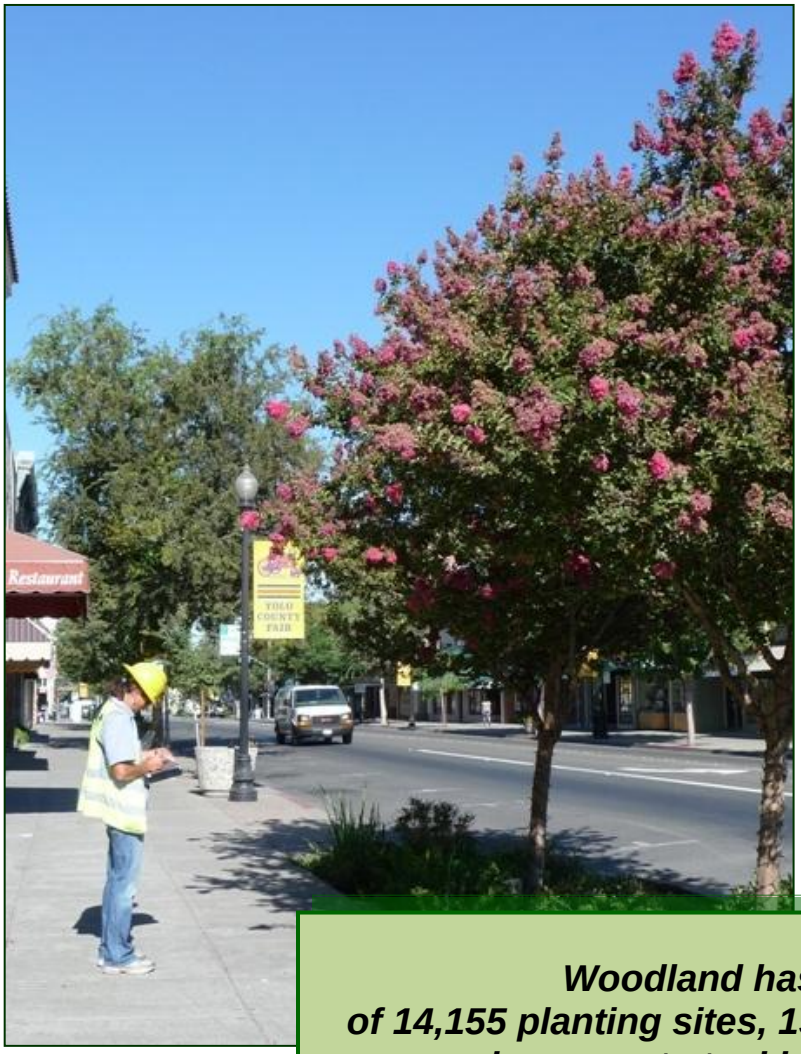
serrata) represent more than 3% of the total population yet has an IV of only 2.14. An analysis of species age distribution, however, shows that 93% of the medium-growing zelkova are young trees (<12 inches DBH). In contrast, crapemyrtle, a small-statured tree, represents 6.4% of the total population and has an IV of 2.7. Whereas medium- and large-growing species such as Japanese zelkova have the potential to significantly increase in importance value as the population matures, small-statured trees such as the crapemyrtle have no such potential.

Table 2. Importance Value (IV) of Woodland's Public Tree Species.

Species	Common Name	Number of Trees	% of Total Trees	Leaf Area (ft2)	% of Total Leaf Area	Canopy Cover (ft2)	% of Total Canopy Cover	Importance Value
Platanus X acerifolia	London planetree	1,520	11.57	4,117,950	20.04	1,350,052	23.04	**18.22**
Pistacia chinensis	Chinese pistache	1,196	9.10	2,297,648	11.18	815,483	13.92	**11.40**
Pyrus calleryana	Flowering pear	1,064	8.10	906,182	4.41	303,779	5.18	**5.90**
Lagerstroemia indica	Crapemyrtle	842	6.41	147,540	0.72	56,346	0.96	**2.70**
Prunus cerasifera	Cherry plum	588	4.47	102,335	0.50	40,074	0.68	**1.89**
Sequoia sempervirens	Coast redwood	546	4.16	989,844	4.82	240,311	4.10	**4.36**
Zelkova serrata	Japanese zelkova	417	3.17	334,342	1.63	95,593	1.63	**2.14**
Quercus lobata	Valley oak	396	3.01	1,174,046	5.71	248,563	4.24	**4.32**
Triadica sebifera	Tallowtree	361	2.75	301,030	1.47	99,248	1.69	**1.97**
Quercus ilex	Holly oak	350	2.66	81,240	0.40	15,797	0.27	**1.11**
Pinus canariensis	Canary Island Pine	315	2.40	116,438	0.57	37,713	0.64	**1.20**
Fraxinus velutina	Velvet ash	278	2.12	73,638	0.36	14,808	0.25	**0.91**
Malus species	Crabapple, flowering	276	2.10	28,517	0.14	10,677	0.18	**0.81**
Ulmus parvifolia	Chinese elm	220	1.67	29,146	0.14	7,981	0.14	**0.65**
Cedrus deodara	Deodar cedar	204	1.55	364,449	1.77	92,093	1.57	**1.63**
Celtis sinensis	Chinese hackberry	202	1.54	500,222	2.43	149,541	2.55	**2.17**
Koelreuteria paniculata	Goldenrain tree	200	1.52	65,806	0.32	30,825	0.53	**0.79**
Tilia species	Basswood	187	1.42	37,321	0.18	5,559	0.09	**0.57**
Ulmus species	English/American Elm	176	1.34	1,841,928	8.96	216,522	3.70	**4.67**
Pinus species	Pine	165	1.26	378,276	1.84	102,016	1.74	**1.61**
Ginkgo biloba	Ginkgo	152	1.16	24,706	0.12	7,632	0.13	**0.47**
Olea europaea	Olive	152	1.16	577,152	2.81	133,858	2.28	**2.08**
Fraxinus velutina 'Modesto'	Modesto ash	150	1.14	756,528	3.68	224,857	3.84	**2.89**
Xylosma congestum	Xylosma	148	1.13	174,936	0.85	66,287	1.13	**1.04**
Quercus rubra	Northern red oak	134	1.02	11,198	0.05	694	0.01	**0.36**
Other trees	Other trees	2,901	22.08	5,113,620	24.89	1,493,517	25.49	**24.15**
Total		**13,140**	**100.00**	**20,546,039**	**100.00**	**5,859,826**	**100.00**	**100.00**

Stocking Level

Vacant planting sites were collected as a component of the public tree inventory. A vacant site was defined as a site where a tree was previously planted, but non-existent at the time of the inventory, including stumps. In addition, properties without either an existing tree in the adjacent planter strip or one in close proximity in the front yard, were allotted one vacant site. A total of 1,015 vacant sites were identified, including 144 sites requiring stump removal prior to replanting. To increase and maximum benefits available from the urban forest, Woodland is encouraged to continue their new tree establishment program with the goal of utilizing all available planting space to the fullest potential. Consideration should be given to importance value, relative performance, and age distribution, as well as available growing area when determining the most appropriate species (see *Tree Condition and Relative Performance*, page 14).



Woodland has a total of 14,155 planting sites, 13,140 existing trees, and a current stocking level of 93%.

Relative Age Distribution

The distribution of individual tree ages within a tree population influences present and future costs as well as the flow of benefits. An unevenly 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 the largest fraction of trees (40% of the total) should be young, with diameters less than eight inches, while only 10% should be in the large diameter classes (>24 inches).

Overall, the age distribution of Woodland's public tree population is positively weighted in young trees, with approximately 63.6% of the population consisting of trees with a DBH (diameter at breast height) of eight inches or smaller, 28.5% established trees (9-24 inches DBH), and 7.9% maturing or mature trees with a DBH of 25 inches or greater (Figure 3). Given the current stocking level of 93%, it is obvious that Woodland has been proactive about the establishment of new trees and the replacement of removals. With a relatively young urban forest and continued proactive management, Woodland can expect greater benefits as this vital resource matures. New installations should carefully consider and plan for the necessary resources to ensure proper maintenance as trees mature. Regular inspection and proactive pruning cycles will ensure Woodland's trees mature into well-structured, healthy specimens, thereby maximizing benefits to the community, reducing risk, and promoting a consistent flow of benefits for many generations to come.

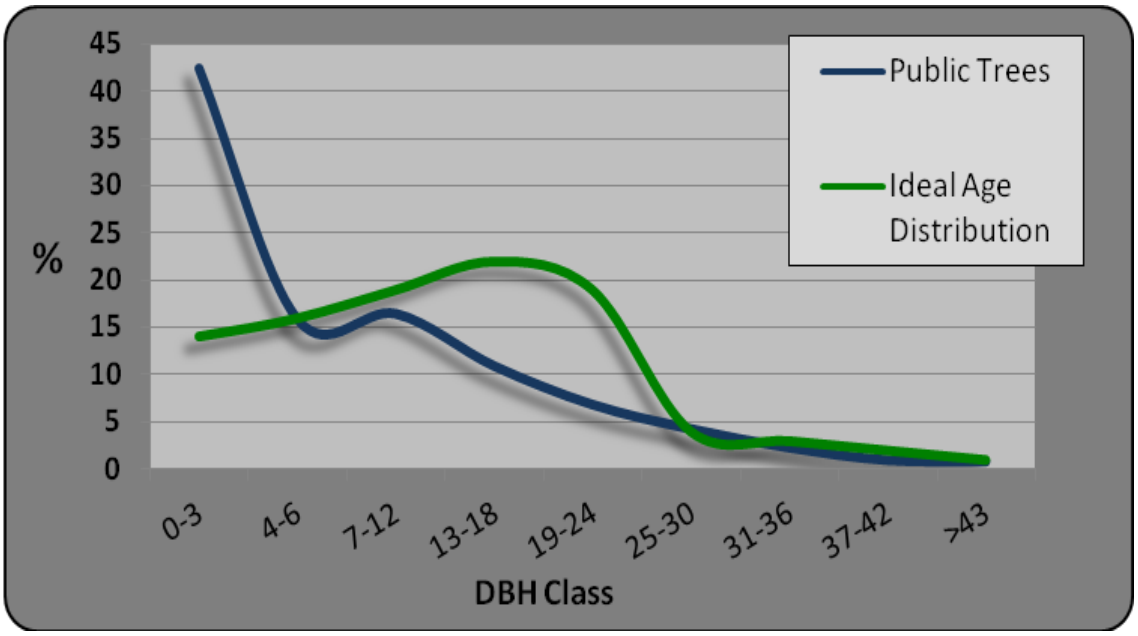


Figure 3. Overall Relative Age Distribution of Woodland's Public Tree Population.

Of Woodland's top ten public tree species (Figure 4), holly oak (*Quercus ilex*, 97%), crapemyrtle (*Lagerstroemia indica*, 69%), purple-leaf plum (*Prunus cerasifera*, 66%), and Japanese zelkova (*Zelkova serrata*, 64%) are each heavily represented in the small size class (< 3 inches DBH), indicating that recent plantings have concentrated on these species.

London planetree (*Platanus X acerifolia*, 18%) and valley oak (*Quercus lobata*, 18%) dominate the larger size (>24 inches DBH), and each has adequate representation in the smaller size classes (0-8 inches DBH). As these species begins to senesce, their maintenance needs become more frequent. However, with their adequate age distribution, there will likely be sufficient replacement stock established to help stabilize the functional capacity of these large-stature trees.

The majority of Chinese pistache (*Pistacia chinensis*, 69%) are found in the middle size classes (7-24 inches DBH), but still have adequate representation (30%) in the smaller size class (0-6 inches DBH).

Woodland's most abundant public tree, London planetree, has 35% of its total population in the 0 to 6-inch DBH class, 47% in the 7 to 24-inch DBH class and 18% in the 25 inch and greater DBH class. Having 18% of this population in the 25-inch plus DBH class, suggests this population is mature and well established. While this is a greater percentage than the ideal suggests, Woodland has compensated well with recent plantings to ensure this important species will continue to supply a consistent flow of benefits to the Woodland community.

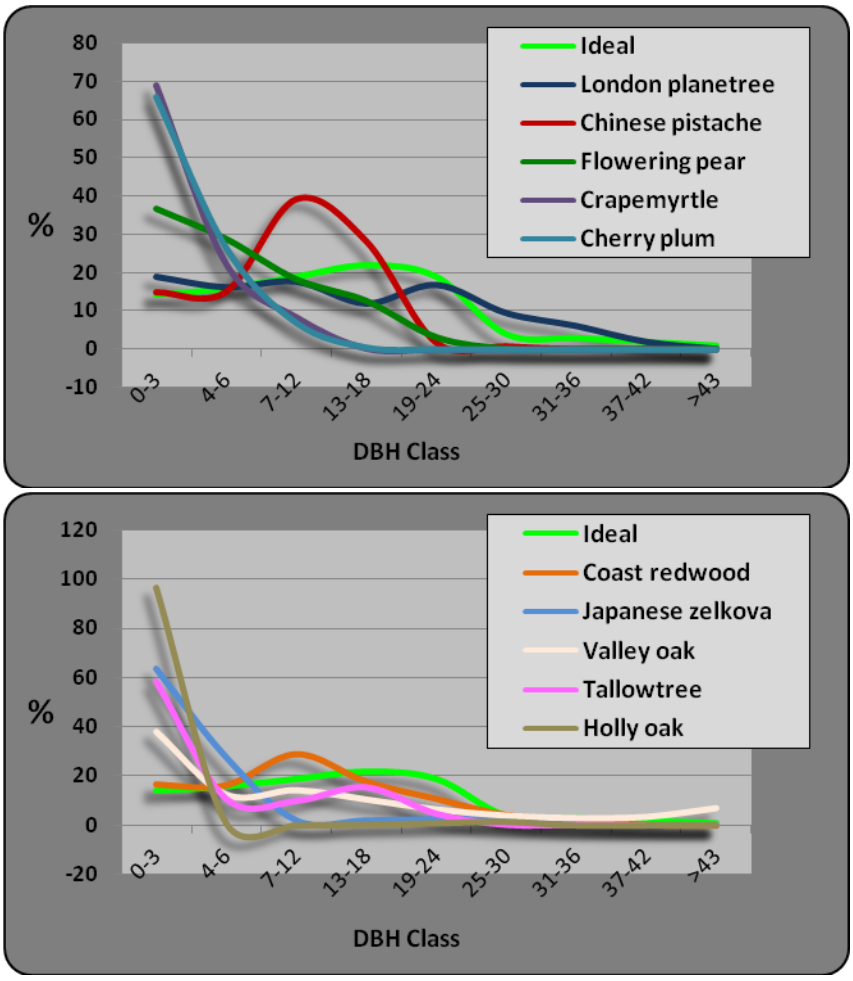


Figure 4. Relative Age Distribution of Woodland's Top Ten City Owned Tree Species.

Tree Condition and Relative Performance

Tree condition is an indication of how well trees are managed and how well they are performing in a given site-specific environment. Each tree inventoried was rated for both woody and foliage condition. Woody condition (Figure 5) is an indication of the structure and soundness of the stem, roots, and branches. Foliage condition (Figure 6) is based on shoot growth as well as the size, density, color, and appearance of the leaves. When trees are performing at their peak, as are 63% of Woodland's trees classified as good (woody condition), the benefits they provide are maximized. The inventory found 30% of Woodland's trees in fair condition (woody), which may be an indication of age, inadequate resources or maintenance, and/or a poorly sited species. Approximately 5% of Woodland's public tree resource was determined to be in poor condition, with an additional 2% either dead or failing. Removing or mitigating dead and failing trees is recommended as soon as possible to reduce liability exposure.

The *relative performance index* (RPI) is one way to further analyze the condition and suitability of specific urban tree species. The RPI provides an urban forest manager with a detailed perspective on how one species' performance compares to that of another. The index compares the condition rating of each tree of each species and relates that condition to that of every other tree and species within a given urban forest population. The RPI is calculated by taking the percentage of each species in good condition and dividing it by the percentage of the total population that is in good condition. An RPI value of 1.0 or better indicates that the species is performing well when compared to other species (i.e., its percentage of good trees is equal to or better than that of the entire population). An RPI value below 1.0 indicates that the species is not performing as well in comparison to the rest of the population.

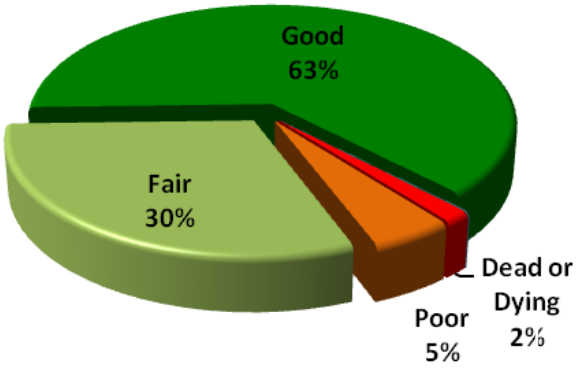


Figure 5. Woody Condition of Woodland's Public Trees.

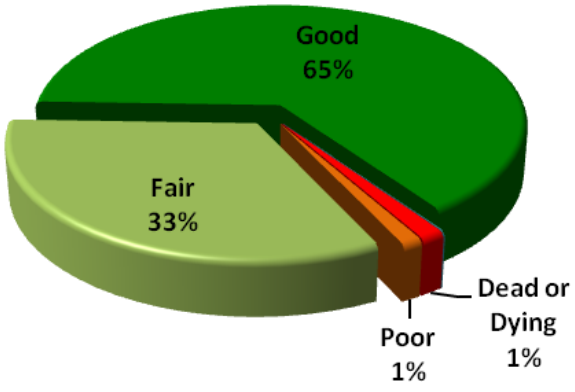


Figure 6. Foliage Condition of Woodland's Public Trees.

Among the 23 most common species identified in the inventory (>150 trees), 16 have a RPI greater than 1.0 (Table 3). Of these, Canary Island pine (*Pinus canariensis*, RPI=1.13), velvet ash (*Fraxinus velutina*, RPI=1.12), and holly oak (*Quercus ilex*, RPI=1.10) have the highest rating. Modesto ash (*Fraxinus velutina* 'Modesto,' RPI=0.64) and olive (*Olea europaea*, RPI=0.82) are each performing far below average. **Valley oak (*Quercus lobata*), is a population with a close to ideal age distribution, an indicator that their RPI of 1.05 is a true performance measure.** Woodland's most important tree species, London planetree (*Platanus X acerifolia*) has a slightly lower RPI value of 0.96. This value is likely reflective of the higher percentage of mature individuals within the population as well as a susceptibility to anthracnose, a fungus which often causes twig dieback and can affect overall structure. New plantings of resistant cultivars of this species should reduce the incidence of future infections and positively affect the RPI of this important species.

Table 3. Relative Performance Index (RPI) for Woodland's Most Abundant Public Trees.

Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Platanus X acerifolia	*London planetree*	0.53	1.28	47.27	50.93	**0.96**	1,520	12
Pistacia chinensis	*Chinese pistache*	0.84	1.34	29.31	68.52	**1.03**	1,196	9
Pyrus calleryana	*Flowering pear*	3.05	3.81	31.11	62.03	**0.98**	1,064	8
Lagerstroemia indica	*Crapemyrtle*	1.07	1.19	35.63	62.12	**1.00**	842	6
Prunus cerasifera	*Cherry plum*	1.02	2.38	15.73	80.87	**1.07**	588	4
Sequoia sempervirens	*Coast redwood*	0.00	0.64	32.42	66.94	**1.03**	546	4
Zelkova serrata	*Japanese zelkova*	0.24	1.08	38.25	59.95	**1.00**	417	3
Quercus lobata	*Valley oak*	0.51	0.63	25.88	72.98	**1.05**	396	3
Triadica sebifera	*Tallowtree*	0.42	1.94	23.27	74.38	**1.05**	361	3
Quercus ilex	*Holly oak*	2.29	0.29	8.86	88.57	**1.10**	350	3
Pinus canariensis	*Canary Island Pine*	0.00	0.32	8.10	91.75	**1.13**	315	2
Fraxinus velutina	*Velvet ash*	0.00	0.00	11.33	88.67	**1.12**	278	2
Malus species	*Crabapple, flowering*	6.16	2.54	11.23	80.07	**1.03**	276	2
Ulmus parvifolia	*Chinese elm*	2.73	9.09	37.73	50.45	**0.91**	220	2
Cedrus deodara	*Deodar cedar*	0.49	1.47	23.28	74.75	**1.06**	204	2
Celtis sinensis	*Chinese hackberry*	0.00	3.47	60.15	36.39	**0.90**	202	2
Koelreuteria paniculata	*Goldenrain tree*	1.50	2.75	23.25	72.50	**1.03**	200	2
Tilia species	*Basswood*	2.67	1.07	10.96	85.29	**1.08**	187	1
Ulmus species	*Elm*	0.00	3.41	34.09	62.50	**1.00**	176	1
Pinus species	*Pine*	1.21	0.91	19.09	78.79	**1.07**	165	1
Ginkgo biloba	*Ginkgo*	4.61	1.32	34.87	59.21	**0.96**	152	1
Olea europaea	*Olive*	2.96	68.42	11.18	51.64	**0.82**	152	1
Fraxinus velutina 'Modesto'	*Modesto ash*	5.33	35.67	55.00	6.67	**0.64**	150	1
Citywide total		**1.58**	**4.78**	**30.45**	**63.14**	**1.00**	**13,140**	**100**

The RPI can be a useful tool for urban forestry managers. For example, if a City has been planting two or more new species in their urban forest, the RPI can be utilized to compare their performance. If the RPI indicates that one is performing relatively poorly, a municipality 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. Species planted for many years that have an RPI of 1.00 or greater have performed well when compared to the population as a whole. These top performers should be retained as a significant portion of the urban forest population.

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. Prior to selecting trees on the basis of RPI alone, managers are encouraged to take into account the age distribution of the species among other factors. A species that has a RPI of less than 1.00, but has a significant number of trees in larger DBH classes, may just be exhibiting signs of population senescence. The individuals of this species may have produced substantial benefits over the years and should continue to be considered when making species selection determinations.

The RPI value can also be used to identify underutilized species that are demonstrating good performance. Trees with an RPI value greater than 1.00 and representing a substantial portion of the total population may be indicating their suitability in the local environment and should receive consideration for additional planting (Table 4).

Based on Woodland's inventory, velvet ash (*Fraxinus velutina*, RPI 1.12), red oak (*Quercus rubra*, RPI 1.11), and valley oak (*Quercus lobata*, RPI 1.05) are demonstrating positive performance as a large-stature deciduous trees, while Idaho locust (*Robinia ambigua idahoensis*, RPI 1.14), tilia (*Tilia cordata* and *T. americana*, RPI 1.08), and goldenrain tree (*Koelreuteria paniculata*, RPI 1.03) are each showing promising results as medium-stature deciduous trees.

Cork oak (*Quercus suber*, RPI 1.09), is performing well as a large-stature evergreen, while Canary Island pine (*Pinus canariensis*, RPI 1.13) deodar cedar (*Cedrus deodara*, RPI 1.06) are each performing well as large coniferous species.

Species	# of Trees in Population	% of Population	RPI
Broadleaf Deciduous Large (BDL)			
Fraxinus velutina (Velvet ash)	278	2.12	**1.12**
Quercus rubra (Northern red oak)	134	1.02	**1.11**
Quercus lobata (Valley oak)	396	3.02	**1.05**
Broadleaf Deciduous Medium (BDM)			
Robinia ambigua idahoensis (Idaho locust)	108	0.82	**1.14**
Tilia species (Basswood)	187	1.42	**1.08**
Koelreuteria paniculata (Goldenrain tree)	200	1.52	**1.03**
Broadleaf Evergreen Large (BEL)			
Quercus suber (Cork oak)	131	1.00	**1.09**
Conifer Large (CEL)			
Pinus canariensis (Canary Island pine)	315	2.40	**1.13**
Cedrus deodara (Deodar cedar)	204	1.52	**1.06**

Table 4. Trees Worthy of Further Consideration Based on RPI.

Replacement Value

The current value of Woodland's public tree resource is more than $29.2 million. The community forest is a public asset which, when properly cared for, has the potential to appreciate in value as the trees mature over time. Replacement value accounts for the historical investment in trees over their lifetime and is a way of describing the value of a tree population (and/or average value per tree) at a given time. Replacement value is a reflection of 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 cost approach 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). To replace Woodland's current public tree population of 13,140 trees with trees of similar size, species, and condition would cost more than $29.2 million (Table 5). The average replacement value per tree is approximately $2,224.

London planetree (*Platanus X acerifolia*) accounts for 17.7% ($5.2 million) of the total estimated replacement value, followed by Chinese pistache (*Pistacia chinensis*, 13.8%, $4 million), and valley oak (*Quercus lobata*, 11.8%, $3.4 million). The high value of each of these species reinforces their importance to the City. Many of the highest valued species are large- and medium-stature trees with large canopies and are therefore likely to have high importance values (IV) as well.

Species with lower replacement values are generally smaller-stature trees with a lower importance value (IV), as evidenced by crapemyrtle (*Lagerstroemia indica*) with a replacement value of $369,772 (1.27%), despite its prevalence in the population (6.4%).

Woodland's public trees are a vital component of the City's infrastructure and a public asset valued at over $29.2 million. An asset that, with proper care and maintenance, will increase in value over time. Distinguishing replacement value from the value of annual benefits produced by Woodland's public trees is, however, very important. Annual benefits are discussed in Chapter Three.

Table 5. Replacement Value of Woodland's Most Valuable Public Tree Species.

		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Platanus X acerifolia	London planetree	45,254	102,216	338,511	480,964	1,230,253	1,196,902	1,171,658	551,126	67,751	**5,184,634**	17.74
Pistacia chinensis	Chinese pistache	28,382	129,701	1,167,045	2,213,842	257,839	189,077	0	42,110	0	**4,027,999**	13.78
Quercus lobata	Valley oak	27,047	35,620	141,887	269,439	329,814	330,711	356,927	596,807	1,356,626	**3,444,879**	11.79
Pyrus calleryana	Flowering pear	62,186	149,584	273,488	454,224	206,020	26,540	0	0	0	**1,172,043**	4.01
Sequoia sempervirens	Coast redwood	13,154	31,313	161,095	248,710	280,512	195,411	171,189	46,610	14,968	**1,162,962**	3.98
Ulmus species	American/English Elm	15,448	2,942	0	0	6,827	16,716	68,226	331,315	576,946	**1,018,421**	3.48
Quercus suber	Cork oak	9,256	12,303	69,937	47,446	96,108	185,589	191,471	140,852	115,026	**867,988**	2.97
Pinus species	Pine	8,561	14,367	20,192	38,192	218,867	245,498	207,926	78,512	27,331	**859,445**	2.94
Olea europaea	Olive	1,597	5,721	27,406	132,124	197,688	228,011	88,618	20,597	0	**701,761**	2.40
Casuarina cunninghamiana	River-she oak	459	3,200	0	40,437	272,778	170,816	58,371	32,792	38,193	**617,045**	2.11
Triadica sebifera	Tallowtree	37,616	23,780	67,392	283,911	166,312	15,776	19,457	0	0	**614,244**	2.10
Juglans hindsii	Hind walnut	1,567	7,720	5,861	26,084	20,852	60,329	66,719	137,781	264,774	**591,688**	2.02
Cedrus deodara	Deodar cedar	10,936	7,171	47,128	62,396	230,353	167,115	16,320	19,396	18,690	**579,505**	1.98
Platanus racemosa	Western Sycamore	2,413	5,226	76,280	158,847	72,080	86,496	23,510	0	0	**424,851**	1.45
Celtis sinensis	Chinese hackberry	5,080	7,784	60,582	169,391	92,849	59,039	0	0	14,796	**409,521**	1.40
Zelkova serrata	Japanese zelkova	44,659	65,510	14,514	33,612	82,660	138,720	23,510	0	0	**403,186**	1.38
Lagerstroemia indica	Crapemyrtle	98,786	112,956	147,409	10,621	0	0	0	0	0	**369,772**	1.27
Cupressus species	Cypress	195	3,752	27,918	66,372	42,584	102,258	59,242	27,520	32,043	**361,883**	1.24
Xylosma congestum	Xylosma	2,155	5,514	214,681	114,266	12,075	0	0	0	0	**348,692**	1.19
Fraxinus velutina 'Modesto'	Modesto ash	717	0	415	2,409	67,519	145,604	92,073	18,878	5,144	**332,758**	1.14
Morus species	Mulberry	456	0	5,757	14,809	155,750	120,959	18,263	0	0	**315,993**	1.08
Celtis occidentalis	Northern hackberry	1,955	13,235	26,758	78,558	59,664	50,268	58,372	17,014	0	**305,825**	1.05
Juglans species	Walnut	0	0	2,282	19,640	79,473	46,457	11,520	67,553	41,274	**268,197**	0.92
Fraxinus americana	White ash	162	0	3,389	39,413	98,861	102,272	0	21,484	0	**265,582**	0.91
All Other Species	All Other Species	518,273	296,717	657,026	890,920	971,097	772,909	366,888	80,273	22,618	**4,576,719**	16.00
Citywide total		**936,315**	**1,036,332**	**3,556,951**	**5,896,627**	**5,248,836**	**4,653,474**	**3,070,260**	**2,230,619**	**2,596,179**	**29,225,592**	**100.00**

Chapter 3: Benefits of Woodland's Public Trees

Street and park trees are important to Woodland. Environmentally, they help conserve and reduce energy use, reduce local and 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 beauty and calming effect. Environmentally, trees make good sense, working ceaselessly to provide benefits back to the community. However, the question remains, are the collective benefits worth the costs of management? In other words, are trees a good investment for Woodland? To answer that question, we must quantify these benefits in financial terms.

This analysis utilized Woodland's current public tree inventory and i-Tree's *Streets* model to assess and quantify the beneficial functions of Woodland's public tree resource and to place a dollar value on the annual environmental benefits they provide. These estimates provide first-order approximations of tree value. While *Streets* only generally accounts for the benefits produced by Woodland's public tree population, it is an accounting based on the best available science with an accepted degree of uncertainty. The data returned from *Streets* can provide a platform from which real management decisions can be made (Maco and McPherson, 2003). A discussion on the methods used to quantify and price these benefits can be found in Appendix A.

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 overall heat island effect.**
- **Transpiration converts moisture to water vapor, cooling the air by using solar energy that would otherwise result in heating of the air.**
- **Wind speed reduction reduces the movement of outside air into interior spaces and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows [Simpson, 1998]).**

Trees and other vegetation within an urbanized environment may lower air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger citywide 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 and others, 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. By reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding), trees reduce conductive heat loss from buildings. 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 Results

Electricity and natural gas saved annually in Woodland from both the shading and climate effects of public trees is equal to 1010 MWh ($117,792) and 3,364 therms ($4,214), for a total retail savings of approximately $122,007 and an average of $9.29 per tree (Table 6). London planetree (*Platanus X acerifolia*), which represents 12% of the population with an IV of 18.2, accounts for 22.6% of the total energy savings. Chinese pistache (*Pistacia chinensis*, 14.5%) and flowering pear (*Pyrus calleryana*, 5.9%) provide the next greatest contribution towards total energy savings, due in large part to their canopy size and prevalence. Crapemyrtle (*Lagerstroemia indica*), the fourth most abundant public tree in Woodland (6% of the total population), accounts for only 1.2% of the total energy savings due to its smaller stature. In contrast, holly oak (*Quercus ilex*), which represents 2.7% of the total population, contributes only 0.26% of the total energy savings because of the relatively young age distribution of this population (97% of trees <4" DBH). As this population of large-growing evergreens matures, the provided benefits can be expected to increase substantially. The same can be said for Woodland's redwoods (*Sequoia sempervirens*), also a relatively young population.

Examining average energy savings on a per tree basis (Figure 7), Modesto ash (*Fraxinus velutina* 'Modesto', $31.53), American and English elms (*Ulmus procera* and *U. americana*, $19.13), and olive (*Olea europaea*, $18.45), are the currently the greatest contributors, primarily due to their large stature and relatively mature age distribution as compared to the rest of the tree population. Small-stature trees, such as purple-leaf plum (*Prunus cerasifera*, $1.21), and crapemyrtle (*Lagerstroemia indica*, $1.19) are contributing energy-saving benefits well below that of the average of $7.20. Although both these populations have very young age distributions, their contribution to energy savings will not increase substantially as they age. Conversely, red oak (*Quercus rubra*, $0.10/tree), which are well below average, is a species with 100% of its population currently smaller than three inches DBH. Since red oak is a large-stature species with a great deal of maturing to do, its per tree and overall benefits can be expected to greatly increase.

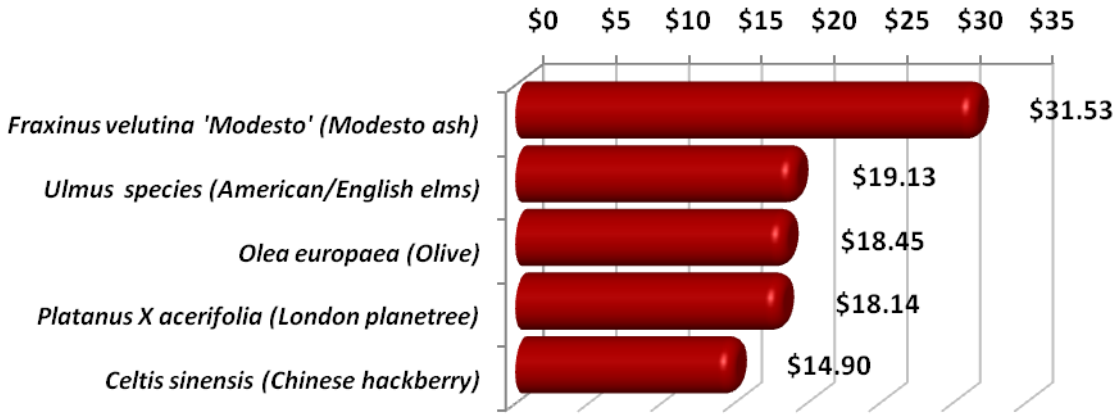


Figure 7. Top Five Trees for Electricity and Natural Gas Benefits.

Table 6. Annual Electricity and Natural Gas Energy Benefits Provided by Woodland's Public Tree Resource.

Species	Common Name	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Platanus X acerifolia	London planetree	220.19	25,674.48	1,517.27	1,900.69	27,575.17	11.57	22.60	**18.14**
Pistacia chinensis	Chinese pistache	152.02	17,725.60	- 337.18	- 422.38	17,303.22	9.10	14.18	**14.47**
Pyrus calleryana	Flowering pear	56.24	6,557.56	505.67	633.45	7,191.01	8.10	5.89	**6.76**
Lagerstroemia indica	Crapemyrtle	8.08	941.97	48.31	60.52	1,002.50	6.41	0.82	**1.19**
Prunus cerasifera	Cherry plum	5.75	669.90	33.41	41.85	711.75	4.47	0.58	**1.21**
Sequoia sempervirens	Coast redwood	47.01	5,481.22	17.49	21.91	5,503.13	4.16	4.51	**10.08**
Zelkova serrata	Japanese zelkova	15.99	1,864.04	- 41.09	- 51.48	1,812.57	3.17	1.49	**4.35**
Quercus lobata	Valley oak	43.14	5,030.12	- 61.15	- 76.60	4,953.52	3.01	4.06	**12.51**
Triadica sebifera	Tallowtree	18.03	2,102.47	169.37	212.17	2,314.65	2.75	1.90	**6.41**
Quercus ilex	Holly oak	2.70	314.96	5.94	7.44	322.40	2.66	0.26	**0.92**
Pinus canariensis	Canary Island Pine	6.16	718.51	49.23	61.67	780.18	2.40	0.64	**2.48**
Fraxinus velutina	Velvet ash	1.80	209.97	46.46	58.20	268.17	2.12	0.22	**0.96**
Malus species	Crabapple, flowering	1.40	162.75	16.21	20.31	183.06	2.10	0.15	**0.66**
Ulmus parvifolia	Chinese elm	1.10	128.79	10.72	13.43	142.22	1.67	0.12	**0.65**
Cedrus deodara	Deodar cedar	17.50	2,040.04	61.77	77.39	2,117.42	1.55	1.74	**10.38**
Celtis sinensis	Chinese hackberry	25.37	2,958.32	41.19	51.60	3,009.91	1.54	2.47	**14.90**
Koelreuteria paniculata	Goldenrain tree	5.40	629.87	67.84	84.99	714.86	1.52	0.59	**3.57**
Tilia species	Basswood	0.83	97.09	10.50	13.15	110.24	1.42	0.09	**0.59**
Ulmus species	Elm	30.35	3,538.87	- 136.72	- 171.28	3,367.59	1.34	2.76	**19.13**
Pinus species	Pine	18.31	2,135.20	117.24	146.87	2,282.07	1.26	1.87	**13.83**
Ginkgo biloba	Ginkgo	1.38	161.44	11.61	14.54	175.98	1.16	0.14	**1.16**
Olea europaea	Olive	24.71	2,880.66	- 60.57	- 75.88	2,804.78	1.16	2.30	**18.45**
Fraxinus velutina 'Modesto'	Modesto ash	37.13	4,329.51	319.78	400.58	4,730.09	1.14	3.88	**31.53**
Xylosma congestum	Xylosma	11.91	1,389.09	57.96	72.61	1,461.70	1.13	1.20	**9.88**
Quercus rubra	Northern red oak	0.08	9.01	3.37	4.22	13.22	1.02	0.01	**0.10**
Other trees	**Other trees**	257.64	30,040.85	889.58	1,114.38	31,155.23	22.08	25.54	**10.74**
Citywide total		**1,010.23**	**117,792.28**	**3,364.21**	**4,214.35**	**122,006.63**	**100.00**	**100.00**	**9.29**

Atmospheric Carbon Dioxide Reduction

As environmental awareness continues to increase, governments are paying particular attention to global warming and the effects of greenhouse gas emissions. Two national policy options are currently under debate, the establishment of a carbon tax and a greenhouse gas cap-and-trade system, aimed at the reduction of atmospheric carbon dioxide (CO_2) and other greenhouse gases. A carbon tax would place a tax burden on each unit of greenhouse gas emission and would require regulated entities to pay for their level of emissions. Alternatively, in a cap-and-trade system, an upper limit (or cap) is placed on global (federal, regional, or other jurisdiction) levels of greenhouse gas emissions and the regulated entities would be required to either reduce emissions to required limits or purchase emissions allowances in order to meet the cap (Williams and others, 2007). The concept of purchasing emission allowances (offsets) has led to the acceptance of carbon credits as a commodity that can be exchanged for financial gain. The Center for Urban Forest Research (CUFR, Pacific Southwest Research Station, and USDA Forest Service) recently led the development of Urban Forest Project Reporting Protocol. The protocol incorporates methods of the Kyoto Protocol and Voluntary Caron Standard (VCS) and establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides urban forest managers in developing tree planting and stewardship projects that could be registered for greenhouse gas (GHG) reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, educational campuses, and utility service areas anywhere in the U.S.

While Woodland's urban forest resource may not qualify for carbon offset credits or be traded in the open market, the City's public trees are nonetheless providing a significant reduction in atmospheric carbon dioxide (CO_2) for a positive environmental and financial benefit to the community and should be considered as a positive credit when calculating Woodland's carbon footprint.

Urban trees reduce atmospheric carbon dioxide (CO_2) in two ways:

- **Directly, through growth and the sequestration of CO_2 as woody and foliar biomass.**
- **Indirectly, by lowering the demand for heating and air conditioning, thereby reducing the emissions associated with electric power generation and natural gas consumption.**

Conversely, CO_2 is released by vehicles, chain saws, chippers, and other equipment used to plant and care for trees. Additionally, when a tree dies, most of the CO_2 that accumulated as woody biomass is released back into the atmosphere during decomposition, except in cases where the wood is recycled. Each of these factors must be considered when calculating the CO_2 reduction benefits of trees.

Sequestered Carbon Dioxide

To date, Woodland's public urban forest has stored a total of 8551 tons of carbon dioxide (CO_2) valued at $128,267. Annually, Woodland's public tree resource directly reduces 311 tons of CO_2, valued at $4,670, into woody and foliar biomass. Accounting for CO_2 emissions from tree decomposition (-97 tons), tree related maintenance activity (-7 tons), and Avoided CO_2 (475 tons), Woodland's public trees provide an annual net reduction in atmospheric CO_2 of 682 tons, valued at $10,224 with an average of $0.78 per tree (Table 7). Olive (*Olea europaea*, $2.06) and Modesto ash (*Fraxinus velutina* 'Modesto', $1.88) are currently providing the highest per tree benefit (Figure 8). London planetree (*Platanus X acerifolia)* are providing the greatest percentage of overall benefits at 17.5% due to the prevalence in the population.

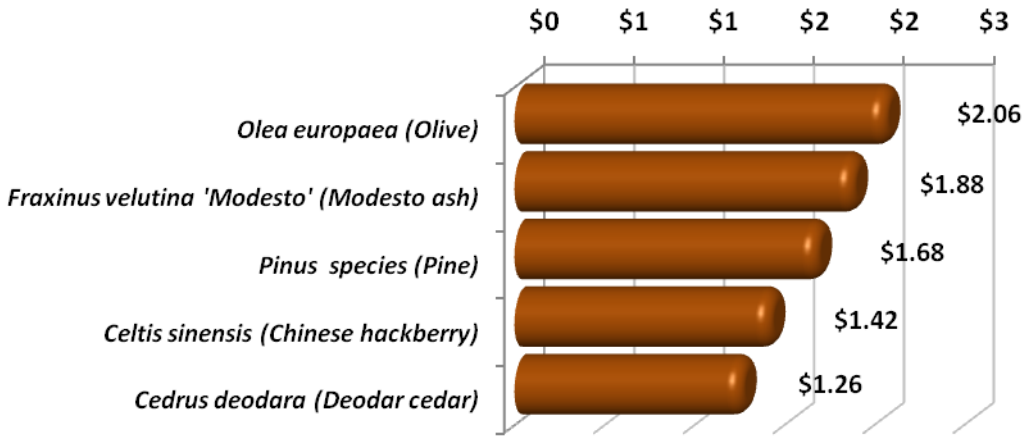


Figure 8. Top Five Species for Reducing CO_2.

Table 7. Annual CO_2 Reduction Benefits Provided by Woodland's Public Tree Resource.

Species	Common Name	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
Platanus X acerifolia	London planetree	81,310.85	609.83	- 47,146.01	- 2,633.89	- 373.35	206,900.70	1,551.76	238,431.65	1,788.24	11.57	17.49	**1.18**
Pistacia chinensis	Chinese pistache	45,033.05	337.75	- 9,670.73	- 1,441.06	- 83.34	142,843.71	1,071.33	176,764.96	1,325.74	9.10	12.97	**1.11**
Pyrus calleryana	Flowering pear	29,889.07	224.17	- 5,287.56	- 847.09	- 46.01	52,844.83	396.34	76,599.25	574.49	8.10	5.62	**0.54**
Lagerstroemia indica	Crapemyrtle	2,306.90	17.30	- 394.62	- 310.25	- 5.29	7,591.00	56.93	9,193.03	68.95	6.41	0.67	**0.08**
Prunus cerasifera	Cherry plum	1,645.73	12.34	- 267.41	- 220.74	- 3.66	5,398.47	40.49	6,556.04	49.17	4.47	0.48	**0.08**
Sequoia sempervirens	Coast redwood	54,614.87	409.61	- 7,360.82	- 790.55	- 61.14	44,171.01	331.28	90,634.51	679.76	4.16	6.65	**1.24**
Zelkova serrata	Japanese zelkova	10,562.31	79.22	- 1,735.99	- 210.60	- 14.60	15,021.61	112.66	23,637.33	177.28	3.17	1.73	**0.43**
Quercus lobata	Valley oak	48,410.17	363.08	- 26,432.72	- 610.13	- 202.82	40,535.78	304.02	61,903.09	464.27	3.01	4.54	**1.17**
Triadica sebifera	Tallowtree	8,129.81	60.97	- 2,128.97	- 269.49	- 17.99	16,943.02	127.07	22,674.37	170.06	2.75	1.66	**0.47**
Quercus ilex	Holly oak	6,466.71	48.50	- 1,353.11	- 95.36	- 10.86	2,538.10	19.04	7,556.34	56.67	2.66	0.55	**0.16**
Pinus canariensis	Canary Island Pine	5,613.58	42.10	- 482.91	- 131.43	- 4.61	5,790.23	43.43	10,789.48	80.92	2.40	0.79	**0.26**
Fraxinus velutina	Velvet ash	2,610.35	19.58	- 68.49	- 71.76	- 1.05	1,692.08	12.69	4,162.18	31.22	2.12	0.31	**0.11**
Malus species	Crabapple, flowering	572.96	4.30	- 50.68	- 69.23	- 0.90	1,311.52	9.84	1,764.57	13.23	2.10	0.13	**0.05**
Ulmus parvifolia	Chinese elm	1,890.94	14.18	- 4.62	- 46.41	- 0.38	1,037.84	7.78	2,877.75	21.58	1.67	0.21	**0.10**
Cedrus deodara	Deodar cedar	21,283.93	159.63	- 3,062.64	- 287.84	- 25.13	16,439.88	123.30	34,373.34	257.80	1.55	2.52	**1.26**
Celtis sinensis	Chinese hackberry	18,055.05	135.41	- 3,236.92	- 287.24	- 26.43	23,839.91	178.80	38,370.80	287.78	1.54	2.81	**1.42**
Koelreuteria paniculata	Goldenrain tree	4,465.00	33.49	- 467.24	- 104.72	- 4.29	5,075.90	38.07	8,968.95	67.27	1.52	0.66	**0.34**
Tilia species	Basswood	1,375.21	10.31	- 92.69	- 41.54	- 1.01	782.38	5.87	2,023.37	15.18	1.42	0.15	**0.08**
Ulmus species	Elm	2,997.57	22.48	- 10,389.14	- 388.52	- 80.83	28,518.37	213.89	20,738.28	155.54	1.34	1.52	**0.88**
Pinus species	Pine	24,359.06	182.69	- 4,282.02	- 290.76	- 34.30	17,206.72	129.05	36,993.00	277.45	1.26	2.71	**1.68**
Ginkgo biloba	Ginkgo	1,461.23	10.96	- 85.28	- 43.88	- 0.97	1,300.98	9.76	2,633.05	19.75	1.16	0.19	**0.13**
Olea europaea	Olive	25,643.73	192.33	- 6,882.86	- 317.46	- 54.00	23,214.09	174.11	41,657.49	312.43	1.16	3.06	**2.06**
Fraxinus velutina 'Modesto'	Modesto ash	14,285.10	107.14	- 11,057.84	- 499.20	- 86.68	34,889.83	261.67	37,617.88	282.13	1.14	2.76	**1.88**
Xylosma congestum	Xylosma	7,352.11	55.14	- 748.50	- 172.58	- 6.91	11,194.13	83.96	17,625.16	132.19	1.13	1.29	**0.89**
Quercus rubra	Northern red oak	1,085.60	8.14	- 1.30	- 26.13	- 0.21	72.57	0.54	1,130.73	8.48	1.02	0.08	**0.06**
All other trees	All other trees	201,265.47	1,509.49	- 52,222.21	- 3,555.53	- 418.33	242,087.56	1,815.66	387,575.29	2,906.81	22.08	28.43	**1.00**
Citywide total		**622,686.39**	**4,670.15**	**- 194,913.29**	**- 13,763.38**	**- 1,565.08**	**949,242.22**	**7,119.32**	**1,363,251.94**	**10,224.39**	**100.00**	**100.00**	**0.78**

Air Quality Improvement

Urban trees improve air quality in five fundamental ways:

- **Absorption of gaseous pollutants such as ozone (O_3) and nitrogen dioxide (NO_2) through leaf surfaces;**
- **Interception of particulate matter (PM_{10}), such as dust, ash, dirt, pollen, and smoke;**
- **Reduction of emissions from power generation by reducing energy consumption;**
- **Increase of oxygen levels through photosynthesis; and**
- **Transpiration of water and shade provision, resulting in lower local air temperatures, thereby reducing O_3 levels.**

While air quality in the City of Woodland is generally good, according to data gathered by the Yolo-Solano Air District, 2009 saw 75 days with a Moderate Air Quality Index (AQI), meaning "air quality is acceptable, however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution." In addition, seven days were reported to have an AQI of Unhealthy for Sensitive Groups, meaning "members of sensitive groups may experience health effects, while the general public is not likely to be effected the air quality was considered." (sparetheair.com). Additionally, since 2000, there have been a total of 51 exceedances of the California one-hour standard for ground level ozone (0_3) and 20 exceedances of the Federal eight-hour standard. Since healthy air is a quality of life issue for all members of the community, it's easy to see why protection of the Woodland's urban forest is so important.

In the absence of cooling effects provided by trees, higher temperatures contribute to ozone (O3) formation. Additionally, short-term increases in ozone concentrations have been statistically associated with increased tree mortality for 95 large U. S. cities (Bell and others, 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 various biogenic volatile organic compounds (BVOCs), such as isoprenes and monoterpenes, which can also contribute to ozone formation. These BVOC emissions are accounted for by i-Tree *Streets* in the air quality net benefit.

Year	Ozone > State 1-hour Standard	Ozone > Federal 8-hour Standard
2009	2	1
2008	7	3
2007	2	1
2006	8	4
2005	2	2
2004	1	1
2003	4	0
2002	11	4
2001	7	2
2000	7	2
Average	**5.1**	**2**

Table 8. Number of Exceedances of Federal and State Ground-Level Ozone.

Deposition and Interception

Each year, more than five tons of nitrogen dioxide (NO2), small particulate matter (PM10), sulfur dioxide (SO_2), and ozone (O3) are intercepted or absorbed by the public trees in Woodland, for a value of $117,232 (Table 9). As a population, London planetree (*Platanus X acerifolia*, 1,906 lbs.), Chinese pistache (*Pistacia chinensis*, 1,301 lbs.) and flowering pear (*Pyrus calleryana*, 517 lbs.) are the greatest contributors to air quality improvements, accounting for approximately 40% of total benefits.

Avoided Pollutants

By reducing energy needs, the 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, 1, 913 pounds of pollutants, valued at $18,618, are avoided annually through the shading effects of Woodland's public trees. The populations of London planetree (*Platanus X acerifolia*, 425 lbs.), Chinese pistache (*Pistacia chinensis*, 280 lbs.) and flowering pear (*Pyrus calleryana*, 110 lbs.) provide a combined 42% of the total benefits and have the greatest impact on reducing energy needs and therefore avoiding the additional generation of pollutants.

BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered. Nearly three tons of BVOCs are annually emitted from Woodland's public trees, offsetting the total air quality benefit by $27,746. Valley oak (*Quercus lobata*) are the heaviest per tree emitters of BVOCs, accounting for 23% (1,347 lbs.) of the total BVOC emissions, while representing only 3% of the total population. The large amount of BVOC emissions by the valley oak population outweigh the benefits of air pollutants deposited, removed, and avoided in terms of pounds of pollutants. However, the monetary value of the air pollutants removed by that population is greater than the disadvantage of BVOC emissions, creating a positive flow of monetary benefits in terms of air quality for the valley oak population.

Net Air Quality Improvement

Net air pollutants removed, avoided, and released by Woodland's public tree population are valued at $108,104 annually. The average net benefit per tree is $8.23. Trees vary dramatically in their ability to produce net air quality benefits. Typically, large-canopied trees with large leaf surface areas that are not high emitters of BVOCs produce the greatest benefits. On a per tree basis, Modesto ash (*Fraxinus velutina* 'Modesto', $30.35), American and English elms (*Ulmus procera* and *U. americana*, $25.17), and olive (*Olea europeae*, $23.58) currently produce the greatest per tree net air quality improvements (Figure 9). London planetree (*Platanus X acerifolia*), due in large part to its prevalence in the population but also due to the fact that it is a solid performer, accounts for the greatest air quality improvements in terms of total benefits by species, collectively removing a net of 467 pounds of pollutants at a net value of $19,862 annually.

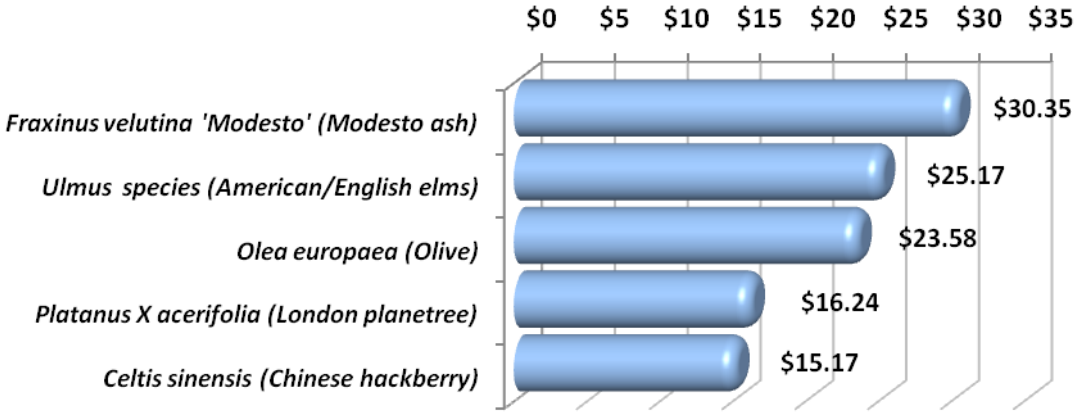


Figure 9. Top Five Species for Improving Air Quality.

Urban trees improve air quality in five fundamental ways, including absorption of ozone and nitrogen dioxide.

Table 9. Annual Air Quality Improvements Provided by Woodland's Public Tree Resource.

Species	Common Name	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 Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	% of Total Tree Numbers	Avg. $/tree
Platanus X acerifolia	London planetree	1,202.27	306.93	696.26	0.00	25,854.49	252.53	47.19	12.50	111.60	4,147.69	- 2,162.11	- 10,140.29	467.18	19,861.90	11.57	**13.07**
Pistacia chinensis	Chinese pistache	747.26	179.88	373.72	0.00	15,374.91	162.35	31.87	7.99	77.62	2,702.59	- 812.76	- 3,811.85	767.94	14,265.64	9.10	**11.93**
Pyrus calleryana	Flowering pear	280.86	72.05	164.16	0.00	6,058.44	66.08	12.23	3.27	28.76	1,082.62	0.00	0.00	627.42	7,141.06	8.10	**6.71**
Lagerstroemia indica	Crapemyrtle	46.84	11.07	22.65	0.00	953.79	9.02	1.70	0.45	4.05	148.57	0.00	0.00	95.78	1,102.36	6.41	**1.31**
Prunus cerasifera	Cherry plum	33.32	7.87	16.11	0.00	678.35	6.40	1.21	0.32	2.88	105.50	0.00	0.00	68.11	783.85	4.47	**1.33**
Sequoia sempervirens	Coast redwood	244.03	69.60	173.74	0.00	5,646.23	51.56	9.97	2.54	24.08	854.77	- 133.52	- 626.23	442.00	5,874.77	4.16	**10.76**
Zelkova serrata	Japanese zelkova	84.37	20.15	41.46	0.00	1,726.83	16.87	3.32	0.83	8.10	281.08	0.00	0.00	175.10	2,007.92	3.17	**4.82**
Quercus lobata	Valley oak	252.41	71.99	179.71	0.00	5,840.12	46.29	9.04	2.28	21.94	769.47	- 1,347.32	- 6,318.91	- 763.65	290.68	3.01	**0.73**
Triadica sebifera	Tallowtree	91.76	23.54	53.63	0.00	1,979.37	21.25	3.92	1.05	9.21	347.90	0.00	0.00	204.37	2,327.27	2.75	**6.45**
Quercus ilex	Holly oak	16.04	4.57	11.42	0.00	371.15	2.98	0.57	0.15	1.37	49.34	- 93.23	- 437.25	- 56.12	- 16.76	2.66	**- 0.05**
Pinus canariensis	Canary Island Pine	38.30	10.92	27.27	0.00	886.10	7.10	1.32	0.35	3.12	116.55	- 15.71	- 73.66	72.68	928.98	2.40	**2.95**
Fraxinus velutina	Velvet ash	12.77	2.88	5.64	0.00	253.11	2.33	0.40	0.12	0.90	37.41	0.00	0.00	25.02	290.52	2.12	**1.05**
Malus species	Crabapple, flowering	8.88	2.10	4.29	0.00	180.73	1.63	0.30	0.08	0.70	26.60	0.00	0.00	17.97	207.33	2.10	**0.75**
Ulmus parvifolia	Chinese elm	7.04	1.68	3.46	0.00	144.17	1.27	0.24	0.06	0.55	20.82	0.00	0.00	14.31	164.99	1.67	**0.75**
Cedrus deodara	Deodar cedar	93.52	26.67	66.58	0.00	2,163.77	19.70	3.75	0.97	8.96	325.10	- 49.16	- 230.57	170.99	2,258.30	1.55	**11.07**
Celtis sinensis	Chinese hackberry	137.03	32.99	68.53	0.00	2,819.41	27.86	5.36	1.37	12.88	461.14	0.00	0.00	286.03	3,280.55	1.54	**16.24**
Koelreuteria paniculata	Goldenrain tree	27.20	6.50	13.37	0.00	556.84	6.50	1.18	0.32	2.75	105.98	- 83.97	- 393.80	- 26.14	269.01	1.52	**1.35**
Tilia species	Basswood	5.14	1.32	3.00	0.00	110.88	1.00	0.18	0.05	0.43	16.37	0.00	0.00	11.12	127.25	1.42	**0.68**
Ulmus species	Elm	191.09	45.63	93.91	0.00	3,911.37	31.09	6.18	1.53	15.16	519.36	0.00	0.00	384.59	4,430.73	1.34	**25.17**
Pinus species	Pine	103.60	29.54	73.76	0.00	2,396.92	21.07	3.95	1.04	9.35	346.24	- 51.03	- 239.32	191.27	2,503.84	1.26	**15.17**
Ginkgo biloba	Ginkgo	6.74	1.61	3.31	0.00	137.87	1.62	0.30	0.08	0.71	26.57	- 4.27	- 20.01	10.10	144.44	1.16	**0.95**
Olea europaea	Olive	135.93	38.77	96.78	0.00	3,145.05	26.34	5.18	1.30	12.61	438.62	0.00	0.00	316.90	3,583.67	1.16	**23.58**
Fraxinus velutina 'Modesto'	Modesto ash	193.84	43.71	85.57	0.00	3,843.45	43.28	8.02	2.14	18.85	709.24	0.00	0.00	395.42	4,552.68	1.14	**30.35**
Xylosma congestum	Xylosma	67.31	19.20	47.93	0.00	1,557.43	13.48	2.55	0.67	6.07	222.09	0.00	0.00	157.20	1,779.53	1.13	**12.02**
Quercus rubra	Northern red oak	0.71	0.20	0.50	0.00	16.31	0.11	0.02	0.01	0.04	1.75	- 12.85	- 60.27	- 11.27	- 42.21	1.02	**- 0.31**
All other trees	**All other trees**	1,413.01	366.57	835.67	0.00	30,624.57	288.08	54.82	14.23	131.08	4,754.76	- 1,150.07	- 5,393.85	1,953.39	29,985.48	22.08	**10.34**
Citywide total		**5,441.26**	**1,397.93**	**3,162.42**	**0.00**	**117,231.64**	**1,127.80**	**214.77**	**55.71**	**513.79**	**18,618.14**	**-5,915.99**	**-27,746.01**	**5,997.69**	**108,103.78**	**100.00**	**8.23**

Stormwater Runoff Reductions

According to Federal Clean Water Act regulations, municipalities must obtain a permit for managing their stormwater discharges into water bodies. Each city's program must identify the *best management practices* (BMPs) it will implement to reduce its pollutant discharge.

Rainfall interception by trees can reduce 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. This is especially important in an urban setting with a significant quantity of impervious surfaces in proximity to a major waterway. Healthy urban trees can 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 reduces overland flow; and**
- **Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on barren surfaces.**

Woodland's public trees intercept 6.5 million gallons of stormwater annually for an average of 497 gallons per tree (Table 10). The total value of this benefit to the City is $50,943, an average of $3.88 per tree. Olive (*Olea europaea*) provides the greatest per tree benefit of $13.52 (Figure 10) and 4% of the total stormwater benefits, while representing only 1.2% of the population. Due in large part to the prevalence and large stature of the population (11.6%), London planetree (*Platanus X acerifolia*) provide the greatest overall percentage of benefits (20%) and a per tree benefit of $6.70. Many of the species currently demonstrating very low benefits, including holly oak (*Quercus ilex*), velvet ash (*Fraxinus velutina*), tilia (*Tilia* spp.), Chinese elm (*Ulmus parvifolia*), ginkgo (*Ginkgo biloba*) and red oak (*Quercus rubra*) are very immature populations of large-growing trees. With appropriate maintenance, benefits from stormwater runoff reductions as well as for energy, air quality, carbon sequestration, and aesthetics will continue to increase dramatically as these species mature.

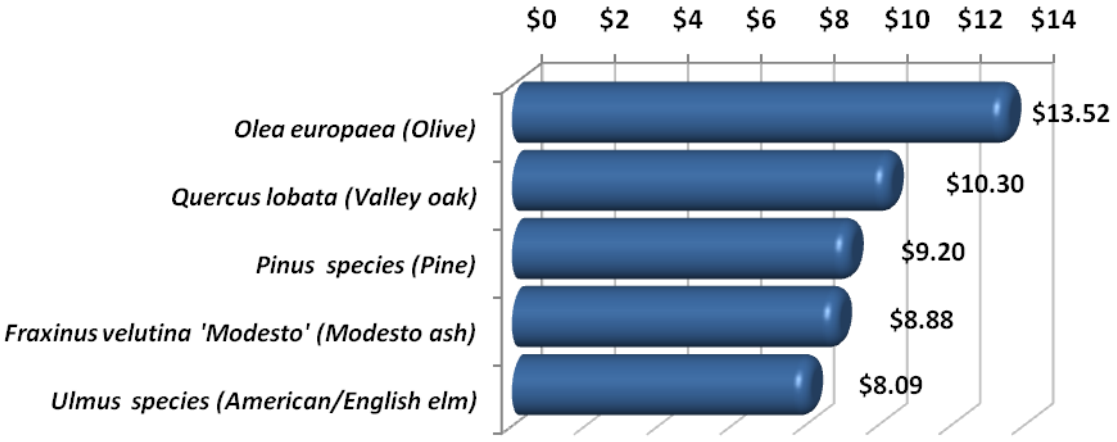


Figure 10. Top Five Species for Reducing Stormwater Runoff.

Table 10. Annual Stormwater Runoff Reduction Benefits Provided by Woodland's Public Tree Resource.

Species	Common Name	Total Rainfall Interception (Gal)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Platanus X acerifolia	London planetree	1,306,003.01	10,187.53	11.57	20.00	**6.70**
Pistacia chinensis	Chinese pistache	587,476.79	4,582.64	9.10	9.00	**3.83**
Pyrus calleryana	Flowering pear	288,477.00	2,250.28	8.10	4.42	**2.11**
Lagerstroemia indica	Crapemyrtle	39,487.79	308.03	6.41	0.60	**0.37**
Prunus cerasifera	Cherry plum	27,899.62	217.63	4.47	0.43	**0.37**
Sequoia sempervirens	Coast redwood	487,591.25	3,803.48	4.16	7.47	**6.97**
Zelkova serrata	Japanese zelkova	70,208.51	547.66	3.17	1.08	**1.31**
Quercus lobata	Valley oak	522,701.27	4,077.35	3.01	8.00	**10.30**
Triadica sebifera	Tallowtree	94,129.64	734.26	2.75	1.44	**2.03**
Quercus ilex	Holly oak	33,088.69	258.11	2.66	0.51	**0.74**
Pinus canariensis	Canary Island Pine	62,156.72	484.86	2.40	0.95	**1.54**
Fraxinus velutina	Velvet ash	11,461.01	89.40	2.12	0.18	**0.32**
Malus species	Crabapple, flowering	7,537.95	58.80	2.10	0.12	**0.21**
Ulmus parvifolia	Chinese elm	6,093.74	47.53	1.67	0.09	**0.22**
Cedrus deodara	Deodar cedar	182,518.98	1,423.75	1.55	2.79	**6.98**
Celtis sinensis	Chinese hackberry	116,572.63	909.33	1.54	1.78	**4.50**
Koelreuteria paniculata	Goldenrain tree	20,992.74	163.75	1.52	0.32	**0.82**
Tilia species	Basswood	6,367.99	49.67	1.42	0.10	**0.27**
Ulmus species	American/English elm	182,514.08	1,423.71	1.34	2.79	**8.09**
Pinus species	Pine	194,630.04	1,518.22	1.26	2.98	**9.20**
Ginkgo biloba	Ginkgo	5,721.50	44.63	1.16	0.09	**0.29**
Olea europaea	Olive	263,413.44	2,054.77	1.16	4.03	**13.52**
Fraxinus velutina 'Modesto'	Modesto ash	170,704.94	1,331.59	1.14	2.61	**8.88**
Xylosma congestum	Xylosma	101,020.61	788.02	1.13	1.55	**5.32**
Quercus rubra	Northern red oak	2,513.16	19.60	1.02	0.04	**0.15**
All other trees	**All other trees**	1,739,465.47	13,568.77	22.08	26.64	**4.68**
Citywide total		**6,530,748.54**	**50,943.38**	**100.00**	**100.00**	**3.88**

Aesthetic, Property Value, Social, Economic, and Other Benefits

Trees provide beauty in the urban landscape, privacy to homeowners, improved human health, a sense of comfort and place, and refuge for urban wildlife. There is documented evidence 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 may be captured as a percentage of the value of the property on which a tree stands. To determine the value of these less tangible benefits, research that compares differences in sales prices of homes is used 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. Consideration is given to the location of the street tree in relation to the land use. Street trees located in front of multi-family homes will not increase the property value at the same rate as single-family homes.

Furthermore, street trees located adjacent to commercial and nonresidential properties do not have the same resale potential as residential areas. These factors are taken into consideration and the value of those trees is adjusted accordingly. 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 public tree population, benefits reflect the increase in leaf area for each tree over the course of a single year. As a result, a very young population of 100 velvet ash (*Fraxinus velutina)* will have a greater annual aesthetic benefit than an equal number of mature planetree (*Platanus X acerifolia*). However, the cumulative aesthetic value of the planetree would be much greater than that of the ash.

The total annual benefit associated with property value increases and other less tangible benefits is $758,033, an average of $57.69 (Table 11). Tree species that produced the highest average annual aesthetic benefits include velvet ash (*Fraxinus velutina*, $177.29), Chinese hackberry (*Celtis sinensis*, $113.20), olive (*Olea europaea*, $112.53), tilia (*Tilia* spp., $78.12), and redwood (*Sequoia sempervirens*, $77.62)(Figure 11). Some species may rank high due to their size and growth rates, but may be undesirable for new plantings for other reasons. For example, the majority (60%) of Woodland's Chinese hackberry, which has a relatively low relative performance index of 0.90, are in only fair condition and 3.5% are in poor condition. While there may be a number of factors affecting the performance of individual trees in this population, it is important to recognize that an investment in Chinese hackberry with the expectation of receiving high aesthetic benefits may in fact lead to greater liability and increased maintenance costs, negating any relative aesthetic benefits.

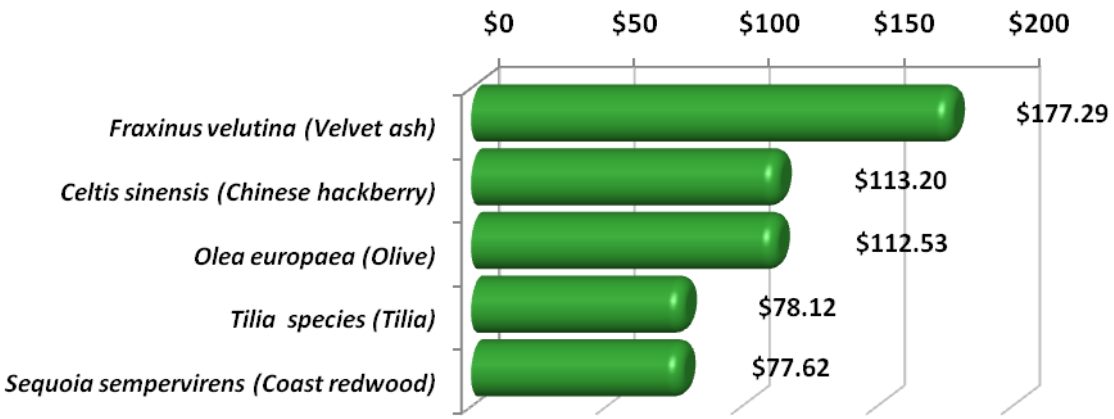


Figure 11. Top Five Species for Increased Property and Socioeconomic Values.

Urban trees promote retail shopping by stimulating more frequent visits and a willingness to pay more for goods and services.

Table 11. Annual Aesthetic, Property Value, Social, Economic, and Other Related Benefits of Woodland's Public Tree Resource

Species	Common Name	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Platanus X acerifolia	London planetree	111,131.07	11.57	14.66	**73.11**
Pistacia chinensis	Chinese pistache	79,156.88	9.10	10.44	**66.18**
Pyrus calleryana	Flowering pear	62,880.18	8.10	8.30	**59.10**
Lagerstroemia indica	Crapemyrtle	7,144.86	6.41	0.94	**8.49**
Prunus cerasifera	Cherry plum	4,962.33	4.47	0.65	**8.44**
Sequoia sempervirens	Coast redwood	42,381.64	4.16	5.59	**77.62**
Zelkova serrata	Japanese zelkova	27,120.20	3.17	3.58	**65.04**
Quercus lobata	Valley oak	21,174.27	3.01	2.79	**53.47**
Triadica sebifera	Tallowtree	22,492.17	2.75	2.97	**62.31**
Quercus ilex	Holly oak	13,446.89	2.66	1.77	**38.42**
Pinus canariensis	Canary Island Pine	17,744.44	2.40	2.34	**56.33**
Fraxinus velutina	Velvet ash	49,285.37	2.12	6.50	**177.29**
Malus species	Crabapple, flowering	2,370.40	2.10	0.31	**8.59**
Ulmus parvifolia	Chinese elm	11,781.46	1.67	1.55	**53.55**
Cedrus deodara	Deodar cedar	14,602.72	1.55	1.93	**71.58**
Celtis sinensis	Chinese hackberry	22,866.80	1.54	3.02	**113.20**
Koelreuteria paniculata	Goldenrain tree	5,405.36	1.52	0.71	**27.03**
Tilia species	Basswood	14,609.06	1.42	1.93	**78.12**
Ulmus species	American/English elm	9,016.13	1.34	1.19	**51.23**
Pinus species	Pine	11,913.67	1.26	1.57	**72.20**
Ginkgo biloba	Ginkgo	3,007.44	1.16	0.40	**19.79**
Olea europaea	Olive	17,105.02	1.16	2.26	**112.53**
Fraxinus velutina 'Modesto'	Modesto ash	5,290.12	1.14	0.70	**35.27**
Xylosma congestum	Xylosma	7,094.59	1.13	0.94	**47.94**
Quercus rubra	Northern red oak	4,848.90	1.02	0.64	**36.19**
All other trees	**All other trees**	169,201.14	22.08	22.32	**58.33**
Citywide total		**758,033.11**	**100.00**	**100.00**	**57.69**

Figure 12. Summary of Annual Per Tree Benefits from Woodland's Most Prevalent Species.

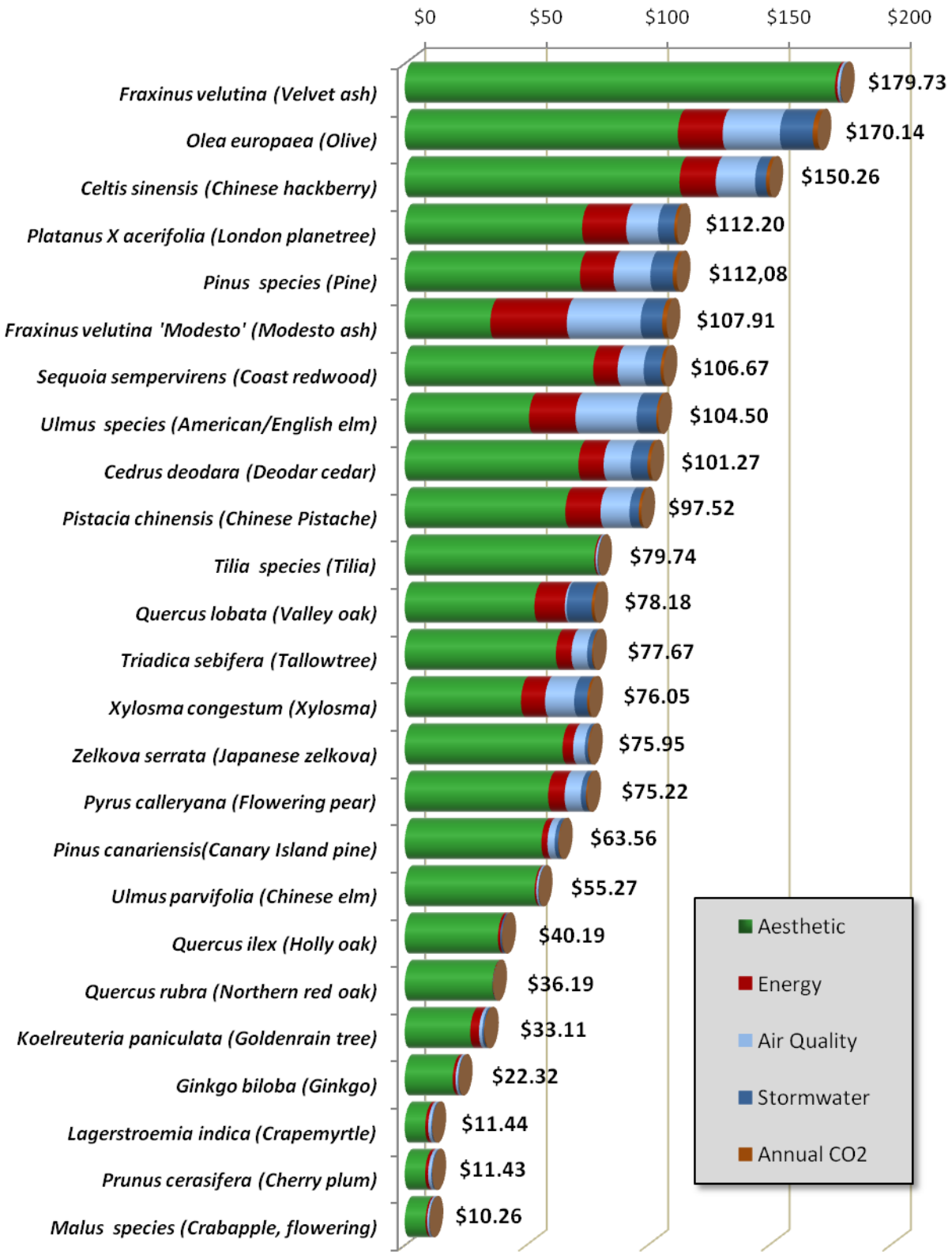


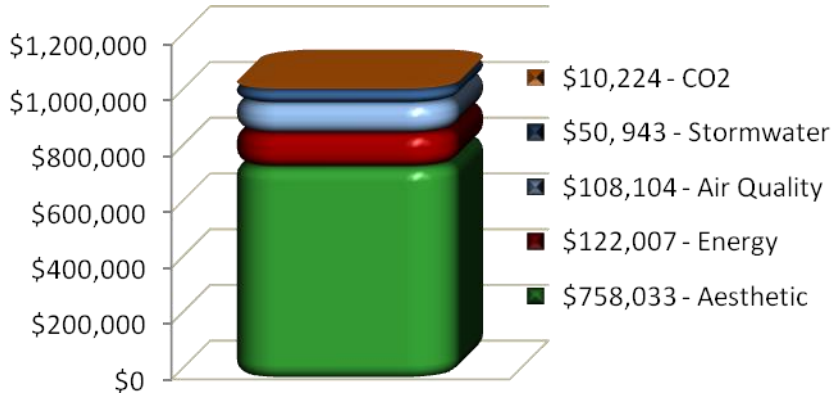
Table 12. Summary of Average Current Annual Per Tree Related Benefits of Woodland's Public Tree Resource.

Species	Common Name	Energy Avg. $/tree	Storm-water Avg. $/tree	CO2 Avg. $/tree	Air Quality Avg. $/tree	Aesthetic Avg. $/tree	% of Total Tree Numbers	Total Benefits Avg. $/tree
Platanus X acerifolia	London planetree	18.14	6.70	1.18	13.07	73.11	11.57	**112.20**
Pistacia chinensis	Chinese pistache	14.47	3.83	1.11	11.93	66.18	9.10	**97.52**
Pyrus calleryana	Flowering pear	6.76	2.11	0.54	6.71	59.10	8.10	**75.22**
Lagerstroemia indica	Crapemyrtle	1.19	0.37	0.08	1.31	8.49	6.41	**11.44**
Prunus cerasifera	Cherry plum	1.21	0.37	0.08	1.33	8.44	4.47	**11.43**
Sequoia sempervirens	Coast redwood	10.08	6.97	1.24	10.76	77.62	4.16	**106.67**
Zelkova serrata	Japanese zelkova	4.35	1.31	0.43	4.82	65.04	3.17	**75.95**
Quercus lobata	Valley oak	12.51	10.30	1.17	0.73	53.47	3.01	**78.18**
Triadica sebifera	Tallowtree	6.41	2.03	0.47	6.45	62.31	2.75	**77.67**
Quercus ilex	Holly oak	0.92	0.74	0.16	- 0.05	38.42	2.66	**40.19**
Pinus canariensis	Canary Island Pine	2.48	1.54	0.26	2.95	56.33	2.40	**63.56**
Fraxinus velutina	Velvet ash	0.96	0.32	0.11	1.05	177.29	2.12	**179.73**
Malus species	Crabapple, flowering	0.66	0.21	0.05	0.75	8.59	2.10	**10.26**
Ulmus parvifolia	Chinese elm	0.65	0.22	0.10	0.75	53.55	1.67	**55.27**
Cedrus deodara	Deodar cedar	10.38	6.98	1.26	11.07	71.58	1.55	**101.27**
Celtis sinensis	Chinese hackberry	14.90	4.50	1.42	16.24	113.20	1.54	**150.26**
Koelreuteria paniculata	Goldenrain tree	3.57	0.82	0.34	1.35	27.03	1.52	**33.11**
Tilia species	Basswood	0.59	0.27	0.08	0.68	78.12	1.42	**79.74**
Ulmus species	American/English elm	19.13	8.09	0.88	25.17	51.23	1.34	**104.50**
Pinus species	Pine	13.83	9.20	1.68	15.17	72.20	1.26	**112.08**
Ginkgo biloba	Ginkgo	1.16	0.29	0.13	0.95	19.79	1.16	**22.32**
Olea europaea	Olive	18.45	13.52	2.06	23.58	112.53	1.16	**170.14**
Fraxinus velutina 'Modesto'	Modesto ash	31.53	8.88	1.88	30.35	35.27	1.14	**107.91**
Xylosma congestum	Xylosma	9.88	5.32	0.89	12.02	47.94	1.13	**76.05**
Quercus rubra	Northern red oak	0.10	0.15	0.06	- 0.31	36.19	1.02	**36.19**
All other trees	**All other trees**	10.74	4.68	1.00	10.34	58.33	22.08	**85.09**
Citywide total		**9.29**	**3.88**	**0.78**	**8.23**	**57.69**	**100.00**	**79.87**

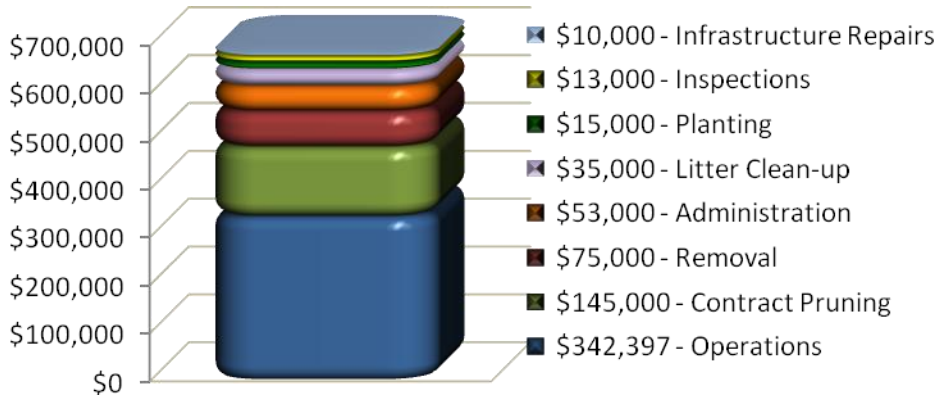
Net Benefits and Benefit-Investment Ratio (BIR)

Woodland receives substantial benefits from its public trees; however, the City must also consider the costs of maintaining this resource. Applying a *benefit-investment ratio* (BIR) is a useful way to evaluate the public investment in the community tree population. A BIR is an indicator used to summarize the overall value compared to the costs of a given project. Specifically in this analysis, BIR is the ratio of the cumulative benefits provided by the City's public trees expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. Woodland's municipal trees have beneficial effects on the environment. Greater than 27% ($291,278) of the total annual benefits quantified in this study are environmental services (Table 13). Air quality benefits ($108,104) account for 37.1% of the annual environmental benefits and 10.3% of all benefits. Energy savings ($122,007) account for 41.9% of the annual environmental benefits and 11.6% of all annual benefits. The reduction of stormwater runoff (17.5%) and CO_2 reduction (3.5%) provide the balance of annual environmental benefits. Annual increases in property value and other aesthetic values are substantial benefits, accounting for 72.2% of the total benefits. The sum of estimated benefits for Woodland's public tree resource is $1,049,311; that is a value of $79.86 per street tree and $19.23 per capita. These benefits are realized on an annual basis. It is important to realize that this is not a full accounting of the benefits provided by Woodland's public trees since 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, but there is limited knowledge about the physical processes at work and their interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and costs 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 we can ever quantify!**

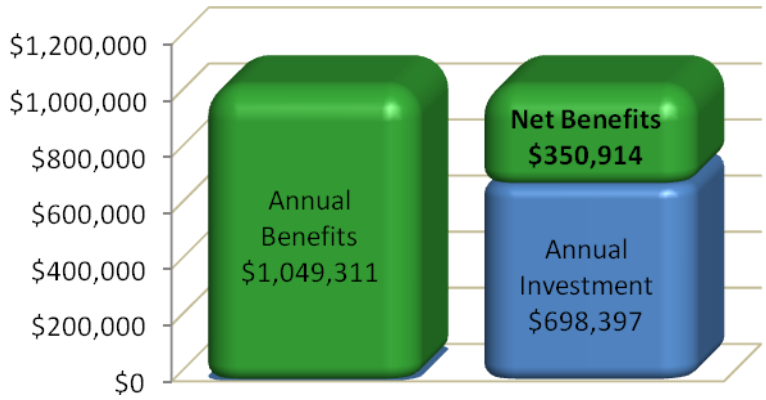
The total annual benefit that trees provide to the City of Woodland is $1,049,311. When the City's annual tree related expenditures (or investment) of $698,397 are considered, the net annual benefit (benefits minus investment) to the City is $350,397. The average net benefit for an individual public tree in Woodland is $26.71, and the per capita benefit is $6.43. Based on the inventory 13,140 public trees, Woodland is receiving $1.50 in benefits for every $1 that is spent on its urban forestry program (Table 13). With appropriate maintenance and regular pruning, Woodland's trees will only appreciate in value and the benefits they are currently providing can be expected to increase exponentially.



Total Annual Benefits from Woodland's Public Tree Resource: $1,049,311
Average Annual Per Tree Benefits: $79.86
Annual Value of Benefits Per Capita: $19.23



Total Annual Investment to Maintain Woodland's Public Tree Resource: $698,397
Average Annual Per Tree Investment: $53.15
Annual Investment Per Capita: $12.80



Annual Net Benefits of Woodland's Public Tree Resource: $350,914
For EVERY $1 invested in public trees, Woodland receives $1.50 in benefits.

Table 13. Benefit Versus Investment Summary for Woodland's Public Tree Resource.

Benefits	Total ($)	$/tree	$/capita
Energy	122,007	9.29	2.24
CO_2	10,224	0.78	0.19
Air Quality	108,104	8.23	1.98
Stormwater	50,943	3.88	0.93
Aesthetic/Other	758,033	57.69	13.89
Total Annual Benefits	**$1,049,311**	**$79.86**	**$19.23**
Investment			
Planting	15,000	1.14	0.27
Contract Pruning	145,000	11.04	2.66
Pest Management	10,000	0.76	0.18
Removal	75,000	5.71	1.37
Administration	53,000	4.03	0.97
Inspections	13,000	0.99	0.24
Infrastructure Repairs	10,000	0.76	0.18
Litter Clean-up	35,000	2.66	0.64
Operations	342,397	26.06	6.27
Total Annual Investment	**$698,397**	**$53.15**	**$12.80**
Net Benefits	**$350,914**	**$26.71**	**$6.43**
Benefit-Investment Ratio	**1.502456339**		

Conclusion

This analysis describes the current structural characteristics of Woodland's public tree resource using i-Tree *Streets*, a STRATUM Analysis Tool, to determine the environmental and aesthetic benefits provided to the community. The approach is based on established tree sampling, numerical modeling, and statistical methods, and provides a general accounting of the benefits produced by Woodland's public trees. From this, a benefit-investment ratio is derived. The analysis provides a "snapshot" in time of Woodland's public trees and demonstrates that money spent on planting and caring for Woodland's trees is a wise investment. It also serves as an opportunity to speculate about the future. Given the current status of the City's tree population, what future trends are likely and what management challenges will need to be met to sustain or, more importantly, increase the current level of benefits? This information can be used to make informed management decisions regarding the current and future status of the City's forestry program and the vital resource it protects and maintains. Future changes and improvements to the urban forestry program should be directed towards sustainability and increasing cost-effectiveness and overall net benefits. A resource analysis can be an important first step and a baseline for developing a comprehensive management plant.

Combining Woodland's tree inventory with i-Tree *Streets* software provides valuable data necessary for complete urban forest resource analysis. The analysis examines trends and performance measures over the entire urban forest and each of the major species populations within. Rather than examining each individual tree as an inventory does, resource analysis examines the entire urban forest system as a whole, quantifying the value, benefits, and performance of the community's trees as they perform as an urban forest system. An urban forest resource analysis provides managers and key decision-makers with invaluable information for the long-range decision-making and policy development necessary for ensuring sustainability of the urban forest.

When evaluating the bottom line, Woodland's public trees are worth the management investment. The public tree resource gives back more than the community investment in stormwater runoff reduction, energy savings, reduction in atmospheric CO_2, and numerous other quantifiable benefits. The City's 13,140 public trees are a valuable asset, providing over $1 million in annual gross benefits. Taking into consideration the investment necessary to manage this resource, Woodland's trees provide $350,914 in annual net benefits. That's an average of $26.71 per tree and $6.43 per capita. **For every $1 invested in Woodland's public trees, the community receives $1.50 in net benefits!**

Information from the urban forest resource analysis can be used to create an urban forest management plan. Performance data from the analysis should be used to make determinations regarding species selection, distribution, and maintenance policies. Structural data is necessary for establishing goals and performance objectives and can serve a benchmark for measuring future success. An urban forest management plan is a critical tool for successful urban forest management, inspiring commitment and providing vision for communication with key decision-makers both inside and outside the organization.

Trees are one community asset that has the potential to increase in value over time and with proper maintenance. Fortunately, Woodland's public tree resource is a relatively young population in overall good condition. And, although it is critical to maintain an adequate level of resources to protect this investment, with more than 140 different species and an estimated

93% stocking rate, Woodland is well positioned to realize a significant increase in benefit flow as this vital resource continues to mature. Based on the resource analysis, DRG recommends the following:

- *Maximize the benefits of the existing tree resource through comprehensive tree maintenance and a cyclical pruning schedule.*
- *Maintain an appropriate age distribution by planting new trees to improve long-term resource sustainability and greater canopy coverage. Focus on large-stature trees where conditions are sustainable to maximize benefits.*
- *Continue to plant new trees with the goal of establishing replacement trees for the City's most mature trees (and top benefit producers) with trees of similar stature before they must be removed, thereby ensuring a consistent benefit flow.*
- *Implement a structural pruning program for young and establishing trees to promote healthy structure, extend life expectancy, and reduce future costs and liability.*

As the "City of Trees" and a recognized Tree City, USA, Woodland, California is a community that recognizes the vital importance of trees to the environmental, social, and economic well-being of the City. Woodland has demonstrated that public trees are a highly valued community resource, a vital component of the urban infrastructure, and an important part of the City's history and identity. The Urban Forestry Group takes a proactive and forwarding-looking approach to caring for Woodland's trees, as evidenced by the condition and structure of the current public resource. Having a complete tree inventory will help staff to more efficiently track maintenance activities and tree health, and will provide a strong basis for making informed management decisions. Though the current resource is already producing a positive net benefit, with continued proactive management, Woodland's young public tree population can be expected to produce a steadily increasing benefit flow for many generations to come as this investment matures. With a demonstrated commitment to maintaining and maximizing the benefits from its community forest, Woodland obviously intends to remain the City of Trees.

Chapter 4: Community Canopy Study, Woodland, CA

Introduction

In addition to the resource analysis of Woodland's public tree assets, Davey Resource Group conducted a community canopy study of Woodland's entire urban forest. Whereas the resource analysis only considered publicly owned and managed trees, the canopy study discussed here includes all trees, both public and private, within the city limits of Woodland.

Both public and private trees provide benefits to the community of Woodland. While a single well-placed tree can often provide significant benefits to a private residence or business in terms of energy savings, property value increase, and ambience, it is important to recognize that each and every tree in the community is also working together as a part of a larger system. Woodland's urban forest system is working around the clock to clean the air, reduce energy needs, intercept stormwater, raise property values, reduce the urban heat island affects, and contribute significantly to the character, history, and permanency of Woodland.

To analyze the urban forest canopy coverage in Woodland, DRG obtained current, leaf-on, one-meter, NAIP color imagery acquired by the USDA in summer 2009. The National Agricultural Imagery Program (NAIP), administered by the USDA's Farm Service Agency acquires imagery at a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within six meters of photo identifiable ground control points (www.fsa.usda.gov). Acquired during the agricultural growing season (or leaf-on), NAIP imagery provides canopy detail for deciduous as well as evergreen tree species.

Davey Resource Group used current, leaf-on, NAIP color imagery (USDA, Summer 2009) to extract Woodland's urban forest canopy coverage.

DRG used an object-oriented classification approach, advanced image analysis, and *automated feature extraction* (AFE) technology to extract, or separate, the canopy cover layer from the overall imagery. The semi-automated extraction process was completed using ArcGIS 9.3 and VLS Feature Analyst®. Secondary source data provided by the City of Woodland was used to aid in the automated feature extraction and the final manual editing process.

Next, two separate quality control and assurance processes were implemented using ArcGIS to identify, define, and correct any misclassifications or errors in the final canopy cover layer. DRG used ArcGIS

geoprocessing tools to identify and correct topography errors, verifying the accuracy of the semi-automated processes. Randomly generated plot locations ensured that the automated mapping and data analysis performed by GIS specialists reflected the true nature and extent of the canopy cover. Additional GIS analysis, using current data sources, confirmed the canopy assessment process to a minimum of 90% accuracy.

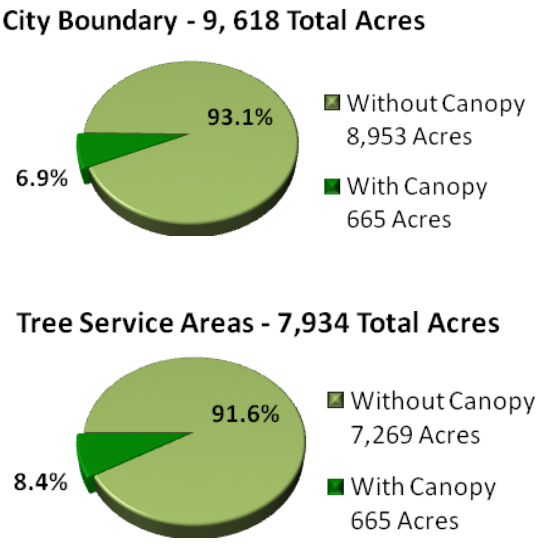
Woodland's Urban Forest Canopy Structure

Once the accuracy of the extracted canopy layer was confirmed, the final comprehensive canopy cover layer was processed in ArcGIS and used to calculate Woodland's existing canopy cover. Using GIS layers provided by the City of Woodland, canopy cover was calculated for parks, tree service areas (TSAs), City facilities, City rights-of way, and City boundaries. DRG determined the following information characterized Woodland's urban forest canopy cover:

- The City of Woodland encompasses a total of 15.03 square miles (9,618 acres) of which approximately 2.6 square miles (1,684 acres) is essentially undeveloped and/or agricultural land. Woodland's urban forest provides 665 acres, or 6.9% canopy coverage of the entire City boundary.
- Woodland has a total of 25 tree service areas (TSAs) which encompass 12.4 square miles (7,934 acres) of developed areas within the City, including residential, commercial, and industrial locales. Woodland's urban forest, which is almost exclusively located within these areas, provides 665 acres or 8.4% canopy coverage in TSAs.
- City rights of way, including streets, sidewalks, and maintenance strips cover a total of 1,504 acres. Woodlands urban forest provides 108 acres (7.2%) canopy coverage of City rights of way.
- Woodland has 32 parks, covering 195 acres of land, of which the urban forest 28 acres (14.1%) of canopy coverage.
- City facilities (excluding parks) cover 390 total acres. Woodland's urban forest provides canopy coverage of 2 acres (0.5%) of City facilities.

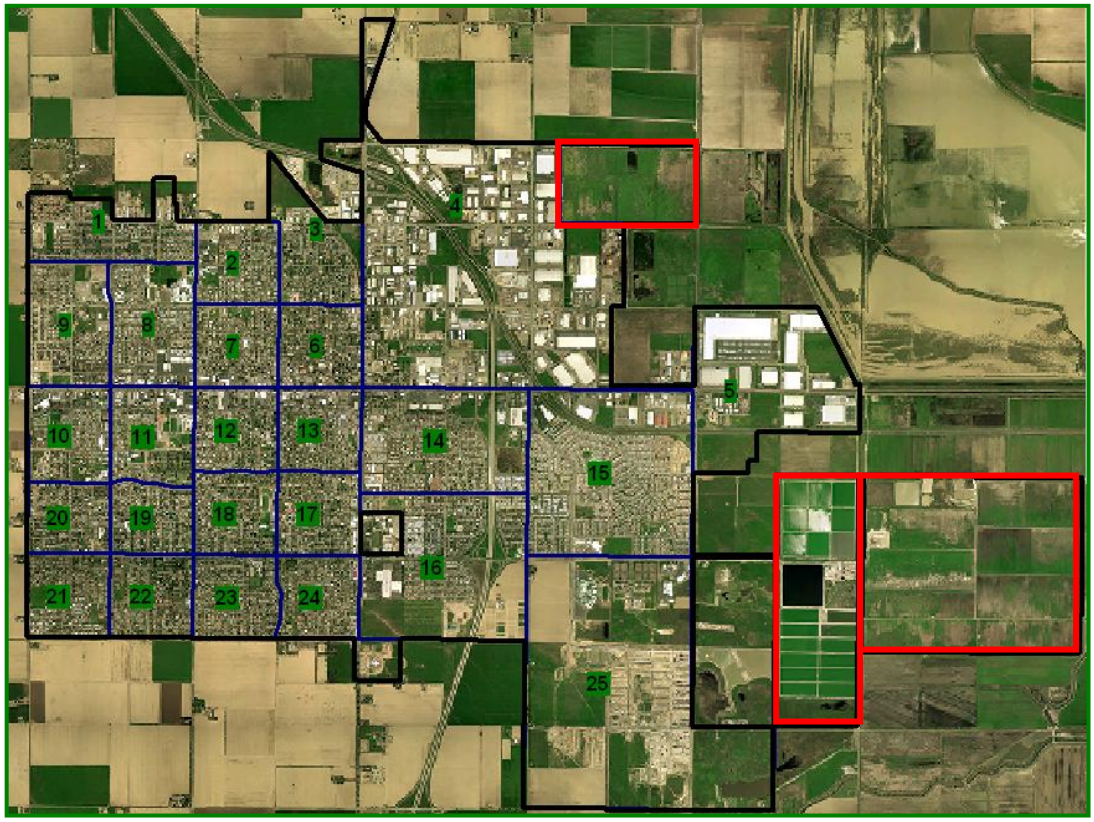
As evidenced in Woodland's public tree resource analysis, the amount and distribution of leaf surface area is the driving force behind the urban forest's ability to produce benefits for the community (Clark, 1997). American Forests recommends an average overall tree canopy of 25% in dry west climate zones (www.americanforests.org). As canopy cover increases, so do the benefits afforded by increased leaf area. Defining the structure and extent of Woodland's urban forest canopy establishes a current baseline and provides an opportunity for the community to establish and track goals for increasing canopy coverage and related benefits, including reducing the community's carbon footprint.

Citywide Canopy Coverage



The City of Woodland, California encompasses just over 15 square miles (9,618 acres) of land, including 12.4 square miles (7,934 acres) of tree service areas (TSAs), 2.35 square miles (1,504 acres) of City right of way (ROW), 195 acres of parks, and 390 acres of City facilities (excluding parks). Woodland's urban forest, composed of both publicly- and privately-owned trees, is estimated to provide canopy coverage over 665 acres, or 6.9% of the overall City boundary. Woodland's trees, however, are found almost exclusively within the 12.4 square miles of tree service areas, which also encompass the majority of Woodland's development, including residential, commercial, and industrial areas. Excluding undeveloped areas (shown in red, Figure 13), and considering only the TSAs, Woodland's urban forest is providing canopy coverage over 8.4% (665 acres) of areas included within TSAs (7,269 acres). Using either figure as a baseline, Woodland's urban forest canopy coverage is significantly lower than the 25% average tree cover goal suggested by American Forests for dry western communities (www.americanforests.org).

Figure 13. City of Woodland Boundaries and Tree Service Areas (TSAs).



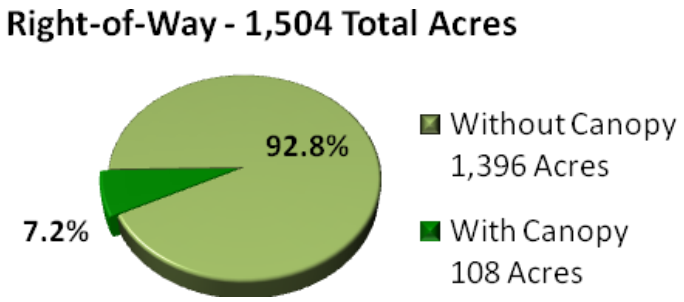
While Woodland's overall canopy coverage may be falling short of recommended goals, a number of individual tree service areas are exceeding the 18% recommended for urban residential zones. The highest canopy coverage of 24.6% is found in TSA 18, followed closely by TSA 17 (22%), TSA 12 (20.9%), TSA 6 (19.9%), and TSA 7 (18.2%). Two tree service areas (TSA 25, 0.77% and TSA 5, 0.93%) have less than 1% overall canopy coverage. The trees in TSA 4 are contributing the greatest overall canopy coverage (52.5 acres) to the community while providing less than 4% coverage to that TSA.

Table 14. Canopy Coverage by Tree Service Areas (TSAs).

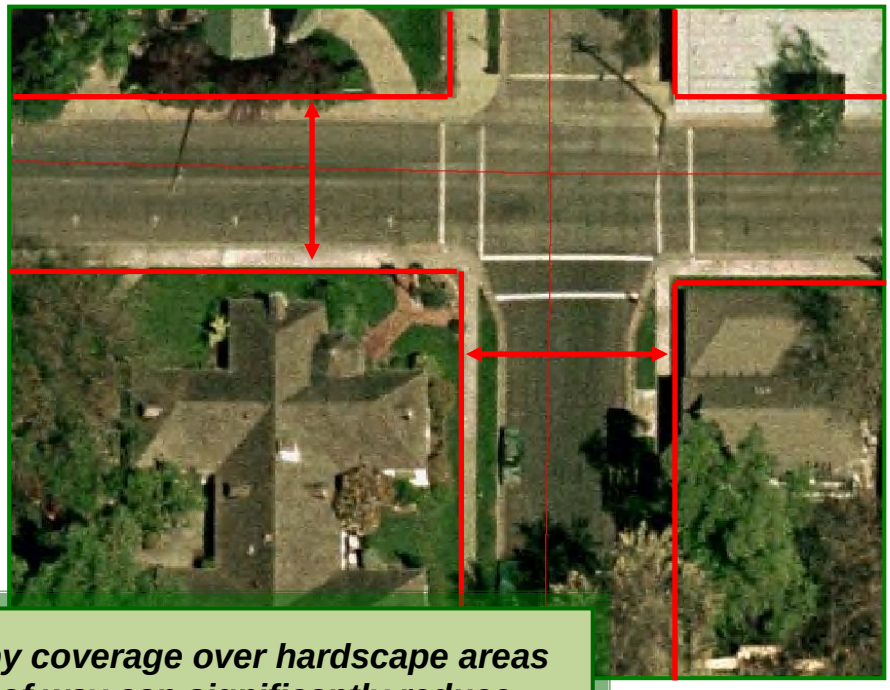
Tree Service Areas Location	Canopy	Total Acres	Total % of Canopy Area
1	25.39	229.06	11.08%
2	21.30	160.20	13.30%
3	29.86	206.19	14.48%
4	52.53	1413.96	3.72%
5	4.70	507.59	0.93%
6	32.00	160.76	19.91%
7	29.00	159.81	18.15%
8	25.47	243.92	10.44%
9	24.79	235.69	10.52%
10	22.92	184.20	12.44%
11	26.64	187.94	14.17%
12	33.87	162.25	20.88%
13	28.88	161.51	17.88%
14	35.57	402.52	8.84%
15	24.52	634.85	3.86%
16	28.23	526.18	5.37%
17	35.33	160.71	21.98%
18	39.30	159.71	24.61%
19	23.75	135.66	17.51%
20	17.62	134.56	13.09%
21	18.73	160.46	11.67%
22	28.21	160.81	17.54%
23	24.20	164.99	14.67%
24	23.42	156.51	14.96%
25	8.69	1123.86	0.77%
All Tree Service Areas	664.92	7933.9	8.38%

Right of Way Canopy Coverage

Woodland has a total of 1,504 acres of City right of way (ROW), including streets, sidewalks, and maintenance strips. Because ROW locations are primarily hardscape (i.e., asphalt and concrete), these locations are also the most critically in need of canopy coverage. On hot summer days, surface temperatures on hardscape surfaces like pavement can reach temperatures 50 to 90° F hotter than the surrounding air temperature (EPA). The unique properties of asphalt allow it to store and hold great quantities of solar energy during the day and slowly release that energy long after sunset, raising nighttime urban temperatures by as much as 22°F in large urban areas over that of surrounding areas.

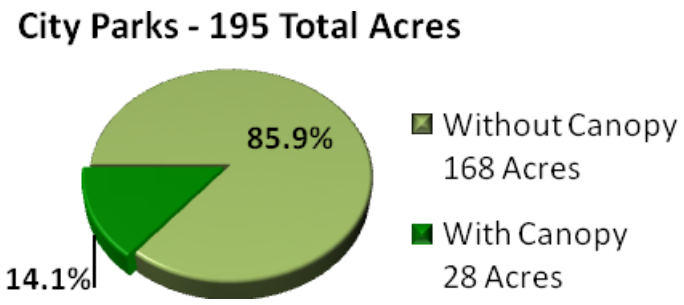


Woodland's canopy study estimates that both publicly- and privately-owned trees are currently providing approximately 7.2% (108 acres) of canopy coverage to City rights of way. By effectively utilizing available planting space, installing large-stature trees whenever possible, and nurturing the current population of young and established trees, Woodland can significantly increase canopy coverage over ROWs, reducing hardscape surface temperatures and increasing the effective life of street surfacing materials.



Increasing canopy coverage over hardscape areas such as rights of way can significantly reduce heat island effects.

Canopy Coverage in Parks



The City of Woodland has 29 city-owned parks and 3 privately owned parks for a total of 32 parks covering 195 acres of land. Public and private trees are providing 28 acres (14.1%) of canopy coverage over all park areas and 4.2% of the entire urban forest canopy. Gary Traynham Park enjoys the highest overall percentage of canopy coverage at 40.6%, followed by Wayne Cline Park (39.2%), and Joseph Schneider Park (35.2%). Jeff Roddy Park, which has a number of newly planted trees, has current canopy coverage of less than 0.0% due to the immaturity of the existing trees. If all of the newly planted trees in this small park reach maturity, however, the canopy coverage could easily reach 70% or more. Conversely, Buchignani Field, a sports complex with 0.78% canopy coverage is likely to retain its sparse canopy due to the nature of the park's use. The Woodland Community & Senior Center, with a low overall canopy coverage of 2.3%, is providing the greatest communitywide contribution of all parks, with 37.3 acres of canopy coverage. Since the large population of trees at the Center are quite young and immature, this park's canopy coverage will also increase significantly over time, providing greater coverage to the park and a greater contribution to the entire urban forest.

Public and private trees provide an average of 14.1% canopy coverage over all parks and 4.2% of the entire urban forest canopy.

Table 15. Canopy Coverage by Tree by Parks.

Parks Location	Canopy	Total Acres	Total % of Canopy Area
Beamer Circle Park	0.03	0.15	20.00%
Beamer Park	0.53	2.26	23.45%
Boy Scout Cabin*	0.04	0.24	16.67%
Buchignani Field	0.11	14.14	0.78%
Campbell Park	1.05	5.57	18.85%
Charles Brooks Community Swim Center	0.08	2.75	2.91%
Christiansen Park and Camarena Fields 1 and 2	0.86	5.60	15.36%
City Park	0.98	3.93	24.94%
Clark Field	0.02	3.52	0.57%
Crawford Park	1.31	8.27	15.84%
Dave Douglass Park	0.54	12.84	4.21%
Dick Klenhard Park	0.99	7.24	13.67%
Everman Park	0.88	3.43	25.66%
Freeman Park	0.74	2.25	32.89%
Gary Traynham Park	0.56	1.38	40.58%
Girl Scout Cabin	0.04	0.21	19.05%
Gonzales Park Soccer Field*	0.02	1.89	1.06%
Grace Hiddleson Pool	0.08	0.79	10.13%
Harris Park & Field	1.01	5.54	18.23%
Jeff Roddy Park	0.00	0.48	0.00%
John Ferns Park	2.25	9.29	24.22%
Joseph Schneider Park	1.03	2.93	35.15%
Pioneer Park	0.63	10.05	6.27%
Southland Park	0.93	3.23	28.79%
Streng Pond Park	0.57	2.50	22.80%
Tredway Park	0.26	1.22	21.31%
Wayne Cline Park	0.94	2.40	39.17%
Woodland Cemetery	7.92	30.66	25.83%
Woodland Community & Senior Center	0.86	37.27	2.31%
Woodland West Park	0.04	0.37	10.81%
Woodside Park	1.92	8.21	23.39%
Yolano Recreation Center - Rick Gonzales Park*	0.33	4.54	7.27%
Total Parks	**27.55**	**195.15**	**14.11%**

*** Boy Scout Cabin, Gonzales Park Soccer Field, and Yolano Recreation Center are privately owned Park areas.**

At approximately 8.4%, Woodland's current canopy coverage from both publicly- and privately-owned trees is far below the recommended average canopy coverage of 25%. Community outreach and education, encouraging additional private tree planting and appropriate maintenance, can be an effected strategy for increasing canopy coverage. In addition, while we cannot effectively measure the overall age distribution of the private tree population, analysis of the public tree resource demonstrates that a large percentage of the community's urban forest is composed of newly planted, immature individuals. As this population matures, with continued proactive management by the Urban Forestry Group, the overall community canopy coverage will increase as well.

Appendix A: Methods and Procedures

The City of Woodland contracted with Davey Resource Group in 2009 to conduct a public tree inventory. This inventory is maintained by the Urban Forestry Group using Cityworks® asset management software to track and manage tree characteristics, health, and maintenance history.

Woodland's public tree inventory was collected by Certified Arborists, using an ArcPad project to assist the inventory arborist in locating the sample plots on the ground and recording attributes (details about each tree's species, size, and condition). The data was formatted for use in i-Tree's public tree population assessment tool, ***i-Tree Streets, a STRATUM Analysis Tool*** (*Streets* Version 3.0.4; i-Tree Version 3.0.5). *Streets* assesses tree population structure and the function of those trees, such as their role in building energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. In order to analyze the economic benefits of Woodland's public trees, *Streets* calculates the dollar value of annual resource functionality and compares that to annual program expenditures. This analysis combines the results of the City's public tree inventory with benefit-cost modeling data to produce information regarding resource structure, resource function, and resource value to make resource management recommendations. *Streets* regionalizes the calculations of its output by incorporating detailed reference City project information for 17 climate zones across the United States. Woodland is located in the Inland Valley Climate Zone.

For each of the modeled benefits, an annual resource unit was determined on a per tree basis. 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, 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.

Prices were assigned to each resource unit using economic indicators of society's willingness to pay for the environmental benefits trees provide. 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. It is meant to be a general accounting of the benefits produced by urban trees. This accounting has an accepted degree of uncertainty that can, nonetheless, provide science-based platform for decision-making.

Table 16. Woodlands Benefit Prices Used In This Analysis.

Benefits	Price	Unit	Source
Electricity	$.1166	$/Kwh	*Streets* default – Inland Valleys
Natural Gas	$1.2527	$/Therm	*Streets* default – Inland Valleys
CO_2	$0.0075	$/lb	*Streets* default – Inland Valleys
PM_{10}	$9.41	$/lb	*Streets* default – Inland Valleys
NO_2	$12.79	$/lb	*Streets* default – Inland Valleys
SO_2	$3.72	$/lb	*Streets* default – Inland Valleys
VOC	$4.69	$/lb	*Streets* default – Inland Valleys
Stormwater Interception	$0.0078	$/gallon	*Streets* default – Inland Valleys
Median Home Resale Value	$260,000	$	California Association of Realtors

Streets default values (Table 16) from the Inland Valleys Climate Zone were used for all benefit prices except for median home resale values. Electrical and natural gas rates were verified on the Pacific Gas and Electric Company Web site (www.pge.com). Median home price (2009) for Woodland was verified at California Association of Realtors Web site (http://car.org/marketdata/). Using these prices, the magnitude of the benefits provided by the public tree resource was calculated using *Streets*.

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Appendix C: Reports

Woodland, CA: Complete Population of Public Trees

Species	Common Name	DBH Class (in) 0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total
Broadleaf Deciduous Large (BDL)											
Platanus X acerifolia	London planetree	289	248	270	183	257	145	94	31	3	**1,520**
Quercus lobata	Valley oak	151	50	57	42	26	16	12	14	28	**396**
Fraxinus velutina	Velvet ash	242	34	0	1	1	0	0	0	0	**278**
Ulmus parvifolia	Chinese elm	211	9	0	0	0	0	0	0	0	**220**
Celtis sinensis	Chinese hackberry	36	21	55	64	18	7	0	0	1	**202**
Ulmus species	American/English elm	95	9	0	0	2	3	7	24	36	**176**
Fraxinus velutina 'Modesto'	Modesto ash	4	0	1	3	47	62	28	4	1	**150**
Quercus rubra	Northern red oak	134	0	0	0	0	0	0	0	0	**134**
Platanus racemosa	Western Sycamore	14	9	37	29	7	6	1	0	0	**103**
Juglans hindsii	Hind walnut	11	21	6	10	4	8	6	9	15	**90**
Celtis occidentalis	Northern hackberry	13	25	14	16	7	4	3	1	0	**83**
Populus species	Cottonwood	1	2	38	33	3	1	0	0	0	**78**
Quercus species	Oak	11	15	19	9	4	3	0	0	0	**61**
Liriodendron tulipifera	Tulip tree	6	11	22	6	0	2	0	0	0	**47**
Acer platanoides	Norway maple	44	0	1	0	0	0	0	0	0	**45**
Acer saccharinum	Silver maple	20	8	5	6	1	0	1	0	0	**41**
Gleditsia triacanthos	Honeylocust	9	12	4	11	4	0	0	0	0	**40**
Juglans species	Walnut	0	0	2	8	16	6	1	4	2	**39**
Celtis species	Hackberry	10	4	15	4	2	1	0	0	0	**36**
Fraxinus americana	White ash	1	0	2	9	11	7	0	1	0	**31**
Liquidambar styraciflua	Sweetgum	4	1	7	2	4	1	0	0	0	**19**
Juglans nigra	Black walnut	1	0	0	1	3	5	3	1	0	**14**
Salix x pendulina Wenderoth	Wisconsin weeping willow	1	1	2	3	2	2	0	0	0	**11**
Quercus coccinea	Scarlet oak	9	0	1	0	0	0	0	0	0	**10**

Taxodium distichum	**Baldcypress**	0	0	0	0	1	3	5	0	0	**9**
Metasequoia glyptostroboi	**Dawn redwood**	2	3	2	1	0	0	0	0	0	**8**
Platanus orientalis	**Oriental planetree**	4	1	1	0	0	0	0	0	0	**6**
Catalpa speciosa	**Western catalpa**	0	1	2	2	0	0	0	0	0	**5**
Gymnocadus dioicus	**Kentucky coffeetree**	0	1	0	3	1	0	0	0	0	**5**
Pterocarya stenoptera	**Chinese wingnut**	0	0	3	1	0	1	0	0	0	**5**
Carya illinoensis	**Pecan**	1	1	1	0	1	0	0	0	0	**4**
Acer negundo	**Boxelder**	0	0	0	1	1	0	0	0	0	**2**
Carya ovata	**Shagbark Hickory**	0	0	0	0	1	0	0	0	0	**1**
Total		**1,324**	**487**	**567**	**448**	**424**	**283**	**161**	**89**	**86**	**3,869**

Broadleaf Deciduous Medium (BDM)											
Pistacia chinensis	**Chinese pistache**	178	180	469	338	21	9	0	1	0	**1,196**
Pyrus calleryana	**Flowering pear**	391	307	195	135	34	2	0	0	0	**1,064**
Zelkova serrata	**Japanese zelkova**	265	115	8	8	10	10	1	0	0	**417**
Triadica sebifera	**Tallowtree**	211	39	36	56	17	1	1	0	0	**361**
Koelreuteria paniculata	**Goldenrain tree**	111	52	27	8	2	0	0	0	0	**200**
Tilia species	**Basswood**	185	0	0	0	2	0	0	0	0	**187**
Ginkgo biloba	**Ginkgo**	134	7	10	1	0	0	0	0	0	**152**
Robinia ambigua idahoensis	**Idaho locust**	107	1	0	0	0	0	0	0	0	**108**
Morus species	**Mulberry**	3	0	7	7	40	19	2	0	0	**78**
Fraxinus species	**Ash**	13	2	13	27	6	3	4	0	1	**69**
Acer rubrum	**Red maple**	59	1	1	0	0	0	0	0	0	**61**
Robinia pseudoacacia	**Black locust**	29	9	5	0	0	0	0	0	0	**43**
Nyssa sylvatica	**Black tupelo**	38	2	0	0	0	0	0	0	0	**40**
Alnus species	**Alder species**	1	3	16	10	9	0	0	0	0	**39**
Fraxinus angustifolia 'Raywood'	**Raywood ash**	1	1	3	11	9	6	2	0	0	**33**
Ailanthus altissima	**Tree of heaven**	8	3	2	3	0	0	0	0	0	**16**
Betula pendula	**European white birch**	4	3	8	1	0	0	0	0	0	**16**
Carpinus betulus	**European hornbeam**	5	0	0	2	5	1	0	0	0	**13**
Acer species	**Maple**	9	2	1	0	0	0	0	0	0	**12**

Sophora japonica	**Japanese pagoda tree**	0	0	0	4	8	0	0	0	0	**12**
Melia azedarach	**Chinaberry**	3	3	2	1	2	0	0	0	0	**11**
Fraxinus pennsylvanica	**Green ash**	1	0	0	7	1	0	0	0	0	**9**
Pyrus species	**Pear**	4	3	1	1	0	0	0	0	0	**9**
Pyrus calleryana 'Red Spire'	**Callery pear 'Redspire'**	4	0	0	0	0	0	0	0	0	**4**
Salix species	**Willow**	3	1	0	0	0	0	0	0	0	**4**
Carpinus caroliniana	**American hornbeam**	2	0	0	0	0	0	0	0	0	**2**
Aesculus californica	**Buckeye**	0	0	1	0	0	0	0	0	0	**1**
Albizia julibrissin	**Mimosa**	1	0	0	0	0	0	0	0	0	**1**
Prunus armeniaca	**Apricot**	0	1	0	0	0	0	0	0	0	**1**
Unknown broadleaf	**Unknown broadleef**	1	0	0	0	0	0	0	0	0	**1**
Total		**1,771**	**735**	**805**	**620**	**166**	**51**	**10**	**1**	**1**	**4,160**

Broadleaf Deciduous Small (BDS)											
Lagerstroemia indica	**Crapemyrtle**	581	188	71	2	0	0	0	0	0	**842**
Prunus cerasifera	**Cherry plum**	388	156	41	3	0	0	0	0	0	**588**
Malus species	**Crabapple, flowering**	253	12	11	0	0	0	0	0	0	**276**
Prunus species	**Plum**	46	26	4	2	0	0	0	0	0	**78**
Chitalpa tashkentensis	**Chitalpa**	11	24	37	0	0	0	0	0	0	**72**
Cercis species	**Redbud**	54	4	0	0	0	0	0	0	0	**58**
Crataegus phaenopyrum	**Washington hawthorn**	30	0	0	0	0	0	0	0	0	**30**
Acer buergerianum	**Trident maple**	12	0	4	7	4	0	0	0	0	**27**
Acer palmatum	**Japanese maple**	21	0	0	0	0	0	0	0	0	**21**
Cercis canadensis	**Eastern redbud**	13	8	0	0	0	0	0	0	0	**21**
Prunus amygdalus	**Almendro**	5	1	1	1	2	0	0	0	0	**10**
Crataegus laevigata	**Smooth hawthorn**	4	3	1	1	0	0	0	0	0	**9**
Prunus serrulata	**Japanese flowering cherry**	0	8	1	0	0	0	0	0	0	**9**
Chionanthus retusus	**Chinese fringe tree**	8	0	0	0	0	0	0	0	0	**8**
Broadleaf Deciduous Small	**Broadleaf Deciduous Small**	2	1	3	0	1	0	0	0	0	**7**
Cotinus coggygria	**Purple smoke tree**	6	0	0	0	0	0	0	0	0	**6**
Chilopsis linearis	**Desert willow**	0	3	2	0	0	0	0	0	0	**5**

Prunus blieriana	**Blierana plum**	3	2	0	0	0	0	0	0	0	**5**
Prunus persica	**Peach**	0	5	0	0	0	0	0	0	0	**5**
Punica granatum	**Pomegranate**	3	1	0	0	0	0	0	0	0	**4**
Ficus carica	**Common fig**	1	1	0	0	0	0	0	0	0	**2**
Magnolia x soulangiana	**Saucer magnolia**	2	0	0	0	0	0	0	0	0	**2**
Hibiscus syriacus	**Rose-of-sharon**	0	1	0	0	0	0	0	0	0	**1**
Total		**1,443**	**444**	**176**	**16**	**7**	**0**	**0**	**0**	**0**	**2,086**

Broadleaf Evergreen Large (BEL)											
Quercus ilex	**Holly oak**	338	3	0	1	3	5	0	0	0	**350**
Quercus suber	**Cork oak**	54	16	26	7	8	9	6	3	2	**131**
Quercus wislizeni	**Interior live oak**	39	40	15	8	2	3	0	0	0	**107**
Quercus agrifolia	**Coastal live oak**	5	6	0	4	5	4	0	2	0	**26**
Umbellularia californica	**California laurel**	7	8	5	2	0	0	0	0	0	**22**
Eucalyptus species	**Gum**	1	0	2	0	5	1	1	0	0	**10**
Podocarpus species	**Podocarpus**	4	0	0	0	0	0	0	0	0	**4**
Total		**448**	**73**	**48**	**22**	**23**	**22**	**7**	**5**	**2**	**650**

Broadleaf Evergreen Medium (BEM)											
Olea europaea	**Olive**	12	16	19	42	33	23	6	1	0	**152**
Cinnamomum camphora	**Camphor tree**	1	0	4	9	14	4	1	0	0	**33**
Laurus nobilis	**Laurel de olor**	9	8	7	3	0	0	0	0	0	**27**
Magnolia grandiflora	**Southern magnolia**	10	2	0	0	0	0	0	0	0	**12**
Ceratonia siliqua	**Algarrobo europeo**	0	1	1	2	0	2	0	0	0	**6**
Maytenus boaria	**Mayten tree**	1	0	1	1	1	0	0	0	0	**4**
Total		**33**	**27**	**32**	**57**	**48**	**29**	**7**	**1**	**0**	**234**

Broadleaf Evergreen Small (BES)											
Xylosma congestum	**Xylosma**	13	10	103	21	1	0	0	0	0	**148**
Prunus caroliniana	**Cherry laurel**	4	28	28	2	0	0	0	0	0	**62**
Pyrus kawakamii	**Evergreen pear**	0	3	23	23	7	1	0	0	0	**57**

Ligustrum lucidum	**Chinese privet**	12	8	8	9	5	2	1	0	0	**45**
Photinia x fraseri	**Fraser photinia**	6	9	10	3	0	0	0	0	0	**28**
Rhus lancea	**African sumac**	2	15	0	3	3	0	0	0	0	**23**
Pittosporum species	**Cheesewood**	0	4	11	2	0	0	0	0	0	**17**
Citrus species	**Citrus**	1	5	3	1	0	0	0	0	0	**10**
Arbutus unedo	**Strawberry tree**	4	2	2	0	1	0	0	0	0	**9**
Cocculus laurifolius	**Laurel-leaf snailseed**	0	0	5	3	0	0	0	0	0	**8**
Heteromeles arbutifolia	**Toyon**	0	3	0	0	0	0	0	0	0	**3**
Nerium oleander	**Oleander**	1	1	1	0	0	0	0	0	0	**3**
Broadleaf Evergreen Small	**Broadleaf Evergreen Small**	0	1	0	0	0	0	0	0	0	**1**
Eriobotrya japonica	**Loquat tree**	0	0	1	0	0	0	0	0	0	**1**
Mahonia spp.	**Mahonia spp.**	1	0	0	0	0	0	0	0	0	**1**
Total		**44**	**89**	**195**	**67**	**17**	**3**	**1**	**0**	**0**	**416**

Conifer Evergreen Large (CEL)											
Sequoia sempervirens	**Coast redwood**	91	91	160	99	61	25	15	3	1	**546**
Pinus canariensis	**Canary Island Pine**	245	41	3	19	7	0	0	0	0	**315**
Cedrus deodara	**Deodar cedar**	69	19	37	20	39	17	1	1	1	**204**
Pinus species	**Pine**	45	28	14	11	30	21	12	3	1	**165**
Pinus densiflora	**Japanese red pine**	4	18	73	1	0	0	0	0	0	**96**
Cupressus species	**Cypress**	1	9	21	18	6	8	3	1	1	**68**
Casuarina cunninghamiana	**River-she oak**	3	6	0	8	30	11	3	1	1	**63**
Cupressus sempervirens	**Italian cypress**	4	0	5	5	13	4	1	1	0	**33**
Casuarina equisetifolia	**Horsetail tree**	14	0	1	0	0	0	2	0	0	**17**
Cedrus atlantica	**Atlas cedar**	10	0	0	0	0	1	2	0	0	**13**
Calocedrus decurrens	**Incense cedar**	3	0	2	2	3	0	2	0	0	**12**
x Cupressocyparis leylandii	**Leyland cypress**	3	2	1	0	0	0	0	0	0	**6**
Cupressus macrocarpa	**Monterey cypress**	0	0	0	1	1	0	0	0	0	**2**
Pinus pinea	**Itailian stone pine**	0	0	0	0	1	1	0	0	0	**2**
Cryptomeria japonica	**Japanese cryptomeria**	1	0	0	0	0	0	0	0	0	**1**
Total		**493**	**214**	**317**	**184**	**191**	**88**	**41**	**10**	**5**	**1,543**

Conifer Evergreen Medium (CEM)											
Juniperus species	**Juniper**	0	0	3	2	0	0	0	0	0	**5**
Total		**0**	**0**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**5**
Conifer Evergreen Small (CES)											
Chamaecyparis pisifera	**Falsecypress, sawara**	1	1	0	0	0	0	0	0	0	**2**
Total		**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Palm Evergreen Large (PEL)											
Phoenix canariensis	**Canary island date palm**	0	0	0	0	3	52	7	0	0	**62**
Total		**0**	**0**	**0**	**0**	**3**	**52**	**7**	**0**	**0**	**62**
Palm Evergreen Medium (PEM)											
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Palm Evergreen Small (PES)											
Washingtonia filifera	**California palm**	4	2	5	6	7	19	52	8	0	**103**
Washingtonia robusta	**Mexican fan palm**	0	1	3	2	1	0	0	0	0	**7**
Arecastrum romanzoffianum	**Queen palm**	1	1	0	0	0	0	0	0	0	**2**
Chamaerops humilis	**Mediterranean fan palm**	0	0	0	0	0	0	1	0	0	**1**
Total		**5**	**4**	**8**	**8**	**8**	**19**	**53**	**8**	**0**	**113**
Citywide Total		**5,562**	**2,074**	**2,151**	**1,424**	**887**	**547**	**287**	**114**	**94**	**13,140**

Woodland, CA: Public Tree Population and Age Distribution Per Tree Service Area

Tree Service Area	DBH Class (in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total
TSA 1	65	92	227	177	42	11	5	1	1	**621**
TSA 2	8	2	7	8	7	1	6	9	13	**61**
TSA 3	34	43	77	63	67	45	22	9	6	**366**
TSA 4	34	27	33	34	13	12	1	1	1	**156**
TSA 5	2	3	2	0	0	0	0	0	0	**7**
TSA 6	98	103	214	151	92	84	62	14	7	**825**
TSA 7	104	69	124	90	80	49	33	10	2	**561**
TSA 8	7	1	9	2	0	1	0	0	0	**20**
TSA 9	26	8	36	31	19	10	4	0	0	**134**
TSA 10	30	37	55	49	36	9	3	5	2	**226**
TSA 11	12	6	20	89	103	114	36	12	12	**404**
TSA 12	116	72	82	91	50	42	32	15	14	**514**
TSA 13	247	166	165	110	77	56	21	13	14	**869**
TSA 14	109	91	153	95	37	13	8	2	2	**510**
TSA 15	699	570	523	78	10	2	0	0	0	**1,882**
TSA 16	488	124	74	75	25	7	3	5	10	**811**
TSA 17	77	67	109	93	83	42	27	8	1	**507**
TSA 18	9	20	23	40	47	21	11	6	3	**180**
TSA 20	30	16	29	39	13	0	0	0	0	**127**
TSA 21	6	7	27	24	41	15	2	1	0	**123**
TSA 22	14	21	51	53	30	4	2	0	0	**175**
TSA 24	23	45	70	32	15	9	9	3	6	**212**
TSA 25	3,087	473	38	0	0	0	0	0	0	**3,598**
TSA 99	237	11	3	0	0	0	0	0	0	**251**
Total	**5,562**	**2,074**	**2,151**	**1,424**	**887**	**547**	**287**	**114**	**94**	**13,140**

Relative Performance Index (RPI) for All Woodland Public Trees								
Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Platanus X acerifolia	London planetree	0.53	1.28	47.27	50.93	**0.96**	1,520	12
Pistacia chinensis	Chinese pistache	0.84	1.34	29.31	68.52	**1.03**	1,196	9
Pyrus calleryana	Flowering pear	3.05	3.81	31.11	62.03	**0.98**	1,064	8
Lagerstroemia indica	Crapemyrtle	1.07	1.19	35.63	62.12	**1.00**	842	6
Prunus cerasifera	Cherry plum	1.02	2.38	15.73	80.87	**1.07**	588	4
Sequoia sempervirens	Coast redwood	0.00	0.64	32.42	66.94	**1.03**	546	4
Zelkova serrata	Japanese zelkova	0.24	1.08	38.25	59.95	**1.00**	417	3
Quercus lobata	Valley oak	0.51	0.63	25.88	72.98	**1.05**	396	3
Triadica sebifera	Tallowtree	0.42	1.94	23.27	74.38	**1.05**	361	3
Quercus ilex	Holly oak	2.29	0.29	8.86	88.57	**1.10**	350	3
Pinus canariensis	Canary Island Pine	0.00	0.32	8.10	91.75	**1.13**	315	2
Fraxinus velutina	Velvet ash	0.00	0.00	11.33	88.67	**1.12**	278	2
Malus species	Crabapple, flowering	6.16	2.54	11.23	80.07	**1.03**	276	2
Ulmus parvifolia	Chinese elm	2.73	9.09	37.73	50.45	**0.91**	220	2
Cedrus deodara	Deodar cedar	0.49	1.47	23.28	74.75	**1.06**	204	2
Celtis sinensis	Chinese hackberry	0.00	3.47	60.15	36.39	**0.90**	202	2
Koelreuteria paniculata	Goldenrain tree	1.50	2.75	23.25	72.50	**1.03**	200	2
Tilia species	Basswood	2.67	1.07	10.96	85.29	**1.08**	187	1
Ulmus species	Elm	0.00	3.41	34.09	62.50	**1.00**	176	1
Pinus species	Pine	1.21	0.91	19.09	78.79	**1.07**	165	1
Ginkgo biloba	Ginkgo	4.61	1.32	34.87	59.21	**0.96**	152	1
Olea europaea	Olive	2.96	68.42	11.18	51.64	**0.82**	152	1
Fraxinus velutina 'Modesto'	Modesto ash	5.33	35.67	55.00	6.67	**0.64**	150	1
Xylosma congestum	Xylosma	0.00	0.68	38.85	60.81	**1.01**	148	1
Quercus rubra	Northern red oak	0.75	1.12	9.33	88.81	**1.11**	134	1
Quercus suber	Cork oak	0.76	0.76	16.41	82.44	**1.09**	131	1
Robinia ambigua idahoensis	Idaho locust	0.00	0.93	5.09	94.44	**1.14**	108	1

Relative Performance Index (RPI) for All Woodland Public Trees								
Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Quercus wislizeni	**Interior live oak**	14.02	0.00	28.50	57.48	**0.89**	107	1
Platanus racemosa	**Western Sycamore**	0.00	1.94	21.84	76.21	**1.06**	103	1
Washingtonia filifera	**California palm**	0.00	0.00	22.33	77.67	**1.08**	103	1
Pinus densiflora	**Japanese red pine**	0.00	1.04	52.60	93.75	**0.95**	96	1
Juglans hindsii	**Hind walnut**	1.11	15.56	66.67	25.00	**0.84**	90	1
Celtis occidentalis	**Northern hackberry**	1.20	4.82	68.67	25.90	**0.85**	83	1
***Morus* species**	**Mulberry**	0.00	8.33	48.08	43.59	**0.91**	78	1
***Populus* species**	**Cottonwood**	0.00	0.00	21.79	78.21	**1.08**	78	1
***Prunus* species**	**Plum**	1.28	1.28	53.21	44.87	**0.94**	78	1
Chitalpa tashkentensis	**Chitalpa**	0.00	4.17	53.47	44.44	**0.94**	72	1
***Fraxinus* species**	**Ash**	0.00	17.39	41.30	50.00	**0.94**	69	1
***Cupressus* species**	**Cypress**	0.00	2.21	38.97	58.82	**0.99**	68	1
Casuarina cunninghamiana	**River-she oak**	1.59	3.17	55.56	42.06	**0.93**	63	0
Prunus caroliniana	**Cherry laurel**	0.00	14.52	29.03	63.71	**0.99**	62	0
Phoenix canariensis	**Canary island date palm**	0.00	0.00	12.90	87.10	**1.11**	62	0
Acer rubrum	**Red maple**	3.28	3.28	23.77	71.31	**1.02**	61	0
***Quercus* species**	**Oak**	0.00	0.00	29.51	70.49	**1.05**	61	0
***Cercis* species**	**Redbud**	7.76	17.24	48.28	26.72	**0.75**	58	0
Pyrus kawakamii	**Evergreen pear**	0.00	3.51	43.86	54.39	**0.98**	57	0
Liriodendron tulipifera	**Tulip tree**	0.00	7.45	47.87	44.68	**0.92**	47	0
Acer platanoides	**Norway maple**	13.33	6.67	35.56	44.44	**0.82**	45	0
Ligustrum lucidum	**Chinese privet**	4.44	13.33	36.67	45.56	**0.87**	45	0
Robinia pseudoacacia	**Black locust**	0.00	6.98	11.63	84.88	**1.09**	43	0
Acer saccharinum	**Silver maple**	2.44	2.44	18.29	79.27	**1.07**	41	0
Gleditsia triacanthos	**Honeylocust**	2.50	7.50	47.50	42.50	**0.89**	40	0
Nyssa sylvatica	**Black tupelo**	0.00	7.50	40.00	56.25	**0.98**	40	0
***Alnus* species**	**Alder species**	2.56	8.97	64.10	25.64	**0.83**	39	0

Relative Performance Index (RPI) for All Woodland Public Trees								
Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Juglans species	Walnut	0.00	15.38	74.36	17.95	**0.81**	39	0
Celtis species	Hackberry	0.00	8.33	33.33	58.33	**0.97**	36	0
Cinnamomum camphora	Camphor tree	0.00	9.09	53.03	42.42	**0.92**	33	0
Cupressus sempervirens	Italian cypress	0.00	3.03	9.09	92.42	**1.12**	33	0
Fraxinus angustifolia 'Raywood'	Raywood ash	0.00	15.15	42.42	50.00	**0.94**	33	0
Fraxinus americana	White ash	3.23	12.90	58.06	33.87	**0.87**	31	0
Crataegus phaenopyrum	Washington hawthorn	73.33	3.33	11.67	13.33	**0.25**	30	0
Photinia x fraseri	Fraser photinia	0.00	8.93	51.79	39.29	**0.89**	28	0
Acer buergerianum	Trident maple	0.00	3.70	64.81	33.33	**0.90**	27	0
Laurus nobilis	Laurel de olor	0.00	3.70	50.00	46.30	**0.94**	27	0
Quercus agrifolia	Coastal live oak	0.00	3.85	38.46	57.69	**0.98**	26	0
Rhus lancea	African sumac	0.00	0.00	26.09	86.96	**1.11**	23	0
Umbellularia californica	California laurel	0.00	9.09	43.18	52.27	**0.96**	22	0
Acer palmatum	Japanese maple	9.52	4.76	28.57	73.81	**0.98**	21	0
Cercis canadensis	Eastern redbud	0.00	7.14	52.38	40.48	**0.90**	21	0
Liquidambar styraciflua	Sweetgum	0.00	0.00	63.16	36.84	**0.92**	19	0
Casuarina equisetifolia	Horsetail tree	0.00	5.88	11.76	91.18	**1.12**	17	0
Pittosporum species	Cheesewood	0.00	11.76	50.00	44.12	**0.92**	17	0
Ailanthus altissima	Tree of heaven	0.00	0.00	34.38	65.63	**1.03**	16	0
Betula pendula	European white birch	0.00	9.38	59.38	31.25	**0.86**	16	0
Juglans nigra	Black walnut	7.14	21.43	57.14	28.57	**0.82**	14	0
Carpinus betulus	European hornbeam	7.69	0.00	46.15	46.15	**0.89**	13	0
Cedrus atlantica	Atlas cedar	0.00	0.00	61.54	38.46	**0.92**	13	0
Acer species	Maple	25.00	0.00	45.83	29.17	**0.69**	12	0
Calocedrus decurrens	Incense cedar	0.00	0.00	20.83	79.17	**1.08**	12	0
Magnolia grandiflora	Southern magnolia	8.33	0.00	8.33	83.33	**1.03**	12	0
Sophora japonica	Japanese pagoda tree	0.00	16.67	50.00	41.67	**0.90**	12	0
Melia azedarach	Chinaberry	0.00	9.09	90.91	100.00	**0.95**	11	0

Relative Performance Index (RPI) for All Woodland Public Trees								
Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Salix x pendulina Wenderoth	**Wisconsin weeping willow**	0.00	18.18	36.36	54.55	**0.95**	11	0
***Citrus* species**	**Citrus**	0.00	10.00	50.00	45.00	**0.93**	10	0
***Eucalyptus* species**	**Gum**	0.00	0.00	50.00	50.00	**0.97**	10	0
Prunus amygdalus	**Almendro**	0.00	10.00	50.00	45.00	**0.93**	10	0
Quercus coccinea	**Scarlet oak**	0.00	0.00	10.00	95.00	**1.14**	10	0
Arbutus unedo	**Strawberry tree**	0.00	11.11	33.33	77.78	**1.05**	9	0
Crataegus laevigata	**Smooth hawthorn**	0.00	0.00	77.78	44.44	**0.86**	9	0
Fraxinus pennsylvanica	**Green ash**	0.00	0.00	44.44	77.78	**1.08**	9	0
Prunus serrulata	**Japanese flowering cherry**	0.00	33.33	27.78	55.56	**0.93**	9	0
***Pyrus* species**	**Pear**	0.00	11.11	55.56	38.89	**0.90**	9	0
Taxodium distichum	**Baldcypress**	0.00	11.11	77.78	50.00	**0.93**	9	0
Chionanthus retusus	**Chinese fringe tree**	0.00	0.00	12.50	93.75	**1.14**	8	0
Cocculus laurifolius	**Laurel-leaf snailseed**	0.00	0.00	0.00	100.00	**1.16**	8	0
Metasequoia glyptostroboi	**Dawn redwood**	0.00	12.50	31.25	56.25	**0.94**	8	0
Broadleaf Deciduous Small	**Broadleaf Deciduous Small**	0.00	28.57	50.00	35.71	**0.86**	7	0
Washingtonia robusta	**Mexican fan palm**	0.00	0.00	0.00	100.00	**1.16**	7	0
Ceratonia siliqua	**Algarrobo europeo**	0.00	33.33	41.67	41.67	**0.87**	6	0
Cotinus coggygria	**Purple smoke tree**	0.00	0.00	0.00	100.00	**1.16**	6	0
x Cupressocyparis leylandii	**Leyland cypress**	0.00	0.00	83.33	16.67	**0.84**	6	0
Platanus orientalis	**Oriental planetree**	0.00	0.00	16.67	91.67	**1.13**	6	0
Catalpa speciosa	**Western catalpa**	0.00	40.00	50.00	20.00	**0.66**	5	0
Chilopsis linearis	**Desert willow**	0.00	0.00	80.00	60.00	**1.01**	5	0
Gymnocadus dioicus	**Kentucky coffeetree**	0.00	20.00	80.00	100.00	**0.93**	5	0
***Juniperus* species**	**Juniper**	0.00	0.00	80.00	60.00	**1.01**	5	0
Prunus blieriana	**Blierana plum**	0.00	20.00	20.00	80.00	**1.05**	5	0
Prunus persica	**Peach**	0.00	0.00	0.00	100.00	**1.16**	5	0
Pterocarya stenoptera	**Chinese wingnut**	0.00	20.00	60.00	30.00	**0.85**	5	0
Carya illinoensis	**Pecan**	0.00	0.00	50.00	50.00	**0.97**	4	0

Relative Performance Index (RPI) for All Woodland Public Trees								
Species	Common Name	Dead or Dying	Poor	Fair	Good	RPI	# of Trees Total	% of Total Population
Maytenus boaria	Mayten tree	0.00	25.00	50.00	75.00	**0.87**	4	0
Podocarpus species	Podocarpus	0.00	0.00	100.00	100.00	**0.97**	4	0
Punica granatum	Pomegranate	0.00	0.00	25.00	75.00	**1.07**	4	0
Pyrus calleryana 'Red Spire'	Callery pear 'Redspire'	0.00	0.00	25.00	75.00	**1.07**	4	0
Salix species	Willow	0.00	0.00	0.00	100.00	**1.16**	4	0
Heteromeles arbutifolia	Toyon	0.00	0.00	50.00	50.00	**0.97**	3	0
Nerium oleander	Oleander	0.00	0.00	100.00	100.00	**0.97**	3	0
Acer negundo	Boxelder	0.00	100.00	100.00	0.00	**0.58**	2	0
Arecastrum romanzoffianum	Queen palm	0.00	0.00	0.00	100.00	**1.16**	2	0
Carpinus caroliniana	American hornbeam	0.00	0.00	50.00	75.00	**1.07**	2	0
Chamaecyparis pisifera	Falsecypress, sawara	0.00	0.00	75.00	50.00	**0.87**	2	0
Cupressus macrocarpa	Monterey cypress	0.00	0.00	100.00	100.00	**0.97**	2	0
Ficus carica	Common fig	0.00	0.00	50.00	50.00	**0.97**	2	0
Magnolia x soulangiana	Saucer magnolia	0.00	0.00	50.00	50.00	**0.97**	2	0
Pinus pinea	Itailian stone pine	0.00	0.00	50.00	50.00	**0.97**	2	0
Aesculus californica	Buckeye	100.00	0.00	0.00	0.00	**0.00**	1	0
Albizia julibrissin	Mimosa	0.00	0.00	0.00	100.00	**1.16**	1	0
Broadleaf Evergreen Small	Broadleaf Evergreen Small	0.00	0.00	0.00	100.00	**1.16**	1	0
Carya ovata	Shagbark Hickory	0.00	0.00	100.00	0.00	**0.77**	1	0
Chamaerops humilis	Mediterranean fan palm	0.00	0.00	0.00	100.00	**1.16**	1	0
Cryptomeria japonica	Japanese cryptomeria	0.00	0.00	0.00	100.00	**1.16**	1	0
Eriobotrya japonica	Loquat tree	0.00	0.00	100.00	100.00	**0.97**	1	0
Hibiscus syriacus	Rose-of-sharon	0.00	0.00	0.00	100.00	**1.16**	1	0
Mahonia spp.	Mahonia spp.	0.00	0.00	100.00	100.00	**0.97**	1	0
Prunus armeniaca	Apricot	0.00	0.00	100.00	100.00	**0.97**	1	0
Unknown broadleaf	Unknown broadleef	100.00	0.00	0.00	0.00	**0.00**	1	0
Citywide total		**1.58**	**4.78**	**30.45**	**63.14**	**1.00**	**13,140**	**100**

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Platanus X acerifolia	London planetree	45,254	102,216	338,511	480,964	1,230,253	1,196,902	1,171,658	551,126	67,751	**5,184,634**	17.74
Pistacia chinensis	Chinese pistache	28,382	129,701	1,167,045	2,213,842	257,839	189,077	0	42,110	0	**4,027,999**	13.78
Pyrus calleryana	Flowering pear	62,186	149,584	273,488	454,224	206,020	26,540	0	0	0	**1,172,043**	4.01
Lagerstroemia indica	Crapemyrtle	98,786	112,956	147,409	10,621	0	0	0	0	0	**369,772**	1.27
Prunus cerasifera	Cherry plum	73,362	55,751	36,072	6,662	0	0	0	0	0	**171,847**	0.59
Sequoia sempervirens	Coast redwood	13,154	31,313	161,095	248,710	280,512	195,411	171,189	46,610	14,968	**1,162,962**	3.98
Zelkova serrata	Japanese zelkova	44,659	65,510	14,514	33,612	82,660	138,720	23,510	0	0	**403,186**	1.38
Quercus lobata	Valley oak	27,047	35,620	141,887	269,439	329,814	330,711	356,927	596,807	1,356,626	**3,444,879**	11.79
Triadica sebifera	Tallowtree	37,616	23,780	67,392	283,911	166,312	15,776	19,457	0	0	**614,244**	2.10
Quercus ilex	Holly oak	61,482	1,931	0	4,948	27,112	73,440	0	0	0	**168,914**	0.58
Pinus canariensis	Canary Island Pine	41,942	13,179	2,154	33,461	23,279	0	0	0	0	**114,015**	0.39
Fraxinus velutina	Velvet ash	43,605	9,121	0	1,127	2,065	0	0	0	0	**55,919**	0.19
Malus species	Crabapple, flowering	44,090	7,580	22,857	0	0	0	0	0	0	**74,527**	0.26
Ulmus parvifolia	Chinese elm	32,269	5,794	0	0	0	0	0	0	0	**38,063**	0.13
Cedrus deodara	Deodar cedar	10,936	7,171	47,128	62,396	230,353	167,115	16,320	19,396	18,690	**579,505**	1.98
Celtis sinensis	Chinese hackberry	5,080	7,784	60,582	169,391	92,849	59,039	0	0	14,796	**409,521**	1.40
Koelreuteria paniculata	Goldenrain tree	19,113	30,729	51,983	39,584	17,524	0	0	0	0	**158,933**	0.54
Tilia species	Basswood	32,305	0	0	0	24,556	0	0	0	0	**56,861**	0.19
Ulmus species	Elm	15,448	2,942	0	0	6,827	16,716	68,226	331,315	576,946	**1,018,421**	3.48
Pinus species	Pine	8,561	14,367	20,192	38,192	218,867	245,498	207,926	78,512	27,331	**859,445**	2.94
Ginkgo biloba	Ginkgo	22,137	2,943	13,982	4,202	0	0	0	0	0	**43,266**	0.15
Olea europaea	Olive	1,597	5,721	27,406	132,124	197,688	228,011	88,618	20,597	0	**701,761**	2.40
Fraxinus velutina 'Modesto'	Modesto ash	717	0	415	2,409	67,519	145,604	92,073	18,878	5,144	**332,758**	1.14
Xylosma congestum	Xylosma	2,155	5,514	214,681	114,266	12,075	0	0	0	0	**348,692**	1.19

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Quercus rubra	Northern red oak	24,471	0	0	0	0	0	0	0	0	**24,471**	0.08
Quercus suber	Cork oak	9,256	12,303	69,937	47,446	96,108	185,589	191,471	140,852	115,026	**867,988**	2.97
Robinia ambigua idahoensis	Idaho locust	18,710	369	0	0	0	0	0	0	0	**19,079**	0.07
Quercus wislizeni	Interior live oak	4,273	27,930	37,423	54,845	28,790	57,212	0	0	0	**210,473**	0.72
Platanus racemosa	Western Sycamore	2,413	5,226	76,280	158,847	72,080	86,496	23,510	0	0	**424,851**	1.45
Washingtonia filifera	California palm	1,130	676	2,130	2,945	4,298	12,443	40,013	6,891	0	**70,526**	0.24
Pinus densiflora	Japanese red pine	607	5,396	62,844	2,169	0	0	0	0	0	**71,017**	0.24
Juglans hindsii	Hind walnut	1,567	7,720	5,861	26,084	20,852	60,329	66,719	137,781	264,774	**591,688**	2.02
Celtis occidentalis	Northern hackberry	1,955	13,235	26,758	78,558	59,664	50,268	58,372	17,014	0	**305,825**	1.05
Morus species	Mulberry	456	0	5,757	14,809	155,750	120,959	18,263	0	0	**315,993**	1.08
Populus species	Cottonwood	186	474	20,939	40,875	6,909	3,317	0	0	0	**72,700**	0.25
Prunus species	Plum	7,398	14,919	6,912	10,621	0	0	0	0	0	**39,850**	0.14
Chitalpa tashkentensis	Chitalpa	1,965	4,983	10,672	0	0	0	0	0	0	**17,620**	0.06
Fraxinus species	Ash	2,416	885	17,632	93,070	34,257	30,053	52,853	0	22,619	**253,785**	0.87
Cupressus species	Cypress	195	3,752	27,918	66,372	42,584	102,258	59,242	27,520	32,043	**361,883**	1.24
Casuarina cunninghamiana	River-she oak	459	3,200	0	40,437	272,778	170,816	58,371	32,792	38,193	**617,045**	2.11
Prunus caroliniana	Cherry laurel	635	16,182	59,333	9,705	0	0	0	0	0	**85,856**	0.29
Phoenix canariensis	Canary island date palm	0	0	0	0	7,319	150,546	21,715	0	0	**179,580**	0.61
Acer rubrum	Red maple	9,127	278	718	0	0	0	0	0	0	**10,124**	0.03
Quercus species	Oak	1,827	10,290	49,173	62,245	51,229	60,700	0	0	0	**235,465**	0.81
Cercis species	Redbud	7,357	1,461	0	0	0	0	0	0	0	**8,817**	0.03
Pyrus kawakamii	Evergreen pear	0	1,396	34,769	87,733	51,847	12,158	0	0	0	**187,902**	0.64
Liriodendron tulipifera	Tulip tree	830	3,950	23,721	17,287	0	17,099	0	0	0	**62,887**	0.22

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Acer platanoides	Norway maple	6,305	0	1,375	0	0	0	0	0	0	**7,679**	0.03
Ligustrum lucidum	Chinese privet	1,842	1,521	2,128	4,968	4,160	2,717	2,139	0	0	**19,475**	0.07
Robinia pseudoacacia	Black locust	5,626	3,309	4,166	0	0	0	0	0	0	**13,100**	0.04
Acer saccharinum	Silver maple	3,808	3,996	6,636	22,124	6,899	0	11,035	0	0	**54,498**	0.19
Gleditsia triacanthos	Honeylocust	1,466	5,841	3,602	33,248	22,838	0	0	0	0	**66,996**	0.23
Nyssa sylvatica	Black tupelo	6,339	961	0	0	0	0	0	0	0	**7,300**	0.02
Alnus species	Alder species	200	645	4,094	5,048	7,689	0	0	0	0	**17,675**	0.06
Juglans species	Walnut	0	0	2,282	19,640	79,473	46,457	11,520	67,553	41,274	**268,197**	0.92
Celtis species	Hackberry	1,351	1,227	18,489	12,377	11,409	7,743	0	0	0	**52,597**	0.18
Cinnamomum camphora	Camphor tree	162	0	7,737	41,119	125,974	63,104	23,510	0	0	**261,607**	0.90
Cupressus sempervirens	Italian cypress	581	0	5,071	12,714	62,158	30,414	11,716	16,302	0	**138,956**	0.48
Fraxinus angustifolia 'Raywood'	Raywood ash	195	442	4,361	38,192	58,523	64,009	33,686	0	0	**199,408**	0.68
Fraxinus americana	White ash	162	0	3,389	39,413	98,861	102,272	0	21,484	0	**265,582**	0.91
Crataegus phaenopyrum	Washington hawthorn	1,801	0	0	0	0	0	0	0	0	**1,801**	0.01
Photinia x fraseri	Fraser photinia	909	4,632	19,162	15,931	0	0	0	0	0	**40,634**	0.14
Acer buergerianum	Trident maple	2,032	0	6,138	29,517	33,395	0	0	0	0	**71,082**	0.24
Laurus nobilis	Laurel de olor	1,489	4,203	12,021	14,844	0	0	0	0	0	**32,557**	0.11
Quercus agrifolia	Coastal live oak	620	2,927	0	15,055	35,167	47,915	0	49,776	0	**151,460**	0.52
Rhus lancea	African sumac	381	9,561	0	15,697	28,766	0	0	0	0	**54,405**	0.19
Umbellularia californica	California laurel	1,164	4,487	9,271	7,337	0	0	0	0	0	**22,260**	0.08
Acer palmatum	Japanese maple	3,359	0	0	0	0	0	0	0	0	**3,359**	0.01
Cercis canadensis	Eastern redbud	1,948	2,193	0	0	0	0	0	0	0	**4,141**	0.01
Liquidambar styraciflua	Sweetgum	664	442	9,385	7,169	22,838	11,319	0	0	0	**51,817**	0.18
Casuarina equisetifolia	Horsetail tree	2,400	0	842	0	0	0	14,655	0	0	**17,897**	0.06

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Pittosporum species	Cheesewood	0	1,701	16,144	6,361	0	0	0	0	0	**24,207**	0.08
Ailanthus altissima	Tree of heaven	1,534	588	519	1,477	0	0	0	0	0	**4,118**	0.01
Betula pendula	European white birch	728	643	3,900	1,135	0	0	0	0	0	**6,407**	0.02
Juglans nigra	Black walnut	148	0	0	1,457	8,256	25,191	19,909	7,304	0	**62,265**	0.21
Carpinus betulus	European hornbeam	672	0	0	9,896	47,943	15,776	0	0	0	**74,287**	0.25
Cedrus atlantica	Atlas cedar	1,376	0	0	0	0	9,356	25,440	0	0	**36,171**	0.12
Acer species	Maple	1,008	885	1,375	0	0	0	0	0	0	**3,267**	0.01
Calocedrus decurrens	Incense cedar	477	0	2,675	6,956	18,098	0	27,839	0	0	**56,044**	0.19
Magnolia grandiflora	Southern magnolia	1,498	805	0	0	0	0	0	0	0	**2,304**	0.01
Sophora japonica	Japanese pagoda tree	0	0	0	19,792	70,096	0	0	0	0	**89,888**	0.31
Melia azedarach	Chinaberry	456	945	1,581	2,169	8,250	0	0	0	0	**13,400**	0.05
Salix x pendulina Wenderoth	Wisconsin weeping willow	148	326	1,436	4,980	6,651	9,890	0	0	0	**23,431**	0.08
Citrus species	Citrus	106	2,745	5,563	4,948	0	0	0	0	0	**13,362**	0.05
Eucalyptus species	Gum	166	0	2,749	0	34,495	11,319	16,843	0	0	**65,572**	0.22
Prunus amygdalus	Almendro	812	454	1,854	4,095	19,177	0	0	0	0	**26,392**	0.09
Quercus coccinea	Scarlet oak	1,381	0	1,661	0	0	0	0	0	0	**3,042**	0.01
Arbutus unedo	Strawberry tree	790	931	3,188	0	6,130	0	0	0	0	**11,039**	0.04
Crataegus laevigata	Smooth hawthorn	606	1,544	1,642	5,310	0	0	0	0	0	**9,103**	0.03
Fraxinus pennsylvanica	Green ash	178	0	0	16,304	4,836	0	0	0	0	**21,319**	0.07
Prunus serrulata	Japanese flowering cherry	0	4,452	1,985	0	0	0	0	0	0	**6,436**	0.02
Pyrus species	Pear	537	1,647	2,174	4,948	0	0	0	0	0	**9,307**	0.03
Taxodium distichum	Baldcypress	0	0	0	0	5,705	28,068	64,799	0	0	**98,571**	0.34
Chionanthus retusus	Chinese fringe tree	1,526	0	0	0	0	0	0	0	0	**1,526**	0.01

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Cocculus laurifolius	Laurel-leaf snailseed	0	0	8,604	13,518	0	0	0	0	0	**22,121**	0.08
Metasequoia glyptostroboi	Dawn redwood	187	1,240	2,282	3,478	0	0	0	0	0	**7,186**	0.02
Broadleaf Deciduous Small	Broadleaf Deciduous Small	389	481	4,927	0	6,748	0	0	0	0	**12,545**	0.04
Washingtonia robusta	Mexican fan palm	0	227	766	572	319	0	0	0	0	**1,884**	0.01
Ceratonia siliqua	Algarrobo europeo	0	371	1,338	4,910	0	15,486	0	0	0	**22,104**	0.08
Cotinus coggygria	Purple smoke tree	1,166	0	0	0	0	0	0	0	0	**1,166**	0.00
x Cupressocyparis leylandii	Leyland cypress	424	336	367	0	0	0	0	0	0	**1,127**	0.00
Platanus orientalis	Oriental planetree	761	549	2,174	0	0	0	0	0	0	**3,484**	0.01
Catalpa speciosa	Western catalpa	0	179	1,495	5,421	0	0	0	0	0	**7,095**	0.02
Chilopsis linearis	Desert willow	0	1,968	5,070	0	0	0	0	0	0	**7,038**	0.02
Gymnocadus dioicus	Kentucky coffeetree	0	371	0	8,899	4,721	0	0	0	0	**13,991**	0.05
Juniperus species	Juniper	0	0	4,250	8,177	0	0	0	0	0	**12,427**	0.04
Prunus blieriana	Blierana plum	584	808	0	0	0	0	0	0	0	**1,392**	0.00
Prunus persica	Peach	0	3,409	0	0	0	0	0	0	0	**3,409**	0.01
Pterocarya stenoptera	Chinese wingnut	0	0	3,422	2,455	0	6,130	0	0	0	**12,007**	0.04
Carya illinoensis	Pecan	142	371	1,141	0	5,705	0	0	0	0	**7,359**	0.03
Maytenus boaria	Mayten tree	169	0	1,468	2,518	7,407	0	0	0	0	**11,561**	0.04
Podocarpus species	Podocarpus	664	0	0	0	0	0	0	0	0	**664**	0.00
Punica granatum	Pomegranate	545	698	0	0	0	0	0	0	0	**1,243**	0.00
Pyrus calleryana 'Red Spire'	Callery pear 'Redspire'	722	0	0	0	0	0	0	0	0	**722**	0.00
Salix species	Willow	520	326	0	0	0	0	0	0	0	**846**	0.00
Heteromeles arbutifolia	Toyon	0	1,396	0	0	0	0	0	0	0	**1,396**	0.00

Replacement Value of Woodland's Public Trees by Species												
		DBH Class (in)										
Species	Common Name	0-3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	>43	Total	% of Total
Nerium oleander	Oleander	166	582	1,985	0	0	0	0	0	0	**2,732**	0.01
Acer negundo	Boxelder	0	0	0	738	1,353	0	0	0	0	**2,091**	0.01
Arecastrum romanzoffianum	Queen palm	257	322	0	0	0	0	0	0	0	**579**	0.00
Carpinus caroliniana	American hornbeam	353	0	0	0	0	0	0	0	0	**353**	0.00
Chamaecyparis pisifera	Falsecypress, sawara	137	582	0	0	0	0	0	0	0	**719**	0.00
Cupressus macrocarpa	Monterey cypress	0	0	0	3,584	6,899	0	0	0	0	**10,483**	0.04
Ficus carica	Common fig	190	454	0	0	0	0	0	0	0	**645**	0.00
Magnolia x soulangiana	Saucer magnolia	325	0	0	0	0	0	0	0	0	**325**	0.00
Pinus pinea	Itailian stone pine	0	0	0	0	4,586	7,506	0	0	0	**12,091**	0.04
Aesculus californica	Buckeye	0	0	123	0	0	0	0	0	0	**123**	0.00
Albizia julibrissin	Mimosa	178	0	0	0	0	0	0	0	0	**178**	0.00
Broadleaf Evergreen Small	Broadleaf Evergreen Small	0	546	0	0	0	0	0	0	0	**546**	0.00
Carya ovata	Shagbark Hickory	0	0	0	0	4,721	0	0	0	0	**4,721**	0.02
Chamaerops humilis	Mediterranean fan palm	0	0	0	0	0	0	736	0	0	**736**	0.00
Cryptomeria japonica	Japanese cryptomeria	173	0	0	0	0	0	0	0	0	**173**	0.00
Eriobotrya japonica	Loquat tree	0	0	1,375	0	0	0	0	0	0	**1,375**	0.00
Hibiscus syriacus	Rose-of-sharon	0	682	0	0	0	0	0	0	0	**682**	0.00
Mahonia spp.	Mahonia spp.	169	0	0	0	0	0	0	0	0	**169**	0.00
Prunus armeniaca	Apricot	0	549	0	0	0	0	0	0	0	**549**	0.00
Unknown broadleaf	Unknown broadleef	23	0	0	0	0	0	0	0	0	**23**	0.00
Citywide total		936,315	1,036,332	3,556,951	5,896,627	5,248,836	4,653,474	3,070,260	2,230,619	2,596,179	29,225,592	100.00