City of Palo Alto, California

Right-of-Way Urban Forest Resource Analysis

January 2011

DAVEY RESOURCE GROUP

A Division of The Davey Tree Expert Company

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January, 2011

Prepared for

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Acknowledgements

While the specific reports and recommendations can be attributed to this study, the basis for its structure and written content comes from the entire series of Municipal Forest Resource Analysis reports prepared and published by the USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research, and credit should be given to those authors. The Municipal Forest Resource Analysis Reports are companions to the regional Tree Guides and i-Tree's STRATUM application developed by the USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research.

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Executive Summary

Trees are important to the residents of Palo Alto, California. Named for 'El Palo Alto' (The Tall Tree), the community has a long-standing history of tree conservation. As a pioneer in the urban forestry industry, the City of Palo Alto has demonstrated that public trees are a highly valued community resource with the adoption in 1984 of the Street Tree Management Program, followed by the Tree Preservation Ordinance (Municipal Code 8.04.020) in 1997, and the development of the Tree Technical Manual (Municipal Code, Chapter 8.10.030) (Dockter, 2001). Since 1995, the Arbor Day Foundation has acknowledged Palo Alto as a Tree City USA.

Continuing with a proactive approach to managing the urban forest, the City of Palo Alto contracted with Davey Resource Group (DRG) in 2010 to update their inventory of trees in public right-of-ways. This update included a brief inspection by a team of inventory arborists who recorded information including species, size, condition, and current maintenance needs, as well as geo-coding the location of 29,151 trees and 2,353 available planting sites. Upon completion of this project in late 2010, DRG developed a detailed and quantified analysis of the current structure, function, and value of this public tree resource using the updated inventory data in conjunction with i-Tree benefit-cost modeling software.

The analysis determined that Palo Alto's right-of-way tree population is a cost-effective resource that provides annual benefits of $6,638,513 ($103.73 per capita). These benefits include energy savings, air quality improvements, stormwater interception, atmospheric CO_2 reduction, and aesthetic contributions to the social and economic health of the community. Considering the annual investment of $2,064,000 ($32.25 per capita) to provide care for this resource, the community realizes an overall net benefit of $4,574,513. **The bottom line is that for every $1 spent on public trees, the community of Palo Alto receives $3.22 in benefits.**

The right-of-way tree population is reducing annual electrical energy consumption by 3,729 megawatt hours (MWh), and annual natural gas consumption by 75,183 therms, for a combined value of $589,805 annually. In addition, canopy from this population is reducing annual stormwater runoff volume by 42.6 million gallons, protecting local water resources, including the Bay, by reducing sediment and pollution loading. While the vast majority of species within the inventory are making a positive contribution to air quality, the prevalence of a small number of species (four of the top ten) within the overall right-of-way tree inventory are creating a deficit in overall air quality because they emit high levels of biogenic volatile organic compounds (BVOCs). The ongoing plan to replace these species, such as liquidambar, as they age with species that improve air quality will mitigate this deficit over time.

Through growth, greater tree canopy coverage, improved overall health, species selection, and increased lifespan, the urban forest is one community asset that has the potential to increase in value over time and with proper maintenance. Palo Alto's right-of-way tree population is relatively mature and in overall good condition. Although it is critical to maintain an adequate level of resources to protect and nurture this investment, the City is well positioned to realize long-term benefits that have the potential to increase over time. Palo Alto's commitment to maintaining and conserving the benefits from its community trees will ensure that the community will always be a great place to live, work, and play.

Introduction

The City of Palo Alto is located in the San Francisco Bay Area, in the northwest corner of Santa Clara County, California. Considered to be the birthplace of Silicon Valley, with a reputation for being progressive, the community is home to many well-known companies including Hewlett-Packard and Tesla. Incorporated in 1894 (paloaltoonline.com), Palo Alto encompasses an area of 25.6 square miles at an elevation of 56 feet above sea level. The climate is mild with an average rainfall around 15 inches. The population, currently estimated at 64,000, enjoys a high quality of life in a community known for its intellect, innovation, culture, and natural beauty, as well as for the quality of its public schools. Portions of Stanford University are located in Palo Alto (Chamber of Commerce).

Named for 'El Palo Alto', an 1,100 year old coast redwood that still stands in one of the City's parks, Palo Alto is Spanish for 'Tall Tree.' Palo Alto's tree conservation history dates back as early as 1914 and a battle known as "Save the Oaks." At a time when motor vehicles were just beginning to enjoy popularity, a number of large, mature oaks still existed in the middle of many of the streets in Palo Alto. In the opinion of motorists, these trees were a hazard to vehicles and their occupants. But, in the opinion of many residents, it was the motor vehicles that were the hazard. By a vote of 528 to 308, residents defeated a Council proposal to remove more than 100 veteran oaks left standing when original street grids were developed. During the debate, many residents expressed deep attachment and appreciation for the trees and some felt the trees provided an incentive for drivers to slow down (Bowling).

Considered by many to be a pioneer in urban forest management and preservation, Palo Alto adopted its Street Tree Management Program in 1984 to regulate the planting and maintenance of public street right-of-way trees. The Tree Preservation Ordinance (Municipal Code 8.04.020) (1997), regulates the care and removal street trees, protected species, and other trees designated for protection in development zones. As a companion guide to the tree preservation ordinance, Palo Alto developed the Tree Technical Manual (Municipal Code, Chapter 8.10.030) (Dockter, 2001). In addition, Palo Alto's urban forest benefits from the support of Canopy, a non-profit urban forest advocacy group whose mission is to educate, inspire, and engage residents, businesses, and government agencies to protect and enhance local urban forests (www.canopy.org).

Individual trees and a healthy urban forest play important roles in the quality of life and the sustainability of Palo Alto. Research has demonstrated that healthy urban trees can improve the local environment and lessen the impact resulting from urbanization and industry (CUFR). Trees improve air quality by manufacturing oxygen and absorbing carbon dioxide (CO_2), as well as filtering and reducing airborne particulate matter such as smoke and dust. Urban trees reduce energy consumption by shading structures from solar energy and reducing the overall rise in temperature created through urban heat island effects (EPA). Urban trees slow and reduce stormwater runoff, helping to protect critical waterways, including the Bay, from excess pollutants and particulates and urban trees provide critical habitat for wildlife and promote a connection to the natural world.

In addition to these direct improvements, healthy urban trees increase the overall attractiveness of a community and have been proven to increase the value of local real estate by 7 to 10%, as well as promoting shopping, retail sales, and tourism (Wolf, 2007). Trees support a more livable community, fostering psychological health and providing residents with a greater sense of place (Ulrich, 1986; Kaplan, 1989). Community trees, both public and private, soften the urban hardscape by providing a green sanctuary and making Palo Alto

a more enjoyable place to live, work, and play. The City's 29,151 public right-of-way trees play a prominent role in the urban forest benefits afforded to the community and the citizens rely on the City of Palo Alto to protect and maintain this vital resource.

Acknowledged by the Arbor Day Foundation since 1995 as a Tree City USA, there is ample evidence that Palo Alto values its trees. Reflecting appreciation, concern, and a proactive stance on the management of the community's urban forest resource, in 2010 the City contracted with Davey Resource Group (DRG) to conduct an inventory update of trees in public right-of-ways. A team of ISA Certified Arborists mapped and geo-coded the location of publicly owned trees using global positioning system (GPS) technology. The inventory data is maintained by the City's urban forest staff using TreeKeeper® 7.7, a software management system developed by Davey to provide accurate and dependable inventory data specific to tree characteristics, health, and performed maintenance.

In addition to geo-coding the location, DRG arborists collected information about the species, size, condition, and current maintenance needs of each tree. The collected data was used in conjunction with *i-Tree's Streets*, a STRATUM Analysis Tool (*Streets* v3.0.15; i-Tree v3.0.19), to develop a resource analysis and report of the current condition of the urban forest. This report, unique to Palo Alto, effectively quantifies the value of the community's right-of-way 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 Palo Alto's public right-of-way tree resource and an established benchmark for future management decisions.
- Current, detailed management expenditures for Palo Alto's publicly managed right-of-way trees and critical baseline information for evaluating program efficiency.
- A quantified value of the environmental benefits provided by Palo Alto's right-of-way trees. This also illustrates the relevance and relationship of the resource to local quality of life issues such as air quality, environmental health, economic development, and psychological health.
- Data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-governmental organizations, air quality districts, federal and state agencies, legislative initiatives, or local assessment fees.
- Benchmark data that can be used in the development of a long-term urban forest management plan.

Palo Alto's urban forest inventory update included all publicly managed trees in street right-of-ways. The inventory update also included some trees in municipal facilities, but did not include geo-coding or data collection on park trees. An estimated 6380 trees were not considered in this resource analysis. Most of these trees are located in parks and municipal facilities

Chapter 1: Urban Forest Resource Summary

Summary of Urban Forest Resource Structure

The City of Palo Alto's right-of-way urban forest resource currently includes 29,151 publicly managed trees and 2,353 available planting sites. A structural analysis is the first step towards understanding the benefits provided by these trees as well as their management needs. Upon examination of species composition, diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes Palo Alto's right-of-way public tree resource:

- More than 230 distinct tree species were identified in the inventory. The predominant tree species are southern magnolia (*Magnolia grandiflora*, 13.9%), London planetree (*Platanus acerifolia*, 9.7%) and liquidambar (*Liquidambar styraciflua*, 9.2%).
- The age structure of Palo Alto's right-of-way tree population is predominantly intermediate to mature, with 64.3% of trees measuring between 6 to 24 inches DBH (diameter at breast height, measured at 4'6" above the ground) and 14.4% measuring greater than 24 inches DBH.

Replacement of Palo Alto's 29,151 right-of-way trees with trees of similar size, species, and condition would cost nearly $120 million.

- The majority of Palo Alto's right-of-way trees (58.5%) were determined to be in good or excellent condition (wood), with an additional 35.3% graded fair. Maintaining the condition of existing trees for as long as possible will increase their useful lifespan and promote a steady flow of benefits to the community.
- Palo Alto's right-of-way tree canopy cover is estimated at 574 acres, or 3.5% of the total land area and 36.8% of the total street and sidewalk area within the City.
- Palo Alto's right-of-way tree population has sequestered 40,819 tons of carbon (CO_2), valued at approximately $612,284.
- Replacement of Palo Alto's 29,151 right-of-way trees with trees of similar size, species, and condition would cost nearly $120 million.
- Palo Alto's current stocking level for right-of-way trees is estimated to be 92.5%, based on a total 31,504 inventoried planting sites, including 29,151 trees, 2,091 vacant sites, and 262 sites requiring stump removal prior to replanting.

Summary of Urban Forest Benefits

Annually, Palo Alto's right-of-way trees provide cumulative benefits to the community at an average value of $227.73 per tree, for a total gross value of $6,638,513 per year. The City's public trees are providing the following substantial annual benefits:

- Right-of-way trees reduce electricity and natural gas use in Palo Alto through shading and climate effects, totaling $589,805, an average of $20.23 per tree.

- The right-of-way trees in Palo Alto currently sequester 2,264 tons of atmospheric CO_2 per year. An additional 1,567 tons is avoided through decreased energy use, resulting in a net value of $51,563 and an average of $1.77 per tree.
- Palo Alto's right-of-way trees intercept an estimated 42.6 million gallons of stormwater annually for a total value of $170,504 per year, an average of $5.85 per tree.
- The total annual benefits contributed by Palo Alto's right-of-way trees to property value increases, aesthetics, and socioeconomic value are nearly $5.9 million, an average of $201.49 per tree.
- While most species in this inventory are providing positive air quality benefits, the prevalence in the right-of-way tree population of four species that emit high levels of biogenic volatile organic compound (BVOCs) is resulting in an air quality deficit of -$46,888 annually.
- When the City's annual investment of $2,064,000 for maintenance of this urban forest resource is considered, the annual net benefit (benefits minus investment) to the City is $4,574,513. The average net benefit for an individual right-of-way tree in Palo Alto is $156.93 per year. **Palo Alto receives $3.22 in benefits for every $1 spent on the right-of-way tree population.**

Urban Forest Resource Management

Palo Alto's public right-of-way tree population is a dynamic resource that is worth continued investment to maintain and extend its full benefit potential. **The community forest is one of the few assets that has the potential to increase in value with time and proper management.** Appropriate and timely tree care can substantially increase lifespan, preserving the higher benefit stream that results from a mature community forest. As individual trees continue to mature, aging trees are replaced, and stocking levels increase, the overall value of the community forest and the amount of benefits provided also increases. This vital, living resource is, however, vulnerable to a host of stressors, requiring ecologically sound and sustainable best management practices to ensure a continued flow of benefits for future generations. With a mature right-of-way urban forest in good condition, Palo Alto can focus resources on maximizing the flow of benefits by increasing the current stocking level of 92.5%. As these populations age, replacing species that emit high levels of biogenic volatile organic compounds (BVOCs) with species that provide net positive air quality benefits will improve air quality throughout the community. Based on the resource analysis, Davey Resource Group recommends the following:

- *Continue annual tree planting efforts with the goal of achieving a 100% stocking rate, utilizing available planting sites identified by the inventory.*
- *Maintain a stable age distribution to ensure long-term resource sustainability and optimal canopy coverage. Where possible, establish 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 flow of benefits. Focus on planting large-stature trees, where space allows, to maximize benefits.*

- *Continue to reduce the prevalence of species that emit high levels of BVOCs. As these populations age, install replacement species that provide positive air quality benefits.*

Planning and funding for tree care and tree management must complement planting efforts in order to ensure the long-term success and health of Palo Alto's urban forest. Existing mature trees should be maintained and protected whenever possible, since the greatest benefits accrue from the continued growth and longevity of the existing canopy. Palo Alto can take pride in knowing that street trees improve the quality of life in the city and that trees are well worth the investment.

This urban forest resource analysis and report, based on the current inventory status, defines the population and structure of Palo Alto's right-of-way urban forest and quantifies the benefits of that resource. The analysis focuses solely on publicly owned, city-managed trees on street right-of-ways. The analysis utilizes *i-Tree Streets*, a STRATUM Analysis Tool (*Streets* v3.0.15; i-Tree v3.0.19), in order to establish baseline information on the value to the community. This report and the included analysis, which is unique to Palo Alto, effectively estimates and quantifies the value of these public tree assets in regards to actual benefits derived from this resource. In addition, the report provides a baseline analysis that can be used when creating, implementing, and updating an urban forest management plan, determining where best to focus available resources, and setting benchmarks for measuring progress. An urban forest resource analysis provides information on the structure, function, and value of the urban forest and its assets so that forest 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 Palo Alto's public right-of-way urban forest resources, establishing a benchmark for future management decisions.*
- *Current, detailed management expenditures for Palo Alto's right-of-way trees and critical baseline information for evaluating program efficiency.*
- *A quantified value of the environmental benefits provided by Palo Alto's right-of-way urban forest, 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 forest resource managers in the pursuit of alternative funding sources and collaborative relationships with utility managers, non-profit organizations, air quality districts, federal and state agencies, legislative initiatives, and/or in establishing or updating local assessment fees.*

For every $1 invested in right-of-way trees, Palo Alto receives $3.22 in benefits

- *Benchmark data that can be used in the development of a long-term urban and community forest management plan.*

Chapter 2: Palo Alto's Urban Forest Resource

Population Composition

Broadleaf hardwood species dominate Palo Alto's right-of-way tree population, comprising 95.5% 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. Larger-statured broadleaf tree species provide greater benefits than smaller-statured trees, independent of diameter (DBH). Deciduous broadleaf species make up 67% of Palo Alto's right-of-way tree population, including 26% large-stature, 36% medium-stature, and 5% small-stature trees. Evergreen broadleaf trees comprise 28% of the population, including 5% large-stature, 21% medium-stature, and 2% small-stature evergreen broadleaf trees. Large-stature conifers represent 3% of the overall population, while small and medium conifers each represent less than 1%. Less than 1% of the population is comprised of palms, including large, medium, and small-canopied species (Figure 1).

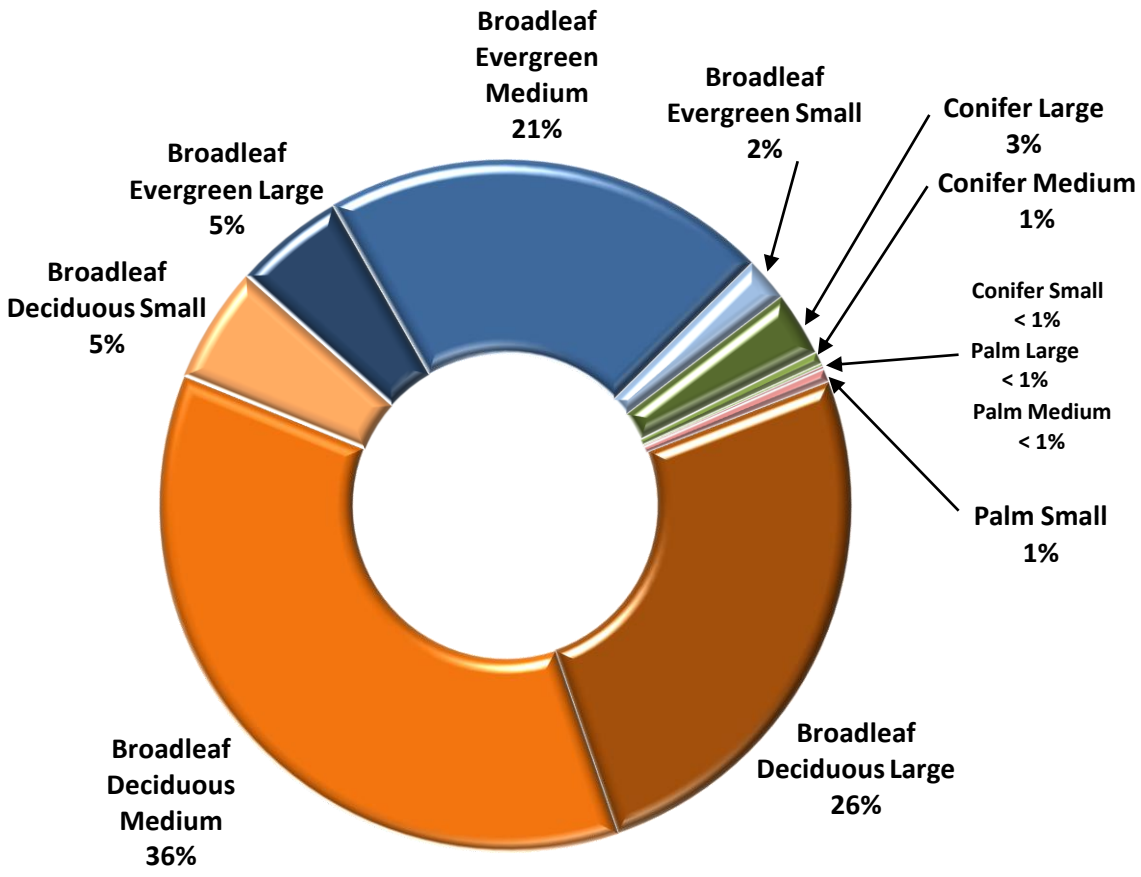


Figure 1. Composition of Palo Alto's Public Right-of-Way Tree Population

Species Richness and Composition

Palo Alto's right-of-way tree population includes a mix of more than 230 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 twelve species represent 58.3% of the total population (Figure 2 and Table 1). The predominant tree species are southern magnolia (*Magnolia grandiflora*, 13.9%), London planetree (*Platanus acerifolia*, 9.7%) and liquidambar (*Liquidambar styraciflua*, 9.2%). Five genera represent 53.5% of the population, comprised of *Magnolia* (14.1%), *Platanus* (12.1%), *Fraxinus* (9.4%), *Liquidambar* (9.2%), and *Quercus* (8.8%). There is a 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). With the exception of southern magnolias, which exceed 10%, the overall population suggests fairly adequate diversification within Palo Alto's public tree canopy. A complete population summary can be found in Appendix C.

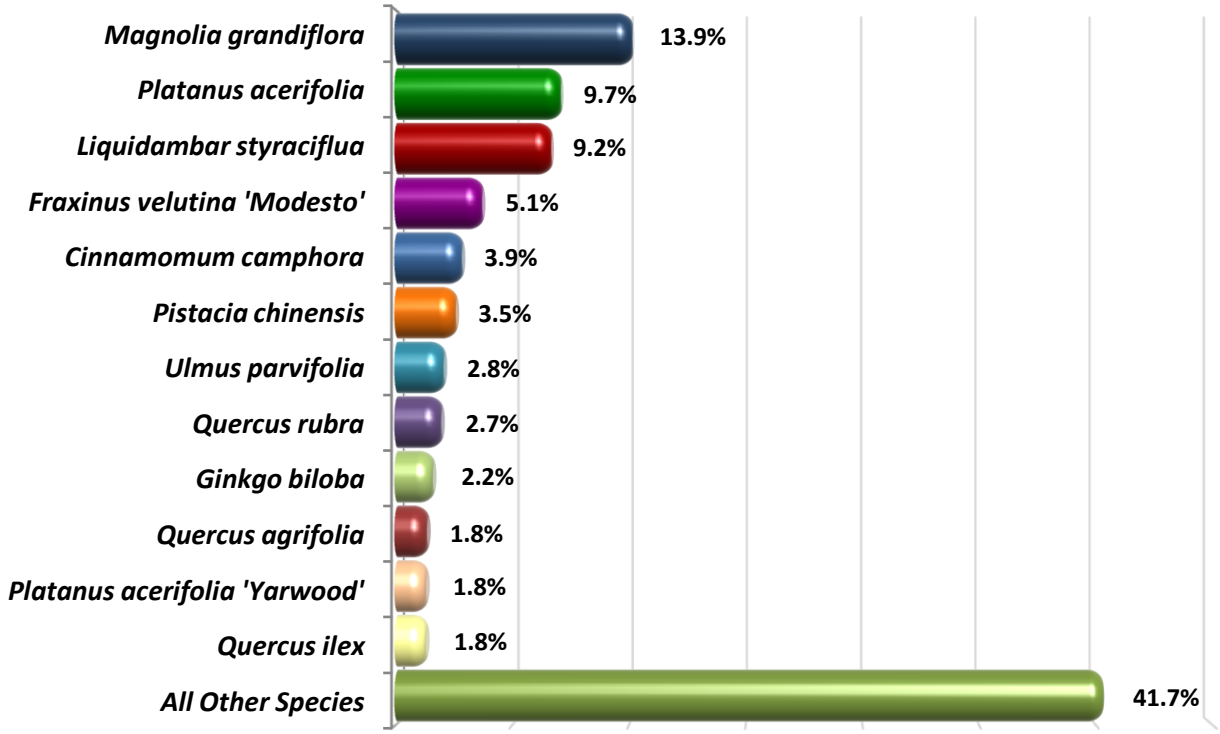


Figure 2. Species Frequency in Palo Alto's Right-of-Way Tree Population

Maintaining a diverse population within an urban forest is important. Dominance of any single species or genus can have detrimental 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 Long-horned Beetle (*Anoplophora glabripennis*), and Sudden Oak Death (SOD) (*Phytophthora ramorum*) are some examples of unexpected, devastating, and costly pests and pathogens that highlight the importance of diversity and the balanced distribution of species and genera.

Table 1. Population Summary of Palo Alto's Right-of-Way Tree Inventory

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total	% of Pop
Broadleaf Deciduous Large (BDL)												
Platanus acerifolia	51	66	420	846	963	385	81	13	6	1	2,832	9.7
Ulmus parvifolia	26	14	53	303	345	75	3	0	1	0	820	2.8
Quercus rubra	151	190	325	95	12	4	1	0	0	0	778	2.7
Platanus acerifolia 'Yarwood'	64	185	244	22	1	0	0	1	0	0	517	1.8
Liriodendron tulipifera	1	9	37	56	111	70	32	21	7	2	346	1.2
Celtis australis	20	27	112	115	26	9	6	2	1	0	318	1.1
Celtis sinensis	10	34	161	69	27	1	0	0	0	0	302	1.0
BDL OTHER	273	284	342	182	173	118	96	38	16	14	1,536	5.3
BDL Total	**596**	**809**	**1,694**	**1,688**	**1,658**	**662**	**219**	**75**	**31**	**17**	**7,449**	**25.6%**
Broadleaf Deciduous Medium (BDM)												
Liquidambar styraciflua	39	62	425	1,080	779	241	41	2	0	0	2,669	9.2
Fraxinus velutina 'Modesto'	20	4	25	158	445	538	259	31	1	0	1,481	5.1
Pistacia chinensis	135	243	434	180	34	1	0	0	0	0	1,027	3.5
Ginkgo biloba	140	160	224	73	21	10	4	1	0	0	633	2.2
Acer rubrum	56	124	213	24	1	0	0	0	0	0	418	1.4
Tilia cordata	16	58	187	115	25	13	1	1	0	0	416	1.4
Betula pendula	26	69	183	84	11	1	0	0	0	0	374	1.3
Fraxinus oxycarpa	13	41	134	126	42	10	5	1	1	0	373	1.3
Fraxinus holotricha 'Moraine'	8	57	164	89	6	5	3	1	1	0	334	1.1
Pyrus calleryana	16	49	105	93	34	4	0	0	0	0	301	1.0
BDM OTHER	614	677	716	354	153	57	12	6	1	1	2,591	8.9
BDM Total	**1,083**	**1,544**	**2,810**	**2,376**	**1,551**	**880**	**325**	**43**	**4**	**1**	**10,617**	**36.4%**
Broadleaf Deciduous Small (BDS)												
BDS OTHER	474	527	453	82	14	2	0	0	0	0	1,552	5.3
BDS Total	**474**	**527**	**453**	**82**	**14**	**2**	**0**	**0**	**0**	**0**	**1,552**	**5.3%**
Broadleaf Evergreen Large (BEL)												
Quercus agrifolia	28	78	121	126	97	38	24	12	8	2	534	1.8
Quercus ilex	16	50	124	163	113	40	8	1	0	0	515	1.8
BEL OTHER	77	52	113	87	58	27	17	8	9	7	455	1.6
BEL Total	**121**	**180**	**358**	**376**	**268**	**105**	**49**	**21**	**17**	**9**	**1,504**	**5.2%**
Broadleaf Evergreen Medium (BEM)												
Magnolia grandiflora	71	102	601	1,421	1,061	527	198	58	19	3	4,061	13.9
Cinnamomum camphora	31	32	106	238	311	255	108	40	10	2	1,133	3.9
Ligustrum lucidum	11	55	113	114	50	17	1	0	0	0	361	1.2
BEM OTHER	37	75	131	127	95	35	19	7	3	0	529	1.8
BEM Total	**150**	**264**	**951**	**1,900**	**1,517**	**834**	**326**	**105**	**32**	**5**	**6,084**	**20.9%**
Broadleaf Evergreen Small (BES)												

Species	DBH Class (in)										Total	% of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48		
BES OTHER	103	203	175	74	53	23	7	1	0	1	640	2.2
BES Total	**101**	**203**	**175**	**66**	**35**	**19**	**7**	**1**	**0**	**1**	**640**	**2.2%**
Conifer Evergreen Large (CEL)												
CEL OTHER	34	25	94	184	197	147	108	48	19	22	878	3.0
CEL Total	**34**	**25**	**94**	**184**	**197**	**147**	**108**	**48**	**19**	**22**	**878**	**3.0%**
Conifer Evergreen Medium (CEM)												
CEM OTHER	37	30	69	25	5	0	1	0	0	1	168	0.6
CEM Total	**37**	**30**	**69**	**25**	**5**	**0**	**1**	**0**	**0**	**1**	**168**	**0.6%**
Conifer Evergreen Small (CES)												
CES OTHER	7	11	23	3	0	0	0	0	0	0	44	0.2
CES Total	**7**	**11**	**23**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**44**	**0.2%**
Palm Evergreen Large (PEL)												
PEL OTHER	0	1	1	0	0	10	15	7	0	0	34	0.1
PEL Total	**0**	**1**	**1**	**0**	**0**	**10**	**15**	**7**	**0**	**0**	**34**	**0.1%**
Palm Evergreen Medium (PEM)												
PEM OTHER	0	0	3	1	1	1	2	0	0	0	8	0.0
PEM Total	**0**	**0**	**3**	**1**	**1**	**1**	**2**	**0**	**0**	**0**	**8**	**0.0%**
Palm Evergreen Small (PES)												
PES OTHER	10	15	57	54	23	8	6	0	0	0	173	0.6
PES Total	**10**	**15**	**57**	**54**	**23**	**8**	**6**	**0**	**0**	**0**	**173**	**0.6%**
Total	**2,615**	**3,609**	**6,688**	**6,763**	**5,287**	**2,672**	**1,058**	**300**	**103**	**56**	**29,151**	**100%**

Species Importance

To quantify the significance of any one particular species found in Palo Alto's right-of-way 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 importance value based on the mean of three values: percentage of total population, percentage of total leaf area, and percentage of total canopy cover.** Importance value goes beyond tree numbers alone to suggest reliance on specific species based on the benefits they provide. The importance value can range from zero (which implies no reliance) to 100 (suggesting total reliance). No single species should dominate the composition in the City's urban forest population. Because importance value goes beyond population numbers alone, it can help managers to better comprehend the resulting loss of benefits from a catastrophic loss of any one species. When importance values are comparatively equal among the ten to 15 most abundant species, the risk of major 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 22 most abundant species identified in Palo Alto's right-of-way tree inventory represent 70.5% of the total population, 79.9% of the total leaf area, and 81.2% of the total canopy

cover for a combined importance value of 77.2 (Table 2). Of these species, Palo Alto relies most on the southern magnolia (*Magnolia grandiflora*, IV=15.35), followed by London planetree (*Platanus acerifolia*, IV=13.59) and liquidambar (*Liquidambar styraciflua*, IV=11.84).

Palo Alto's Modesto ash (*Fraxinus velutina 'Modesto'*), accounting for 5.1% of the population, have an importance value of 8.11 and are providing the greatest per tree functional capacity to provide benefits compared to their representation in the population. Modesto ash are among the largest diameter trees in Palo Alto's right-of-way tree inventory, with a significant percentage of individuals (56%, in relation to their specific population) in the mature size classes (>24 inches DBH). Chinese elm (*Ulmus parvifolia*, population 2.8%; IV= 4.01), London planetree (population 9.7%; IV=13.59) and liquidambar (population 9.2%; IV=11.84) are also performing at a higher functional capacity comparatively.

Table 2. Importance Value (IV) of Palo Alto's Most Abundant Right-of-Way Tree Species

Species	Number of Trees	% of Total Trees	Leaf Area (ft2)	% of Total Leaf Area	Canopy Cover (ft2)	% of Total Canopy Cover	Importance Value
Magnolia grandiflora	4,061	13.93	12,310,318.80	16.19	3,980,964.21	15.93	**15.35**
Platanus acerifolia	2,832	9.71	10,545,347.63	13.87	4,294,652.31	17.18	**13.59**
Liquidambar styraciflua	2,669	9.16	12,026,507.82	15.82	2,633,617.26	10.54	**11.84**
Fraxinus velutina 'Modesto'	1,481	5.08	7,346,706.58	9.66	2,393,494.99	9.58	**8.11**
Cinnamomum camphora	1,133	3.89	3,119,679.03	4.10	1,261,910.26	5.05	**4.35**
Pistacia chinensis	1,027	3.52	1,206,771.45	1.59	477,274.75	1.91	**2.34**
Ulmus parvifolia	820	2.81	2,569,016.98	3.38	1,458,770.22	5.84	**4.01**
Quercus rubra	778	2.67	958,170.55	1.26	217,318.39	0.87	**1.60**
Ginkgo biloba	633	2.17	763,459.99	1.00	203,806.42	0.82	**1.33**
Quercus agrifolia	534	1.83	1,554,443.94	2.04	486,670.13	1.95	**1.94**
Platanus acerifolia 'Yarwood'	517	1.77	626,241.33	0.82	218,560.82	0.87	**1.16**
Quercus ilex	515	1.77	1,439,564.64	1.89	416,051.56	1.66	**1.77**
Acer rubrum	418	1.43	475,593.69	0.63	137,983.48	0.55	**0.87**
Tilia cordata	416	1.43	833,107.50	1.10	258,282.70	1.03	**1.19**
Betula pendula	374	1.28	608,614.84	0.80	184,972.56	0.74	**0.94**
Fraxinus oxycarpa	373	1.28	863,455.91	1.14	271,415.46	1.09	**1.17**
Ligustrum lucidum	361	1.24	423,372.68	0.56	213,067.24	0.85	**0.88**
Liriodendron tulipifera	346	1.19	1,003,891.25	1.32	261,792.78	1.05	**1.18**
Fraxinus holotricha 'Moraine'	334	1.15	626,212.11	0.82	191,786.42	0.77	**0.91**
Celtis australis	318	1.09	565,333.85	0.74	309,285.91	1.24	**1.02**
Celtis sinensis	302	1.04	362,617.83	0.48	250,645.29	1.00	**0.84**
Pyrus calleryana	301	1.03	516,677.02	0.68	183,709.87	0.73	**0.82**
Other trees	8,608	29.53	15,270,759.49	20.09	4,689,526.36	18.76	**22.79**
Total	**29,151**	**100%**	**76,015,864.92**	**100%**	**24,995,559.41**	**100%**	**100**

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, Palo Alto's, red oak (*Quercus rubra*) represents 2.7% of the total population yet has an importance value of only 1.60. An analysis of species age distribution, however, shows that 43.8% of this large-statured broadleaf are young trees (0-6" DBH). The same can be said for Ginkgo (*Ginkgo biloba*, population 2.2%, IV=1.33), red maple (*Acer rubrum*, population 1.4%, IV=0.87) and Yarwood sycamore (*P. acerifolia 'Yarwood'*, population 1.8%, IV=1.16)

Stocking Level

A total of 2,353 vacant planting sites were identified during the update of Palo Alto's right-of-way tree inventory, including 262 sites requiring stump removal prior to replanting. Considering a total of 31,504 sites, including 29,151 existing trees, the right-of-way urban forest resource has a current stocking level of 92.5%.

Increasing the stocking rate to 100%, by using all available planting sites, will increase the benefits to the community provided by this vital urban forest resource. Following the species distribution plan will further maximize those benefits.

Canopy Cover

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). As canopy cover increases, so do the benefits afforded by leaf area. It is important to remember that publicly managed street and park trees throughout the United States, including Palo Alto's right-of-way trees, likely represent less than 10% of the entire urban forest (Moll and Kollin, 1993). In Palo Alto, it is estimated that public right-of-way trees provide 574 acres of tree canopy cover, shading 3.5% of the total land area (16,384 acres) and 36.8% of streets and sidewalks (1,558 acres) within the City.

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 a large fraction of trees (+/-40% of the total) should be young, with diameters at breast height (DBH) less than eight inches, while only 10% should be in the large diameter classes (>24 inches).

Nearing an ideal age distribution, Palo Alto's right-of-way tree population is a bit light in the young (newly planted) age range, with 34.8% of trees between 1" to 8" DBH, and 14.4% of the population greater than 24 inches DBH. Continuing to plant new trees on an annual basis is important to achieving and maintaining an ideal age distribution. However, with appropriate maintenance, Palo Alto's currently stable, mature population should continue to supply a steady stream of environmental benefits to the community. A long-term, sustainable management plan, including regular inspection and reasonable pruning cycles, can ensure Palo Alto's urban forest remains healthy and well-structured, thereby maximizing environmental services to the community, reducing risk, and promoting a consistent flow of benefits for many generations to come.

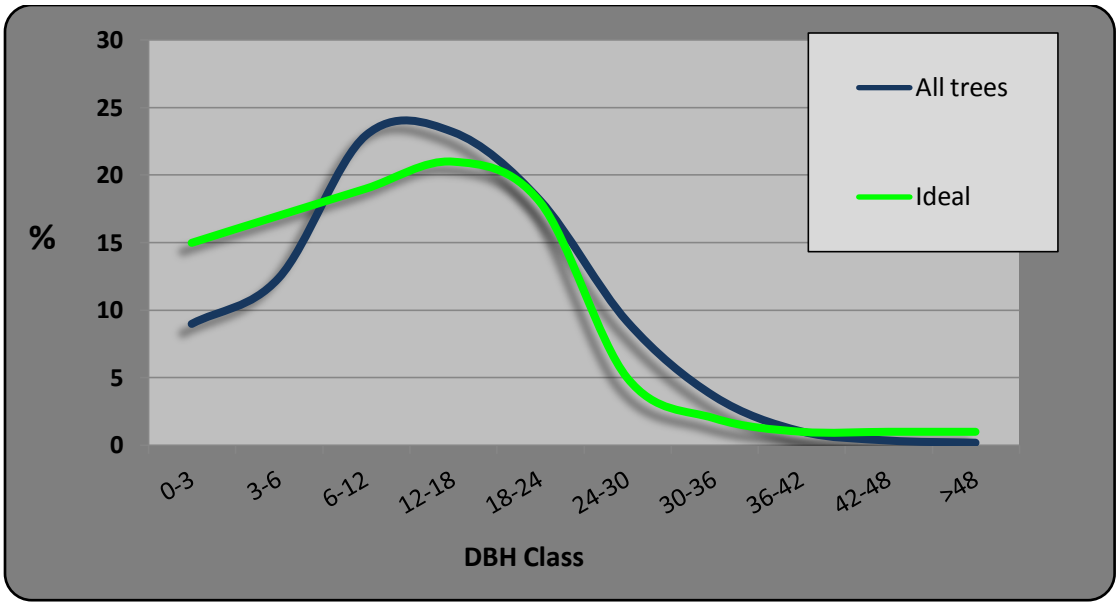


Figure 3. Overall Relative Age Distribution of Palo Alto's Right-of-Way Tree Inventory

Of Palo Alto's top ten right-of-way tree species (Figure 4), Ginkgo (*Ginkgo biloba*, 47.4%), red oak (*Quercus rubra*, 43.85%), and Chinese pistache (*Pistacia chinensis*, 36.8) have significant representation in the small size class (< 6 inches DBH), indicating that recent plantings have focused on these species.

Six of the top ten species have significant representation in the large class range (> 24" DBH), including Modesto ash (*F. velutina 'Modesto'*, 56%), camphor (*Cinnamomum camphora*, 36.6%), southern magnolia (*Magnolia grandiflora*, 19.8%), London planetree (*Platanus acerifolia*, 17.2%), Chinese elm (*Ulmus parvifolia*, 17.2%), and coast live oak (*Quercus agrifolia*, 15.7). Of these six mature populations, coast live oak is the only species that is also well represented in the small diameter class range (< 6" DBH) at 19.9%. As these mature populations begin to senesce, their maintenance needs may become more frequent and, without sufficient replacement plantings, the functional capacity and benefit stream from these populations will eventually begin to decline.

While southern magnolia has only 4.3% in the small class size, that is still an adequate amount, considering this species already accounts for 13.9% of the overall population.

Eighty-six percent (85.9%) of the liquidambar (*Liquidambar styraciflua*) population falls in the mature to semi-mature range between 6 and 24 inches DBH, with 10.6% of the population greater than 24 inches DBH. Of the top ten tree species, Modesto ash (1.6%) has the least representation in the small DBH classes ranges (0-6" DBH), followed by liquidambar (3.8%) and London planetree (4.1%). This indicates that these species are not being planted in as great numbers as they were previously.

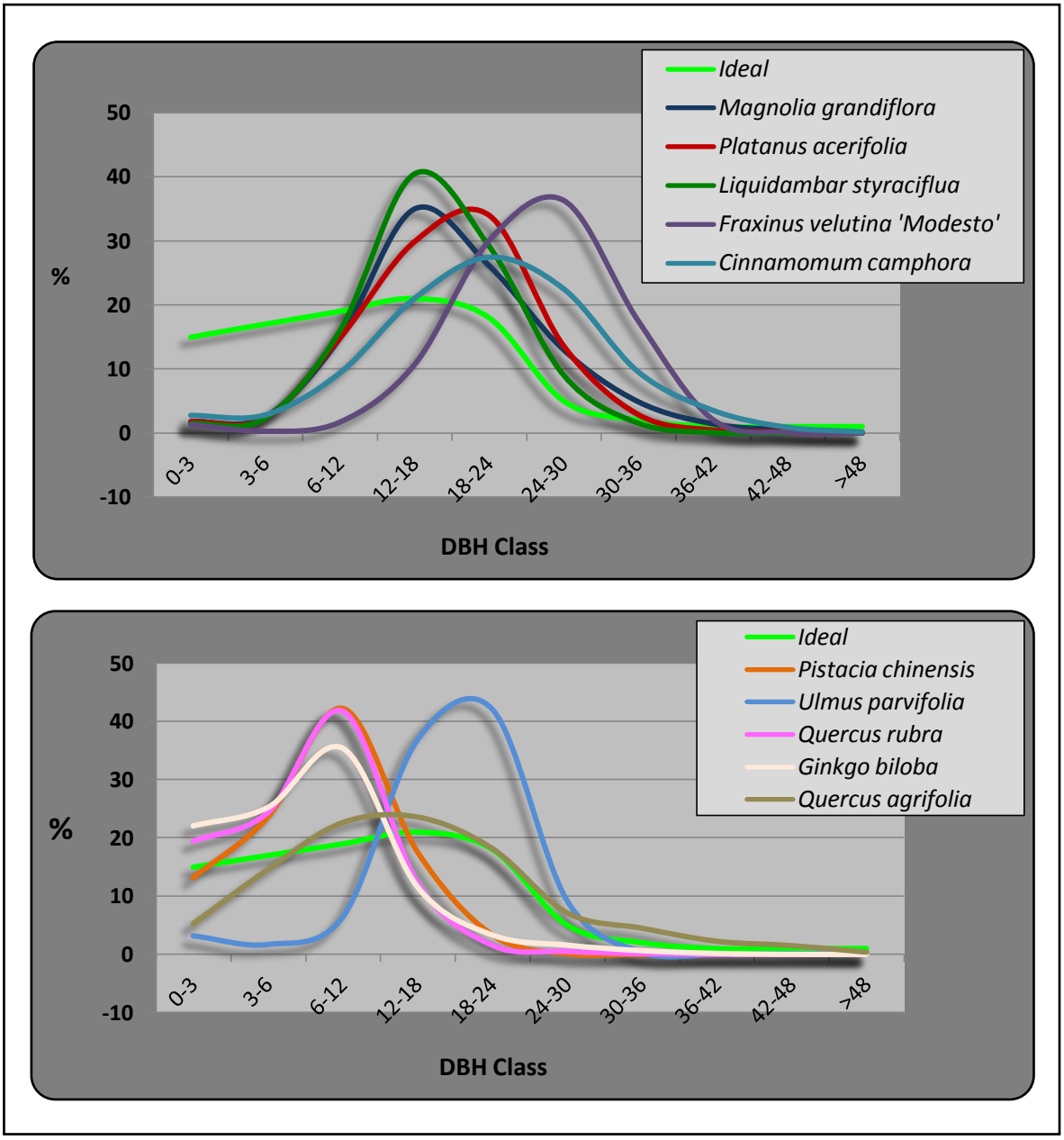


Figure 4. Relative Age Distribution of Palo Alto's Top Ten Right-of-Way Tree Species

Urban Forest Condition and Relative Performance of Species

Tree condition is an indication of how well trees are managed and how well they are performing in a given site-specific environment (e.g., street median, parking lot, etc.). Each tree inventoried was rated for wood and foliage condition. Wood condition (Figure 5) is an indication of the structure and soundness of the stem, roots, and branches. Foliage condition 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 58.5% of Palo Alto's trees classified as good or excellent (wood condition), the benefits they provide are maximized. The inventory found 35.3% of Palo Alto's trees in fair (wood) condition, which may be an indication of age, inadequate resources or maintenance, and/or a poorly sited species, as well as many other factors. While only 0.6% of the population was found to be dead, 6.1% was determined to be in poor or critical condition. Removal or mitigation of 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 ratings (wood and foliage) of each tree species with the condition ratings of every other tree species within a given urban forest population. An RPI value of 1.0 or better indicates that the species is performing as well or better than average when compared to other species. An RPI value below 1.0 indicates that the species is not performing as well in comparison to the rest of the population.

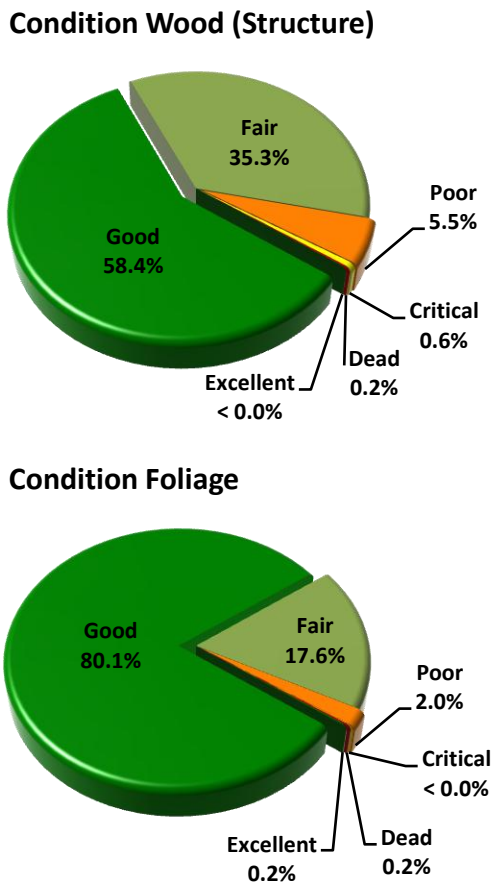


Figure 5. Condition of Palo Alto's Right-of-Way Trees

Among the 22 most common species (>1% of the total population) identified in the inventory, 15 have an RPI of 1.0 or greater (Table 3). Of these, red oak (*Quercus rubra*) has the highest RPI of 1.09, followed by Chinese pistache (*Pistacia chinensis,* RPI=1.08), and ginkgo (*Ginkgo biloba*) and red maple (*Acer rubrum*), each with an RPI of 1.07. Modesto ash (*F. velutina 'Modesto')* has the lowest rating of 0.84 which may be as attributable to the relative age classification of the population, as it is indicative of poor performance. **Raywood ash (*Fraxinus oxycarpa 'Raywood'*, RPI=1.01), ornamental pear (*Pyrus calleryana*, RPI=1.01), holly oak (*Quercus ilex*, RPI-0.98), and glossy privet (*Ligustrum lucidum*, RPI=0.95) are all populations with a close to ideal age distribution, an indicator that their RPI values are an honest measure of performance.**

Palo Alto's most important tree species, southern magnolia (*Magnolia grandiflora*) has an RPI value of 0.95, below average in the overall population. While this may be reflective of the nearly 20% of the magnolia population that is greater than 24 inches DBH, it may also be indicative of a less than optimal performance by this species in the urban environment. Consideration should be given to reducing the importance of this species in Palo Alto's urban forest.

Table 3. Relative Performance Index (RPI) for Palo Alto's Most Abundant Right-of-Way Tree Species

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Magnolia grandiflora	0.11	0.94	6.45	34.87	57.56	0.07	**0.95**	4061	13.9
Platanus acerifolia	0.00	0.23	3.00	41.03	55.72	0.02	**0.96**	2832	9.7
Liquidambar styraciflua	0.04	0.21	3.37	31.51	64.80	0.07	**0.99**	2669	9.2
Fraxinus velutina 'Modesto'	0.14	0.34	14.21	54.02	31.23	0.07	**0.84**	1481	5.1
Cinnamomum camphora	0.09	0.09	3.71	30.19	65.84	0.09	**0.99**	1133	3.9
Pistacia chinensis	0.29	0.05	0.58	9.54	89.44	0.10	**1.08**	1027	3.5
Ulmus parvifolia	0.00	0.00	1.10	17.74	81.10	0.06	**1.05**	820	2.8
Quercus rubra	0.26	0.13	0.51	6.56	92.54	0.00	**1.09**	778	2.7
Ginkgo biloba	0.47	0.00	0.55	12.16	86.33	0.47	**1.07**	633	2.2
Quercus agrifolia	0.56	0.00	1.78	19.76	77.81	0.09	**1.03**	534	1.8
Platanus acerifolia 'Yarwood'	0.00	0.00	0.39	19.73	79.69	0.19	**1.05**	517	1.8
Quercus ilex	0.00	0.68	4.37	30.10	64.85	0.00	**0.98**	515	1.8
Acer rubrum	0.24	0.00	0.84	12.44	86.36	0.12	**1.07**	418	1.4
Tilia cordata	0.00	0.12	0.72	23.44	75.72	0.00	**1.03**	416	1.4
Betula pendula	0.53	0.40	2.54	21.26	75.27	0.00	**1.02**	374	1.3
Fraxinus oxycarpa	0.00	0.00	1.74	28.95	69.17	0.13	**1.01**	373	1.3
Ligustrum lucidum	0.00	1.11	6.65	35.60	56.37	0.28	**0.95**	361	1.2
Liriodendron tulipifera	0.00	0.29	4.62	24.71	70.38	0.00	**1.00**	346	1.2
Fraxinus holotricha 'Moraine'	0.00	0.00	1.20	13.77	85.03	0.00	**1.06**	334	1.1
Celtis australis	0.00	0.16	2.20	18.40	79.25	0.00	**1.04**	318	1.1
Celtis sinensis	0.00	0.17	1.32	12.58	85.76	0.17	**1.06**	302	1.0
Pyrus calleryana	0.00	0.00	2.16	28.57	69.27	0.00	**1.01**	301	1.0
All trees	**0.17**	**0.31**	**3.74**	**26.43**	**69.25**	**0.10**	**1.00**	**29151**	**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 relative 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. It is important to keep in mind that because RPI is based on condition, it may not

reflect cosmetic or nuisance issues, especially seasonal issues that are not threatening the health or structure of the trees.

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 or deselecting 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 for future planting.

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 RPI, relative age distribution, and percentage in the population, the following species may be underused in Palo Alto's urban forest:

- Saw-leaf zelkova (*Zelkova serrata),* a large-stature deciduous tree, currently less than 0.2% of the inventory has an RPI of 1.03.
- Evergreen maple *(Acer oblongum)*, a small-stature evergreen tree, currently less than 0.1% of the inventory, has an RPI of 1.04.

Table 4. Tree species which may be underutilized, based on RPI and Relative Age Distribution

Species	# of Trees in Population	% of Population	RPI
Broadleaf Deciduous Large (BDL)			
Zelkova serrata	55	0.2	**1.03**
Broadleaf Evergreen Small (BES)			
Acer oblongum	32	0.1	**1.04**

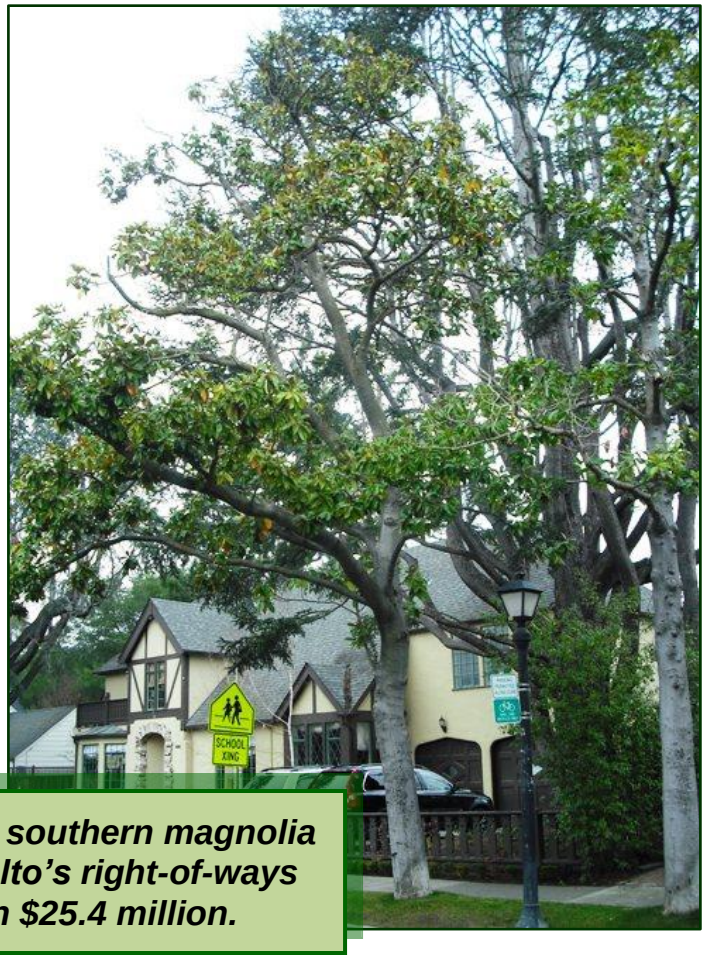
Replacement Value

The current value of Palo Alto's right-of-way tree resource is nearly $120 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, trunk formula method used in this analysis assumes the value of a tree is equal to the cost of replacing the tree in its current state (Cullen, 2002). To replace Palo Alto's current public right-of-way tree population of 29,151 trees with trees of similar size, species, and condition would cost nearly $120 million (Table 5 and Appendix C). The average replacement value per tree is $4,116.

Southern magnolia (*Magnolia grandiflora*) account for 21.2% ($25.4 million) of the total estimated replacement value, followed by London planetree (*Platanus acerifolia*, 14.5%, $17.5 million), and liquidambar (*Liquidambar styraciflua*, 11.5%, $13.8 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 IV, as evidenced by purple-leaf plum (*Prunus cerasifera*) with a replacement value of $167,996 (0.1%), despite its relative prevalence in the population (0.8%).

Palo Alto's right-of-way trees are a vital component of the City's infrastructure and a public asset valued at nearly $120 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 Palo Alto's public trees is very important. Annual benefits are discussed in Chapter Three.



Replacement of the entire southern magnolia tree population in Palo Alto's right-of-ways would cost more than $25.4 million.

Table 5. Replacement Value of Palo Alto's Most Common Right-of-Way Tree Species

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
Magnolia grandiflora	9,564	47,193	863,935	5,321,542	7,651,544	6,222,804	3,449,371	1,223,223	545,379	97,221	**25,431,776**	13.9	21.2
Platanus acerifolia	6,581	29,178	611,374	3,219,246	7,012,513	4,577,571	1,473,657	315,747	174,016	35,929	**17,455,813**	9.7	14.5
Liquidambar styraciflua	6,339	30,014	615,466	3,998,164	5,586,103	2,807,814	688,003	43,512	0	0	**13,775,415**	9.2	11.5
Fraxinus velutina 'Modesto'	2,820	1,071	12,197	161,947	821,903	1,544,796	1,085,586	169,575	6,322	0	**3,806,217**	5.1	3.2
Cinnamomum camphora	5,565	19,369	208,058	1,221,466	3,077,268	4,161,607	2,593,039	1,267,915	371,470	87,723	**13,013,480**	3.9	10.8
Pistacia chinensis	24,723	153,683	910,623	993,859	354,116	18,496	0	0	0	0	**2,455,500**	3.5	2.0
Ulmus parvifolia	4,641	8,728	105,628	1,652,793	3,688,953	1,267,522	78,003	0	43,552	0	**6,849,820**	2.8	5.7
Quercus rubra	27,217	141,937	871,200	684,480	164,272	91,399	24,974	0	0	0	**2,005,479**	2.7	1.7
Ginkgo biloba	26,846	60,737	227,355	176,434	94,207	66,247	43,437	13,124	0	0	**708,388**	2.2	0.6
Quercus agrifolia	3,598	35,692	191,693	518,371	767,641	502,698	452,307	296,659	225,540	61,291	**3,055,492**	1.8	2.5
Platanus acerifolia 'Yarwood'	9,537	88,385	377,767	84,751	6,029	0	0	19,088	0	0	**585,557**	1.8	0.5
Quercus ilex	2,794	28,590	238,557	824,434	1,124,838	636,481	185,189	30,388	0	0	**3,071,271**	1.8	2.6
Acer rubrum	8,721	44,525	222,921	62,446	4,586	0	0	0	0	0	**343,198**	1.4	0.3
Tilia cordata	2,730	42,789	480,307	760,655	330,238	273,499	35,381	45,748	0	0	**1,971,346**	1.4	1.6
Betula pendula	4,387	19,750	116,664	119,036	28,873	4,110	0	0	0	0	**292,820**	1.3	0.2
Fraxinus oxycarpa	2,212	10,494	72,752	149,746	85,324	36,029	26,328	6,273	5,005	0	**394,163**	1.3	0.3
Ligustrum lucidum	1,968	14,649	63,218	158,904	123,304	69,867	6,066	0	0	0	**437,976**	1.2	0.4
Liriodendron tulipifera	161	2,510	23,930	82,952	286,451	303,986	200,114	176,019	74,803	18,883	**1,169,808**	1.2	1.0
Fraxinus holotricha 'Moraine'	1,407	15,104	92,274	110,775	13,817	19,444	15,961	6,273	7,640	0	**282,695**	1.1	0.2
Celtis australis	3,267	11,158	142,328	374,378	156,191	76,137	72,222	29,757	18,179	0	**883,619**	1.1	0.7
Celtis sinensis	1,676	12,193	158,051	163,119	119,906	6,733	0	0	0	0	**461,677**	1.0	0.4
Pyrus calleryana	3,185	18,464	101,211	208,826	142,400	27,445	0	0	0	0	**501,531**	1.0	0.4
Sequoia sempervirens	1,032	1,268	30,678	181,052	322,722	450,220	493,785	296,745	200,002	352,731	**2,330,236**	0.8	1.9
Prunus cerasifera	6,527	25,290	99,175	29,482	4,210	3,312	0	0	0	0	**167,996**	0.8	0.1
Other trees	294,452	797,185	2,432,436	2,969,384	3,656,427	2,953,038	2,503,349	1,376,079	777,636	761,592	**18,521,582**	27.9	15.4
All trees	**461,950**	**1,659,957**	**9,269,799**	**24,228,244**	**35,623,837**	**26,121,259**	**13,426,773**	**5,316,124**	**2,449,545**	**1,415,370**	**$119,972,858**	**100%**	**100%**

Chapter 3: Urban Forest Resource Benefits

Trees are important to Palo Alto. 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 aesthetic effects. 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 Palo Alto? To answer this question, the benefits must be quantified in financial terms. This analysis provides a snapshot of the annual benefits, along with the value of those benefits, produced by Palo Alto's public right-of-way urban forest. While the annual benefits produced by the urban forest can be substantial, it's important to recognize that the greatest benefits from the urban forest are derived from the benefit stream that results over a greater period of time from a mature forest where trees are well managed, healthy, and long-lived.

This analysis utilized Palo Alto's current right-of-way tree inventory and i-Tree's *Streets* model to assess and quantify the beneficial functions of this public tree resource and to place a dollar value on the annual environmental benefits these trees provide. These estimates provide first-order approximations of tree value. While *i-Tree Streets* only generally accounts for the benefits produced by Palo Alto's right-of-way tree population, it is an accounting based on the best available and current scientific research with an accepted degree of uncertainty. The data returned from *i-Tree Streets* can provide a platform from which management decisions can be made (Maco and McPherson, 2003). A discussion on the methods used to quantify and put a monetary value on 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 heat island effect.**
- **Transpiration converts moisture to water vapor, thereby cooling the air by using solar energy that would otherwise result in heating of the air.**
- **Reduction of wind speed and the movement of outside air into interior spaces and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows [Simpson, 1998]).**

Heat island effect describes the increase in urban temperatures in relation to surrounding locations and is related to increased hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger, 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 Reduction

Electricity and natural gas saved annually in Palo Alto from both the shading and climate effects of right-of-way trees is equal to 3,729 MWh ($485,512) and 75,183 therms ($104,293), for a total retail savings of approximately $589,805 and an average of $20.23 per tree (Table 6). liquidambar (*Liquidambar styraciflua*), which represents 9.2% of the population with an importance value of 11.84, accounts for 16.2% of the total energy savings. Southern magnolia (*Magnolia grandiflora,* 16.1%) and London planetree (*Platanus acerifolia,* 12.7%) provide the next greatest contribution towards total energy savings, due in large part to their canopy size and prevalence.

Chinese pistache (*Pistacia chinensis*), which represents 3.5% of the total population, is contributing only 1.84% of the total energy savings because of the relatively young age distribution of this population (36.8% of trees <6" DBH). As this population of medium-stature trees matures, the benefits can be expected to increase substantially. The same can be said for Palo Alto's red oak (*Quercus rubra*), Ginkgo (*Ginkgo biloba*), Yarwood sycamore (*P. acerifolia 'Yarwood'*), and red maple (*Acer rubrum*) which are all relatively young populations.

Examining average energy savings on a per tree basis (Figure 6), liquidambar ($35.79), Modesto ash (*F. velutina 'Modesto'*, $34.62), and tulip tree (*Liriodendron tulipifera*, $27.63), are currently the greatest contributors, primarily due to their large stature and relatively mature age distribution as compared to the rest of the tree population. While not currently contributing a high per tree energy savings, Chinese pistache ($10.59), red maple ($11.16), Yarwood sycamore ($11.18) red oak ($11.29), and ginkgo ($11.40), these large- and medium-stature trees can be expected to make higher contributions as their populations mature.

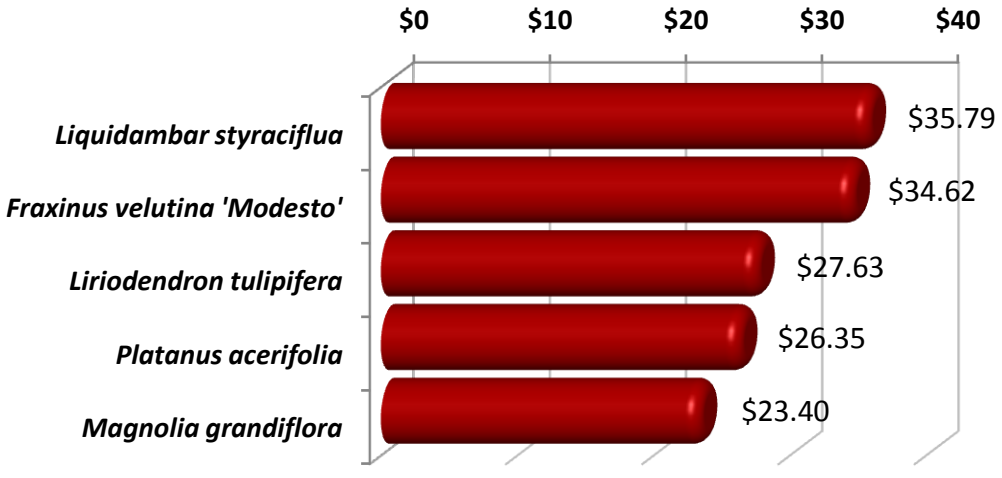


Figure 6. Annual Electricity and Natural Gas Benefits - Top 5 Species

Table 6. Annual Electric and Natural Gas Benefits from Palo Alto's Right-of-Way Tree Resource

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Magnolia grandiflora	609.80	79,396.02	11,262.12	15,622.81	95,018.83	13.93	16.11	**23.40**
Platanus acerifolia	479.45	62,424.73	8,790.16	12,193.71	74,618.45	9.71	12.65	**26.35**
Liquidambar styraciflua	590.12	76,833.48	13,474.92	18,692.41	95,525.89	9.16	16.20	**35.79**
Fraxinus velutina 'Modesto'	325.95	42,438.85	6,366.37	8,831.42	51,270.27	5.08	8.69	**34.62**
Cinnamomum camphora	149.29	19,436.92	2,644.10	3,667.90	23,104.81	3.89	3.92	**20.39**
Pistacia chinensis	67.86	8,835.01	1,472.13	2,042.14	10,877.15	3.52	1.84	**10.59**
Ulmus parvifolia	115.53	15,041.43	1,738.36	2,411.46	17,452.89	2.81	2.96	**21.28**
Quercus rubra	53.57	6,974.30	1,302.17	1,806.38	8,780.68	2.67	1.49	**11.29**
Ginkgo biloba	44.27	5,763.83	1,046.31	1,451.44	7,215.28	2.17	1.22	**11.40**
Quercus agrifolia	72.73	9,469.54	1,319.91	1,830.98	11,300.52	1.83	1.92	**21.16**
Platanus acerifolia 'Yarwood'	35.84	4,666.25	804.17	1,115.55	5,781.80	1.77	0.98	**11.18**
Quercus ilex	72.32	9,415.49	1,458.05	2,022.61	11,438.10	1.77	1.94	**22.21**
Acer rubrum	28.25	3,678.79	712.33	988.15	4,666.94	1.43	0.79	**11.16**
Tilia cordata	45.35	5,905.05	1,074.14	1,490.04	7,395.09	1.43	1.25	**17.78**
Betula pendula	34.54	4,496.70	843.13	1,169.59	5,666.29	1.28	0.96	**15.15**
Fraxinus oxycarpa	45.59	5,935.87	1,055.12	1,463.66	7,399.53	1.28	1.25	**19.84**
Ligustrum lucidum	23.75	3,091.86	377.88	524.20	3,616.06	1.24	0.61	**10.02**
Liriodendron tulipifera	59.05	7,688.87	1,348.88	1,871.17	9,560.04	1.19	1.62	**27.63**
Fraxinus holotricha 'Moraine'	34.52	4,494.26	823.75	1,142.71	5,636.96	1.15	0.96	**16.88**
Celtis australis	28.75	3,742.88	444.52	616.64	4,359.52	1.09	0.74	**13.71**
Celtis sinensis	20.52	2,671.27	292.30	405.48	3,076.75	1.04	0.52	**10.19**
Pyrus calleryana	28.83	3,753.96	636.34	882.74	4,636.70	1.03	0.79	**15.40**
Other trees	763.10	99,356.19	15,895.53	22,050.27	121,406.47	29.53	20.58	**14.10**
Total	**3,728.97**	**485,511.56**	**75,182.70**	**104,293.45**	**589,805.00**	**100.00**	**100%**	**20.23**

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, which incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard (VCS), establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides 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, campuses, and utility service areas anywhere in the U.S.

While Palo Alto's urban forest resource may, or 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.

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

- **<u>Directly</u>, through growth and the sequestration of CO_2 as wood and foliar biomass.**
- **<u>Indirectly</u>, 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 and other combustible engines 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, Palo Alto's right-of-way urban forest has sequestered a total of 40,819 tons of carbon dioxide (CO_2) valued at $612,284[1]. Annually, this public tree resource directly sequesters 2,263.8 tons of CO_2, valued at $33,957, into woody and foliar biomass. Accounting for estimated CO_2 emissions from tree decomposition (-391.9 tons), tree related maintenance activity (-1.7 tons), and avoided CO_2 (1,567.3 tons), Palo Alto's trees provide an annual net reduction in atmospheric CO_2 of 3,437.5 tons, valued at $51,563 with an average of $1.77 per tree (Table 7). Modesto ash (*F. velutina 'Modesto'*, $3.45), holly oak (*Quercus ilex*, $2.70), and coast live oak (*Quercus agrifolia*, $2.69) are currently providing the highest per tree benefit (Figure 7). Southern magnolia (*Magnolia grandiflora*) are providing the greatest percentage of overall benefits at 15.8% due to their prevalence in the population.

[1] Based on i-Tree Streets default value of $15 per ton. Market value may vary.

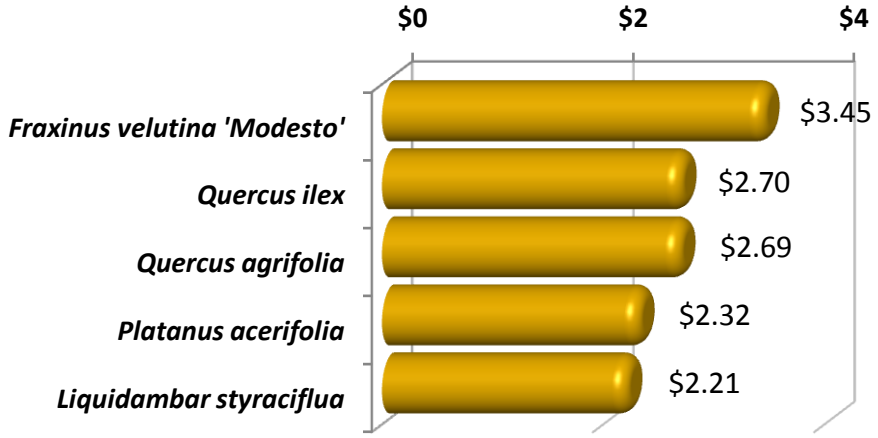
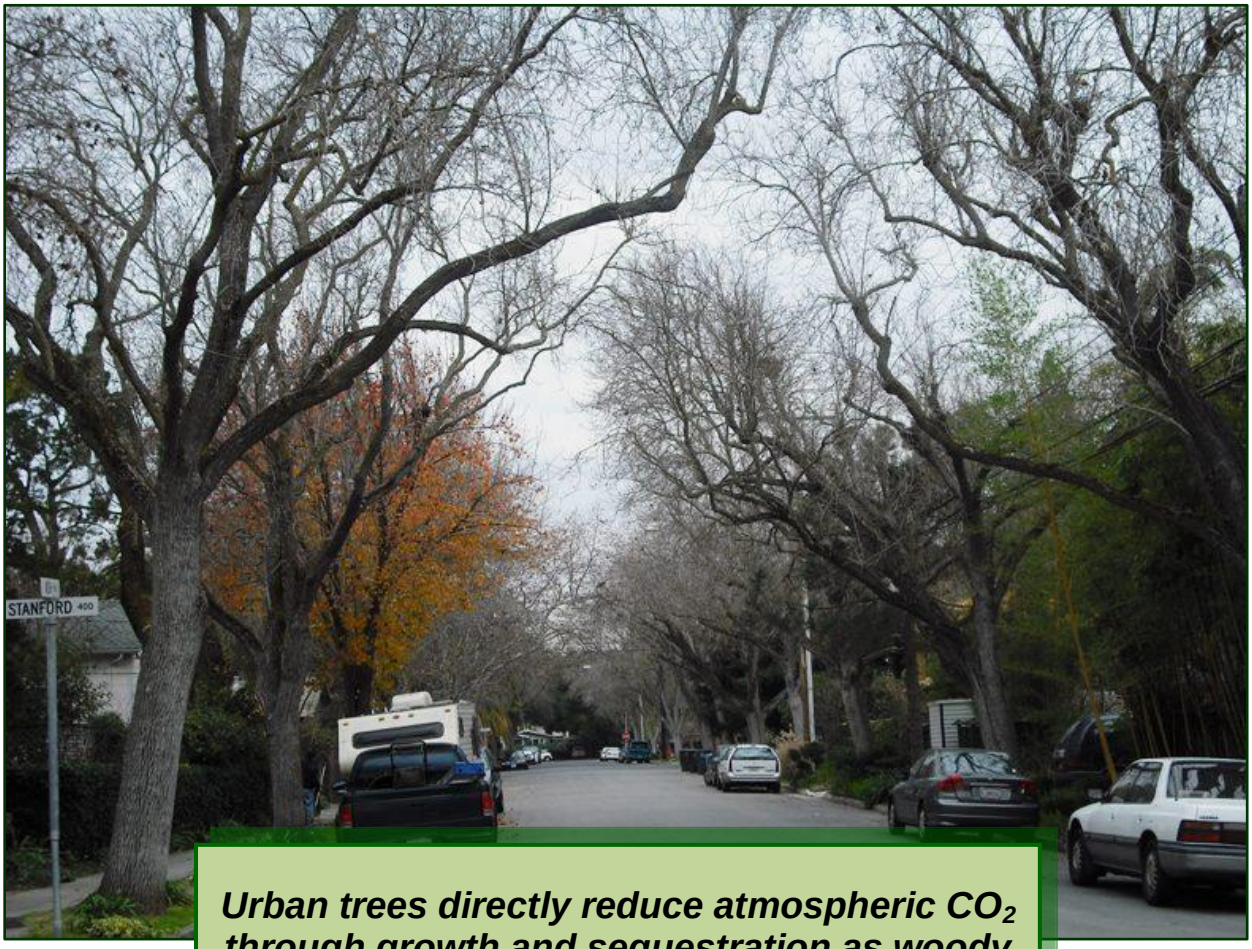


Figure 7. Annual Reduction of CO_2 - Top 5 species



Urban trees directly reduce atmospheric CO_2 through growth and sequestration as woody and foliar biomass.

Table 7. Annual CO_2 Reduction Benefits Provided by Palo Alto's Right-of-Way Tree Resource

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Magnolia grandiflora	693,489.49	5,201.17	- 121,757.71	- 477.55	- 916.76	512,589.66	3,844.42	1,083,843.88	8,128.83	13.93	15.76	**2.00**
Platanus acerifolia	581,881.31	4,364.11	- 109,251.42	- 333.03	- 821.88	403,021.14	3,022.66	875,317.99	6,564.88	9.71	12.73	**2.32**
Liquidambar styraciflua	360,705.52	2,705.29	- 70,528.27	- 313.86	- 531.32	496,045.64	3,720.34	785,909.02	5,894.32	9.16	11.43	**2.21**
Fraxinus velutina 'Modesto'	497,080.89	3,728.11	- 89,841.28	- 174.16	- 675.12	273,990.00	2,054.93	681,055.46	5,107.92	5.08	9.91	**3.45**
Cinnamomum camphora	253,768.87	1,903.27	- 64,042.69	- 133.23	- 481.32	125,486.94	941.15	315,079.88	2,363.10	3.89	4.58	**2.09**
Pistacia chinensis	13,760.25	103.20	- 2,237.02	- 120.77	- 17.68	57,039.84	427.80	68,442.31	513.32	3.52	1.00	**0.50**
Ulmus parvifolia	88,957.38	667.18	- 28,959.43	- 96.43	- 217.92	97,109.19	728.32	157,010.71	1,177.58	2.81	2.28	**1.44**
Quercus rubra	100,432.54	753.24	- 8,165.47	- 91.49	- 61.93	45,026.90	337.70	137,202.48	1,029.02	2.67	2.00	**1.32**
Ginkgo biloba	17,596.91	131.98	- 2,872.22	- 74.44	- 22.10	37,211.96	279.09	51,862.21	388.97	2.17	0.75	**0.61**
Quercus agrifolia	157,416.01	1,180.62	- 27,227.16	- 62.80	- 204.67	61,136.41	458.52	191,262.47	1,434.47	1.83	2.78	**2.69**
Platanus acerifolia 'Yarwood'	32,097.00	240.73	- 2,011.35	- 60.80	- 15.54	30,125.87	225.94	60,150.72	451.13	1.77	0.87	**0.87**
Quercus ilex	145,161.95	1,088.71	- 20,483.07	- 60.56	- 154.08	60,787.47	455.91	185,405.79	1,390.54	1.77	2.70	**2.70**
Acer rubrum	20,271.90	152.04	- 1,791.25	- 49.15	- 13.80	23,750.68	178.13	42,182.17	316.37	1.43	0.61	**0.76**
Tilia cordata	41,525.17	311.44	- 5,319.25	- 48.92	- 40.26	38,123.69	285.93	74,280.69	557.11	1.43	1.08	**1.34**
Betula pendula	28,085.31	210.64	- 3,116.30	- 43.98	- 23.70	29,031.20	217.73	53,956.23	404.67	1.28	0.78	**1.08**
Fraxinus oxycarpa	45,378.51	340.34	- 6,302.63	- 43.86	- 47.60	38,322.66	287.42	77,354.68	580.16	1.28	1.13	**1.56**
Ligustrum lucidum	34,800.42	261.00	- 6,479.56	- 42.45	- 48.92	19,961.38	149.71	48,239.79	361.80	1.24	0.70	**1.00**
Liriodendron tulipifera	12,066.53	90.50	- 6,521.16	- 40.69	- 49.21	49,640.20	372.30	55,144.88	413.59	1.19	0.80	**1.20**
Fraxinus holotricha 'Moraine'	30,770.15	230.78	- 3,851.43	- 39.28	- 29.18	29,015.42	217.62	55,894.87	419.21	1.15	0.81	**1.26**
Celtis australis	55,070.32	413.03	- 6,677.40	- 37.40	- 50.36	24,164.44	181.23	72,519.96	543.90	1.09	1.05	**1.71**
Celtis sinensis	37,206.86	279.05	- 3,468.99	- 35.51	- 26.28	17,246.00	129.34	50,948.36	382.11	1.04	0.74	**1.27**
Pyrus calleryana	15,976.32	119.82	- 2,037.44	- 35.40	- 15.55	24,236.02	181.77	38,139.50	286.05	1.03	0.55	**0.95**
Other trees	1,264,151.23	9,481.13	- 190,780.49	- 1,012.25	- 1,438.45	641,454.83	4,810.91	1,713,813.31	12,853.60	29.53	24.93	**1.49**
Total	**4,527,650.83**	**33,957.38**	**- 783,723.00**	**- 3,428.00**	**- 5,903.63**	**3,134,517.54**	**23,508.88**	**6,875,017.37**	**51,562.63**	**100%**	**100%**	$1.77

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**
- **Transpiration of water and shade provision, resulting in lower local air temperatures, thereby reducing ozone (0_3) levels**

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.

Deposition and Interception

Each year, approximately 6.7 tons of nitrogen dioxide (NO_2), small particulate matter (PM_{10}), sulfur dioxide (SO_2), and ozone (O_3) are intercepted or absorbed by right-of-way and municipal facility trees in Palo Alto, for a value of $139,391 (Table 9).

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, approximately 2 tons of pollutants, valued at $33,132, are avoided annually through the shading effects of Palo Alto's right-of-way trees.

BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered. Approximately 15.2 tons of BVOCs are annually emitted from Palo Alto's right-of-way trees, offsetting the total air quality benefit by -$219,411. Liquidambar (*Liquidambar styraciflua*) are the heaviest per tree emitters of BVOCs (4.1 lbs), accounting for 35.9% (5.5 tons) of the total BVOC emissions, while representing only 9.2% of the total population. Coast live oak (*Quercus agrifolia*, 3.5 lbs), holly oak (*Q. ilex*, 3.3 lbs), red oak (*Q. rubra*, 1.5 lbs), and southern magnolia (*Magnolia grandiflora*, 1.3 lbs) are also high per tree emitters of BVOCs that result in net negative air quality benefits from each of their respective populations. However, London planetree (Platanus acerifolia) which is also a high per tree emitter of BVOCs (1.0 lbs) intercepts, deposits, and avoids air pollutants (NO_2, PM_{10}, SO_2, and VOCs) valued in excess of its BVOC emissions for a net positive air quality benefit of $2.39 per tree.

Net Air Quality Loss

Trees vary dramatically in their ability to produce net air quality benefits. While all tree species emit some BVOCs, most species contribute benefits to overall air quality that far outweigh these emissions. Most species in Palo Alto's right-of-way tree inventory produce positive air quality benefits. However, four out of the top ten most prevalent tree species in Palo Alto's public tree inventory are high BVOC emitters that result in net negative air quality for the overall tree resource (Table 8). Liquidambar, a species that is no longer planted by the City, results in the greatest overall net loss of 4.5 tons of BVOCs, followed by southern magnolia (1.0 tons BVOCs), coast live oak (0.8 ton s BVOCs) and red oak (0.5 tons BVOCs) for a net of 6.7 tons BVOC emissions and a cost of $82,542 and an average loss of $10.26 per tree. All other trees combined demonstrate a net benefit of 366 pounds of air pollutants removed for a combined benefit of $35,654, and an average per tree benefit of $1.69.

Considering all trees in this population, Palo Alto is experiencing a net air quality loss of $46,888, an average loss of $1.61 per tree.

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, Chinese elm (*Ulmus parvifolia*, $11.73), Modesto ash (*F. velutina 'Modesto'*, $10.16), and camphor (*Cinnamomum camphora*, $9.20) currently produce the greatest per tree net air quality improvements (Figure 8). Due in part to their prevalence in the inventory and the relative maturity of this population (56% are >24" DBH), Modesto ash account for the greatest air quality improvements in terms of total benefits by species, collectively removing a net of 1,504 lbs of pollutants at a net value of $15,045 annually.

Table 8. High BVOC Emitters in Palo Alto's Top Ten Right-of-Way Tree Species

Species	Total Deposition (lb)	Total Avoided (lb)	BVOC Emissions (lb)	Total (lb)	Total ($)	% of Total Tree Numbers	Avg. $/tree
Magnolia grandiflora	2,423.74	627.14	- 5,124.71	- 2,073.82	- 6,322.11	13.93	- 1.56
Liquidambar styraciflua	1,365.15	625.44	- 10,902.59	- 8,912.00	- 59,093.52	9.16	- 22.14
Quercus rubra	44.79	58.72	- 1,143.36	- 1,039.85	- 7,281.84	2.67	- 9.36
Quercus agrifolia	278.36	74.90	- 1,854.88	- 1,501.62	- 9,844.07	1.83	- 18.43
Total these trees	4,112.05	1,386.20	- 19,025.55	- 13,527.30	- 82,541.54	27.59	- 10.26
All other trees	**9,203.08**	**2,527.03**	**- 11,363.83**	**366.28**	**35,653.65**	**72.41**	**1.69**
Total All Trees	**13,315.12**	**3,913.23**	**- 30,389.37**	**- 13,161.02**	**- 46,887.89**	**100%**	**- 1.61**

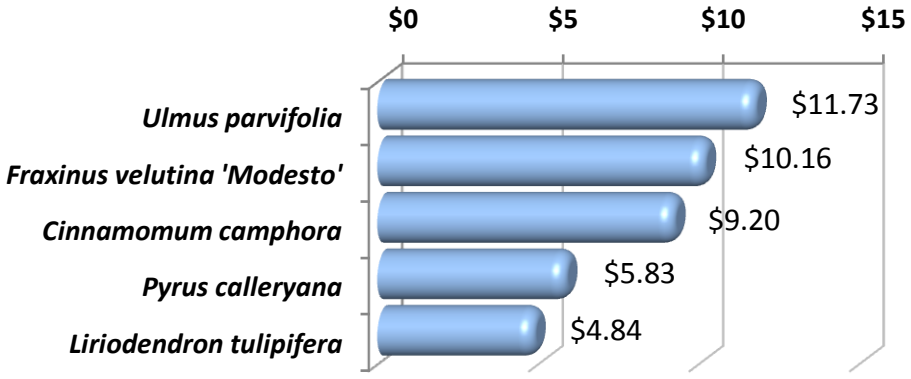


Figure 8. Annual Improvement to Air Quality - Top 5 Species

Table 9. Annual Air Quality Improvements Provided by Palo Alto's Right-of-Way Tree Resource

Species	Deposition O_3 (lb)	Deposition NO_2 (lb)	Deposition PM_{10} (lb)	Deposition SO_2 (lb)	Total Deposition ($)	Avoided NO_2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	Avoided SO_2 (lb)	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	% of Total Tree Numbers	Avg. $/tree
Magnolia grandiflora	1,127.51	496.54	702.91	96.78	25,386.72	325.73	83.20	42.67	175.54	5,291.54	- 5,124.71	- 37,000.37	- 2,073.82	- 6,322.11	13.93	- 1.56
Platanus acerifolia	1,013.22	410.10	607.37	81.54	22,134.76	259.24	65.48	33.65	137.55	4,192.60	- 2,707.56	- 19,548.62	- 99.41	6,778.74	9.71	2.39
Liquidambar styraciflua	658.15	263.36	390.92	52.73	14,303.29	333.54	81.35	42.05	168.50	5,319.92	- 10,902.59	- 78,716.73	- 8,912.00	- 59,093.52	9.16	- 22.14
Fraxinus velutina 'Modesto'	616.77	216.62	291.85	41.12	12,184.22	177.88	44.30	22.82	92.53	2,860.53	0.00	0.00	1,503.89	15,044.75	5.08	10.16
Cinnamomum camphora	408.70	179.96	248.70	35.09	9,130.01	79.90	20.44	10.48	43.16	1,298.92	0.00	0.00	1,026.42	10,428.93	3.89	9.20
Pistacia chinensis	216.94	80.40	100.75	15.47	4,310.27	38.77	9.75	5.01	20.44	625.95	- 384.23	- 2,774.14	103.32	2,162.08	3.52	2.11
Ulmus parvifolia	427.77	171.22	247.14	34.31	9,215.46	60.60	15.80	8.07	33.58	992.61	- 81.13	- 585.75	917.38	9,622.32	2.81	11.73
Quercus rubra	18.95	8.33	15.89	1.61	474.58	31.15	7.67	3.96	15.95	498.66	- 1,143.36	- 8,255.08	- 1,039.85	- 7,281.84	2.67	- 9.36
Ginkgo biloba	69.42	25.74	33.17	4.95	1,390.34	25.50	6.28	3.24	13.05	408.21	- 87.82	- 634.04	93.53	1,164.51	2.17	1.84
Quercus agrifolia	129.12	56.85	81.31	11.08	2,916.68	38.80	9.96	5.10	21.04	631.50	- 1,854.88	- 13,392.25	- 1,501.62	- 9,844.07	1.83	- 18.43
Platanus acerifolia 'Yarwood'	18.75	7.60	14.54	1.51	448.61	20.75	5.16	2.66	10.79	333.64	- 160.79	- 1,160.91	- 79.03	- 378.65	1.77	- 0.73
Quercus ilex	76.89	33.86	52.40	6.60	1,783.82	39.62	10.00	5.14	20.99	640.46	- 1,717.80	- 12,402.52	- 1,472.31	- 9,978.24	1.77	- 19.38
Acer rubrum	9.75	3.42	6.37	0.65	213.29	16.79	4.06	2.10	8.38	266.93	0.00	0.00	51.53	480.23	1.43	1.15
Tilia cordata	33.78	11.87	18.40	2.26	695.83	26.25	6.39	3.30	13.22	418.31	0.00	0.00	115.46	1,114.13	1.43	2.68
Betula pendula	18.87	6.63	11.01	1.26	397.29	20.21	4.90	2.54	10.13	321.66	0.00	0.00	75.54	718.95	1.28	1.92
Fraxinus oxycarpa	40.90	14.37	21.56	2.73	833.98	26.19	6.39	3.30	13.23	417.73	0.00	0.00	128.67	1,251.70	1.28	3.36
Ligustrum lucidum	41.97	18.48	28.19	3.60	968.77	12.55	3.31	1.69	7.07	206.56	0.00	0.00	116.86	1,175.34	1.24	3.26
Liriodendron tulipifera	115.92	41.65	51.77	7.84	2,263.59	33.67	8.24	4.25	17.08	537.61	- 155.86	- 1,125.31	124.54	1,675.89	1.19	4.84
Fraxinus holotricha 'Moraine'	24.05	8.45	13.23	1.61	496.92	20.04	4.87	2.52	10.08	319.22	0.00	0.00	84.84	816.13	1.15	2.44
Celtis australis	59.21	22.59	34.53	4.65	1,267.56	15.57	4.06	2.07	8.63	254.94	0.00	0.00	151.31	1,522.51	1.09	4.79
Celtis sinensis	38.52	14.70	23.61	3.02	838.20	11.14	2.95	1.51	6.32	183.74	0.00	0.00	101.78	1,021.94	1.04	3.38
Pyrus calleryana	74.97	27.79	35.15	5.34	1,493.58	16.33	4.05	2.09	8.45	262.25	0.00	0.00	174.18	1,755.83	1.03	5.83
Other trees	1,217.49	495.09	697.93	97.44	26,243.24	425.47	106.22	54.68	222.09	6,848.86	- 6,068.64	- 43,815.55	- 2,752.21	- 10,723.45	29.53	- 1.25
Total	**6,457.62**	**2,615.61**	**3,728.69**	**513.20**	**139,391.00**	**2,055.70**	**514.82**	**264.91**	**1,077.81**	**33,132.37**	**- 30,389.37**	**- 219,411.26**	**- 13,161.02**	**- 46,887.89**	**100%**	**- 1.61**

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 near 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 reduce overland flow.**
- **Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on barren surfaces.**

Palo Alto's right-of-way trees intercept more than 42.6 million gallons of stormwater annually for an average of 1,462 gallons per tree (Table 11). The total value of this benefit to the City is $170,504, an average of $5.85 per tree. Camphor (*Cinnamomum camphora*) provide the greatest per tree benefit of $8.89 (Figure 9). Southern magnolia (Magnolia grandiflora) provides the second greatest per tree benefit of $8.84 as well as the greatest percentage of overall stormwater benefits (21.1%). Many of the species currently demonstrating very low benefits, including ginkgo (*Ginkgo biloba*, $0.31/tree), red maple (*Acer rubrum*, $0.31/tree), Chinese pistache (*Pistacia chinensis*, $0.38/tree), and Yarwood sycamore (*P. acerifolia 'Yarwood'*, $0.43/tree) are immature populations of medium and 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 significantly as these species mature.

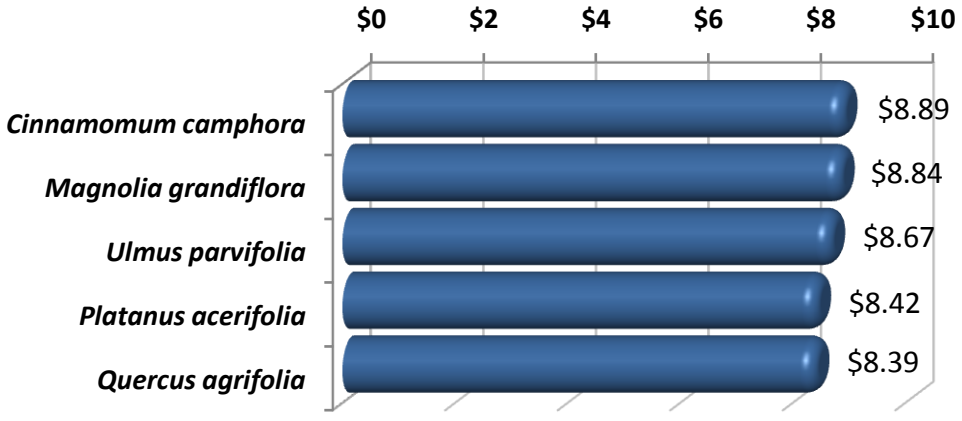


Figure 9. Annual Reduction in Stormwater Runoff - Top 5 Species

Table 10 Annual Stormwater Runoff Reduction Benefits Provided by Palo Alto's Right-of-Way Tree Resource

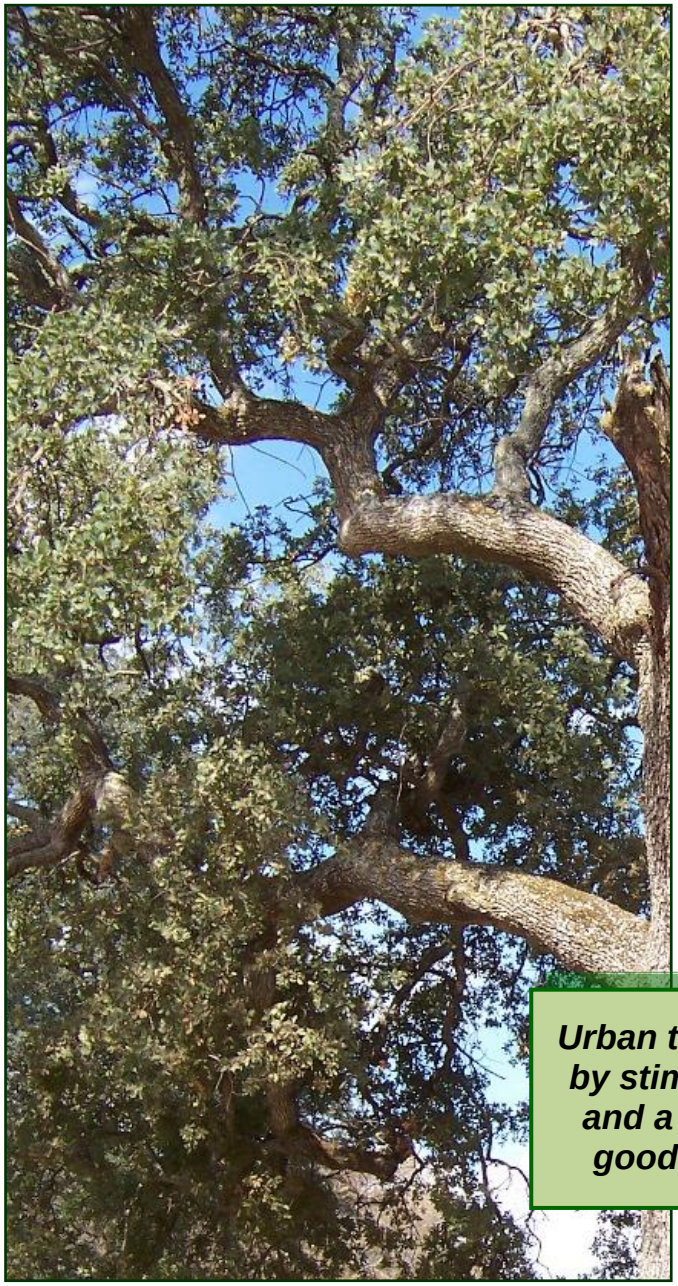
Species	Total Rainfall Interception (Gal)	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Magnolia grandiflora	8,975,852.70	35,905.91	13.93	21.06	**8.84**
Platanus acerifolia	5,958,266.49	23,834.72	9.71	13.98	**8.42**
Liquidambar styraciflua	4,896,874.46	19,588.86	9.16	11.49	**7.34**
Fraxinus velutina 'Modesto'	3,070,703.84	12,283.67	5.08	7.20	**8.29**
Cinnamomum camphora	2,518,356.36	10,074.13	3.89	5.91	**8.89**
Pistacia chinensis	575,904.97	2,303.78	3.52	1.35	**2.24**
Ulmus parvifolia	1,777,649.63	7,111.09	2.81	4.17	**8.67**
Quercus rubra	608,642.16	2,434.74	2.67	1.43	**3.13**
Ginkgo biloba	286,011.64	1,144.13	2.17	0.67	**1.81**
Quercus agrifolia	1,120,446.18	4,482.10	1.83	2.63	**8.39**
Platanus acerifolia 'Yarwood'	323,011.80	1,292.14	1.77	0.76	**2.50**
Quercus ilex	1,004,976.06	4,020.18	1.77	2.36	**7.81**
Acer rubrum	185,459.66	741.89	1.43	0.44	**1.77**
Tilia cordata	337,813.33	1,351.35	1.43	0.79	**3.25**
Betula pendula	243,869.40	975.55	1.28	0.57	**2.61**
Fraxinus oxycarpa	353,043.60	1,412.27	1.28	0.83	**3.79**
Ligustrum lucidum	376,082.44	1,504.43	1.24	0.88	**4.17**
Liriodendron tulipifera	363,171.23	1,452.79	1.19	0.85	**4.20**
Fraxinus holotricha 'Moraine'	252,072.23	1,008.36	1.15	0.59	**3.02**
Celtis australis	353,001.40	1,412.10	1.09	0.83	**4.44**
Celtis sinensis	265,572.76	1,062.36	1.04	0.62	**3.52**
Pyrus calleryana	229,741.42	919.03	1.03	0.54	**3.05**
Other trees	8,546,401.82	34,187.98	29.53	20.05	**3.97**
Total	**42,622,925.58**	**170,503.55**	**100%**	**100%**	**5.85**

Aesthetic, Property Value and Socioeconomic Benefits

Trees provide beauty in the urban landscape, privacy to homeowners, improved human health, a sense of comfort and place, and habitat for urban wildlife. 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, *i-Tree Streets* uses research that compares differences in sales prices of homes to estimate the contribution associated with trees. Differences in housing prices in relation to the presence (or lack) of a street tree help define the aesthetic value of street trees in the urban environment. 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, **aesthetic benefits reflect the increase in leaf area for each species population over the course of a single year.** As a result, a very young population of 100 Yarwood sycamore (*P. acerifolia 'Yarwood')* will have a greater annual aesthetic benefit than an equal number of mature southern magnolia (*Magnolia grandiflora*). However, the cumulative lifetime aesthetic value of the magnolia would be much greater than that of the sycamore.



The total annual benefit associated with property value increases and other less tangible benefits is nearly $5.9 million, an average of $201.49 per tree (Table 11). Tree species that produced the highest average per tree aesthetic benefits include Liquidambar (*Liquidambar styraciflua*, $306.48), Modesto ash (*F. velutina 'Modesto'*, $287.37), and Yarwood sycamore (*P. acerifolia 'Yarwood'*, $257.10).

It is important to recognize that aesthetic value alone is not an indication of the appropriateness of any one tree species. For example, while Liquidambar is currently providing the greatest overall aesthetic benefits ($817,989), this species, which is no longer planted by the City, is the highest emitter of BVOCs, reducing air quality benefits from the urban forest by $59,094 annually.

Urban trees promote retail shopping by stimulating more frequent visits and a willingness to pay more for goods and services (Wolf 1999).

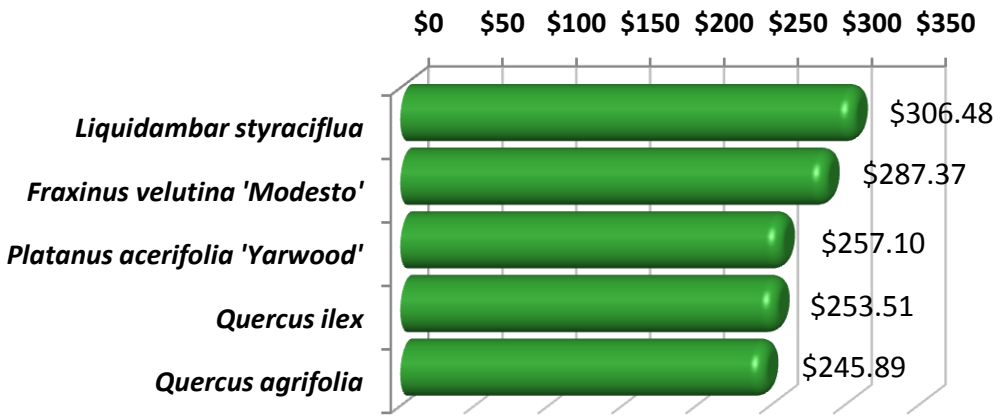


Figure 10. Annual Increase in Property and Socioeconomic Values - Top 5 Species

Table 11. Annual Property Value, Aesthetic, and Socioeconomic Benefits of Palo Alto's Right-of-Way Tree Resource

Species	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Magnolia grandiflora	815,617.33	13.93	13.89	**200.84**
Platanus acerifolia	585,257.80	9.71	9.96	**206.66**
Liquidambar styraciflua	817,989.08	9.16	13.93	**306.48**
Fraxinus velutina 'Modesto'	425,592.96	5.08	7.25	**287.37**
Cinnamomum camphora	180,937.82	3.89	3.08	**159.70**
Pistacia chinensis	106,242.08	3.52	1.81	**103.45**
Ulmus parvifolia	75,973.69	2.81	1.29	**92.65**
Quercus rubra	176,651.03	2.67	3.01	**227.06**
Ginkgo biloba	66,290.42	2.17	1.13	**104.72**
Quercus agrifolia	131,303.95	1.83	2.24	**245.89**
Platanus acerifolia 'Yarwood'	132,920.94	1.77	2.26	**257.10**
Quercus ilex	130,558.26	1.77	2.22	**253.51**
Acer rubrum	71,808.26	1.43	1.22	**171.79**
Tilia cordata	80,527.82	1.43	1.37	**193.58**
Betula pendula	68,558.33	1.28	1.17	**183.31**
Fraxinus oxycarpa	75,561.63	1.28	1.29	**202.58**
Ligustrum lucidum	33,851.61	1.24	0.58	**93.77**
Liriodendron tulipifera	23,192.05	1.19	0.39	**67.03**
Fraxinus holotricha 'Moraine'	63,451.31	1.15	1.08	**189.97**
Celtis australis	76,700.65	1.09	1.31	**241.20**
Celtis sinensis	61,186.74	1.04	1.04	**202.61**
Pyrus calleryana	42,802.87	1.03	0.73	**142.20**
Other trees	1,630,552.81	29.53	27.76	**189.42**
Total	**5,873,529.44**	**100.00**	**100.00**	**201.49**

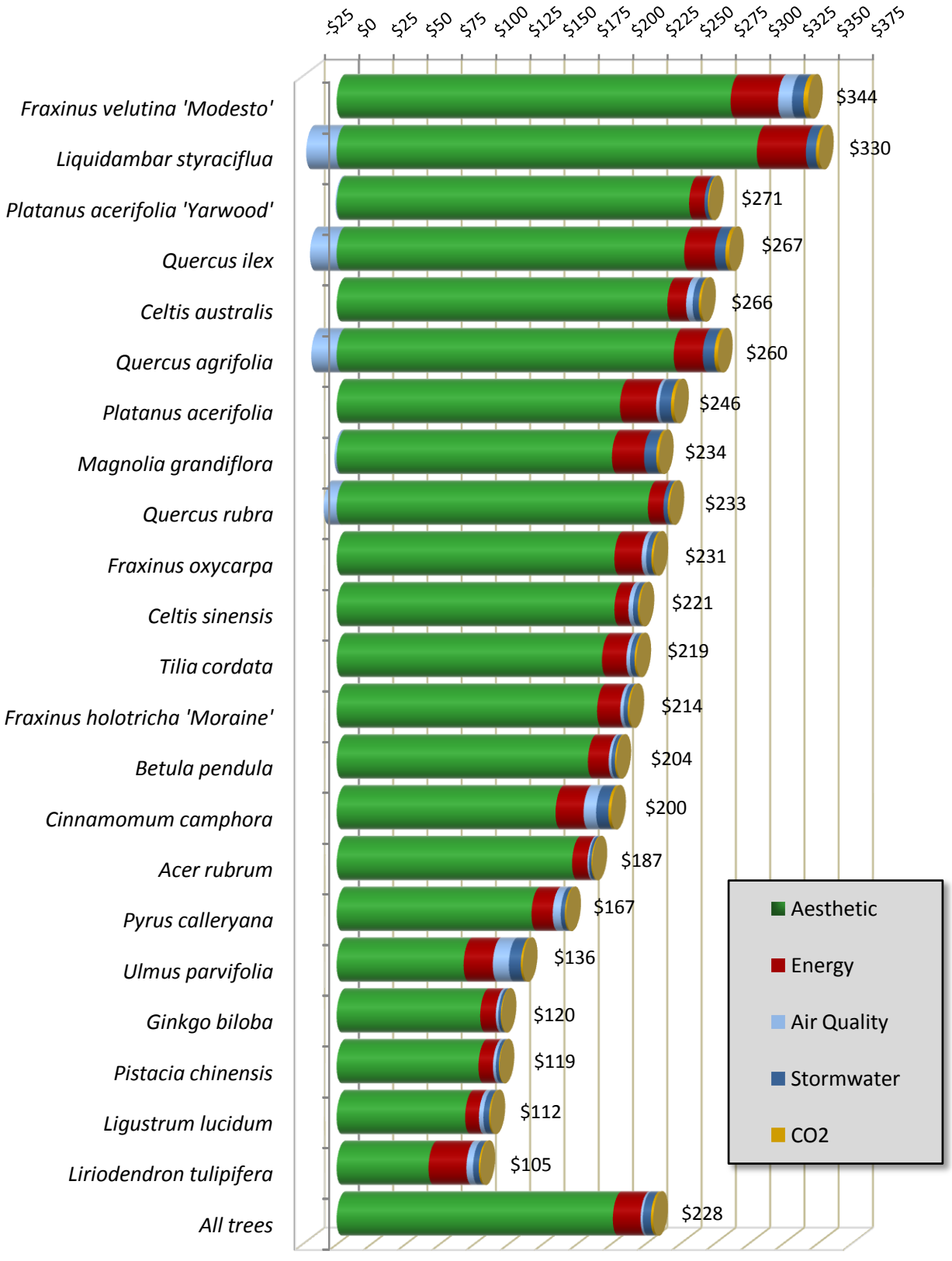


Figure 11. Summary of Annual per Tree Benefits from Palo Alto's Most Prevalent Right-of-Way Species

Table 12 Summary of Average Current Annual Per Tree Related Benefits from Palo Alto's Right-of-Way Tree Resource

Species	Energy $	CO2 $	Air Quality $	Storm water $	Aesthetic & Other $	% of Pop.	Total $
Magnolia grandiflora	23.40	2.00	- 1.56	8.84	200.84	13.93	**$233.52**
Platanus acerifolia	26.35	2.32	2.39	8.42	206.66	9.71	**246.14**
Liquidambar styraciflua	35.79	2.21	- 22.14	7.34	306.48	9.16	**329.68**
Fraxinus velutina 'Modesto'	34.62	3.45	10.16	8.29	287.37	5.08	**343.89**
Cinnamomum camphora	20.39	2.09	9.20	8.89	159.70	3.89	**200.27**
Pistacia chinensis	10.59	0.50	2.11	2.24	103.45	3.52	**118.89**
Ulmus parvifolia	21.28	1.44	11.73	8.67	92.65	2.81	**135.77**
Quercus rubra	11.29	1.32	- 9.36	3.13	227.06	2.67	**233.44**
Ginkgo biloba	11.40	0.61	1.84	1.81	104.72	2.17	**120.38**
Quercus agrifolia	21.16	2.69	- 18.43	8.39	245.89	1.83	**259.70**
Platanus acerifolia 'Yarwood'	11.18	0.87	- 0.73	2.50	257.10	1.77	**270.92**
Quercus ilex	22.21	2.70	- 19.38	7.81	253.51	1.77	**266.85**
Acer rubrum	11.16	0.76	1.15	1.77	171.79	1.43	**186.63**
Tilia cordata	17.78	1.34	2.68	3.25	193.58	1.43	**218.63**
Betula pendula	15.15	1.08	1.92	2.61	183.31	1.28	**204.07**
Fraxinus oxycarpa	19.84	1.56	3.36	3.79	202.58	1.28	**231.13**
Ligustrum lucidum	10.02	1.00	3.26	4.17	93.77	1.24	**112.22**
Liriodendron tulipifera	27.63	1.20	4.84	4.20	67.03	1.19	**104.90**
Fraxinus holotricha 'Moraine'	16.88	1.26	2.44	3.02	189.97	1.15	**213.57**
Celtis australis	13.71	1.71	4.79	4.44	241.20	1.09	**265.85**
Celtis sinensis	10.19	1.27	3.38	3.52	202.61	1.04	**220.97**
Pyrus calleryana	15.40	0.95	5.83	3.05	142.20	1.03	**167.43**
Other trees	14.10	1.49	- 1.25	3.97	189.42	29.53	**207.73**
Total	**20.23**	**$1.77**	**- 1.61**	**5.85**	**201.49**	**100%**	**$227.73**

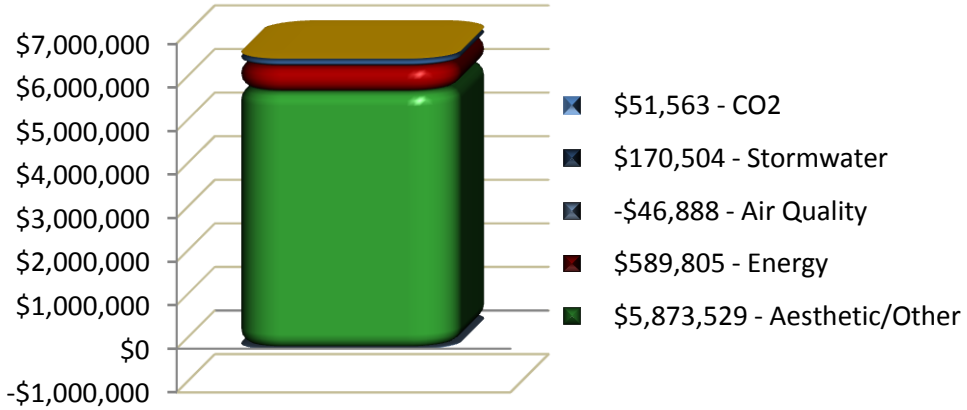
Table 13 Summary of Overall Current Annual Per Species Benefits from Palo Alto's Right-of-Way Tree Resource

Species	Total Energy ($)	Total CO_2 ($)	Total Air Quality ($)	Total Stormwater ($)	Total Aesthetic/Other ($)	Total All Benefits	% of Pop
Magnolia grandiflora	95,018.83	8,128.83	- 6,322.11	35,905.91	815,617.33	**948,348.79**	13.93
Platanus acerifolia	74,618.45	6,564.88	6,778.74	23,834.72	585,257.80	**697,054.59**	9.71
Liquidambar styraciflua	95,525.89	5,894.32	- 59,093.52	19,588.86	817,989.08	**879,904.63**	9.16
Fraxinus velutina 'Modesto'	51,270.27	5,107.92	15,044.75	12,283.67	425,592.96	**509,299.57**	5.08
Cinnamomum camphora	23,104.81	2,363.10	10,428.93	10,074.13	180,937.82	**226,908.79**	3.89
Pistacia chinensis	10,877.15	513.32	2,162.08	2,303.78	106,242.08	**122,098.41**	3.52
Ulmus parvifolia	17,452.89	1,177.58	9,622.32	7,111.09	75,973.69	**111,337.57**	2.81
Quercus rubra	8,780.68	1,029.02	- 7,281.84	2,434.74	176,651.03	**181,613.63**	2.67
Ginkgo biloba	7,215.28	388.97	1,164.51	1,144.13	66,290.42	**76,203.31**	2.17
Quercus agrifolia	11,300.52	1,434.47	- 9,844.07	4,482.10	131,303.95	**138,676.97**	1.83
Platanus acerifolia 'Yarwood'	5,781.80	451.13	- 378.65	1,292.14	132,920.94	**140,067.36**	1.77
Quercus ilex	11,438.10	1,390.54	- 9,978.24	4,020.18	130,558.26	**137,428.84**	1.77
Acer rubrum	4,666.94	316.37	480.23	741.89	71,808.26	**78,013.69**	1.43
Tilia cordata	7,395.09	557.11	1,114.13	1,351.35	80,527.82	**90,945.50**	1.43
Betula pendula	5,666.29	404.67	718.95	975.55	68,558.33	**76,323.79**	1.28
Fraxinus oxycarpa	7,399.53	580.16	1,251.70	1,412.27	75,561.63	**86,205.29**	1.28
Ligustrum lucidum	3,616.06	361.80	1,175.34	1,504.43	33,851.61	**40,509.24**	1.24
Liriodendron tulipifera	9,560.04	413.59	1,675.89	1,452.79	23,192.05	**36,294.36**	1.19
Fraxinus holotricha 'Moraine'	5,636.96	419.21	816.13	1,008.36	63,451.31	**71,331.97**	1.15
Celtis australis	4,359.52	543.90	1,522.51	1,412.10	76,700.65	**84,538.68**	1.09
Celtis sinensis	3,076.75	382.11	1,021.94	1,062.36	61,186.74	**66,729.90**	1.04
Pyrus calleryana	4,636.70	286.05	1,755.83	919.03	42,802.87	**50,400.48**	1.03
Other trees	121,406.47	12,853.60	- 10,723.45	34,187.98	1,630,552.81	**1,788,277.41**	29.53
Total	**589,805.00**	**51,562.63**	**- 46,887.89**	**170,503.55**	**5,873,529.44**	**6,638,512.73**	**100%**

Net Benefits and Benefit-Investment Ratio (BIR)

Palo Alto receives substantial benefits from its right-of-way 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 total benefits provided by the City's right-of-way trees expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. Palo Alto's municipal trees have beneficial effects on the environment. Approximately 11.5% ($764,984) of the total annual benefits quantified in this study are environmental services (Table 13). Energy savings ($589,805) account for 72.7% of the annual environmental benefits and 8.8% of all annual benefits. Stormwater benefits ($170,504) account for 21% of the annual environmental benefits and 2.6% of all benefits. Carbon sequestration, valued at $51,563 accounts for 6.4% of environmental benefits and 0.8% of all benefits. Air quality deficit, as a result of high BVOC emitting tree species, results in a benefit loss of $46,888. Annual increases in property value, socioeconomic, and other aesthetic values are substantial benefits, accounting for 87.9% of the total benefits. The estimated sum of benefits provided by Palo Alto's right-of-way tree resource is $6,638,513; that's a value of $227.73 per tree and $103.73 per capita. These benefits are realized on an annual basis. It is important to acknowledge that this is not a full accounting of the benefits provided by this public tree resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence. Empirical evidence of these benefits does exist (Wolf 2007; Kaplan 1989; Ulrich 1986), but there is limited knowledge about the physical processes at work and 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 one can ever quantify!**

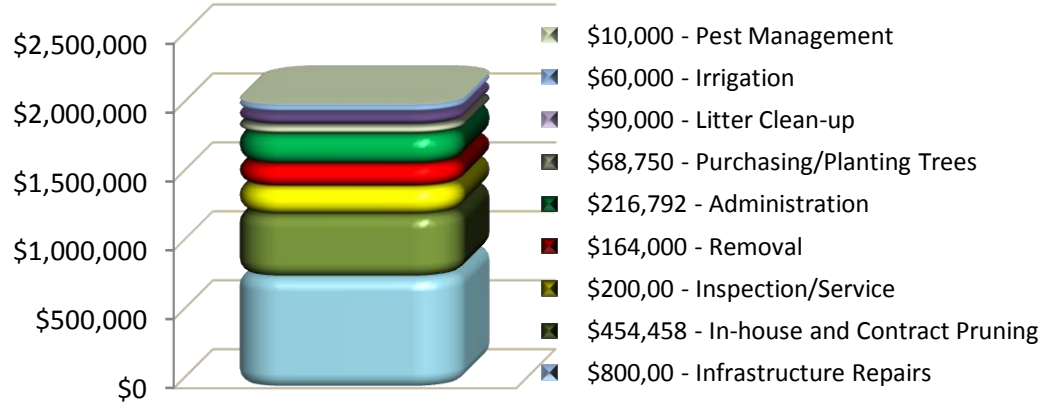
The total annual quantifiable benefit that right-of-way trees provide to the City of Palo Alto is $6,638,513. When the City's annual tree related expenditures (or investment) of $2,064,000 are considered, the net annual benefit (benefits minus investment) to the City is $4,574,513. The average net benefit for an individual right-of-way tree in Palo Alto is $156.93, and the per capita net benefit is $71.48. Based on the inventory of 29,151 public right-of-way trees, Palo Alto is receiving $3.22 in benefits for every $1 that is spent on this urban forest resource (Table 13). Considering the relative stability and maturity of the right-of-way tree population (64% are 6-12" DBH and 14% >24" DBH), Palo Alto can expect that this population will provide a steady flow of benefits for many generations to come. Increasing the stocking level (currently 92.5%), and reducing species that emit high levels of BVOCs and planting replacement trees with positive air quality benefits can maximize canopy cover and increase the value and benefits of this resource over time.



Total Annual Benefits from Palo Alto's Right-of-Way Tree Resource: $6,638,513

Average Annual per Tree Benefits: $227.73

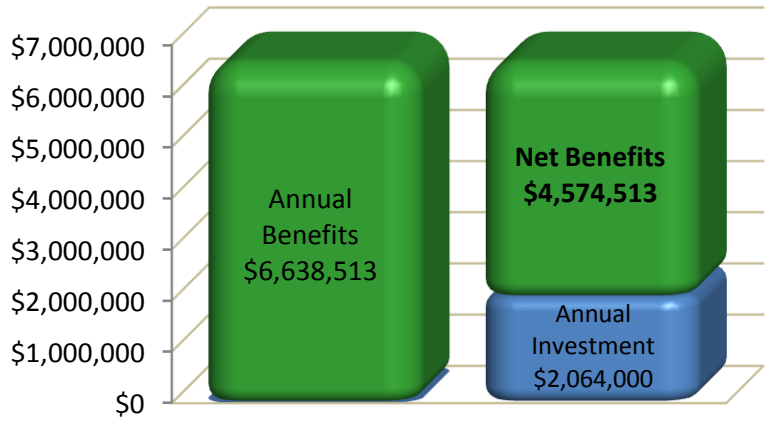
Annual Value of Benefits Per Capita: $103.73



Total Annual Investment to Maintain Palo Alto's Right-of-Way Tree Resource: $2,064,000

Average Annual per Tree Investment: $70.80

Annual Investment Per Capita: $32.25



Annual Net Benefits of Palo Alto's Right-of-Way Tree Resource: $4,574,513

For EVERY $1 Invested in right-of-way trees, Palo Alto receives $3.22 in Benefits.

Table 14. Benefit Versus Investment Summary for Palo Alto's Right-of-Way Tree Resource

Benefits	Total ($)	$/tree	$/capita
Energy	589,805	20.23	9.22
CO2	51,563	1.77	0.81
Air Quality	- 46,888	- 1.61	- 0.73
Stormwater	170,504	5.85	2.66
Aesthetic/Other	5,873,529	201.49	91.77
Total Benefits	**$6,638,513**	**$227.73**	**$103.73**
Investment			
Purchasing/Planting Trees	68,750	2.36	1.07
In-house and Contract Pruning	454,458	15.59	7.10
Pest Management	10,000	0.34	0.16
Irrigation	60,000	2.06	0.94
Removal	164,000	5.63	2.56
Administration	216,792	7.44	3.39
Inspection/Service	200,000	6.86	3.13
Infrastructure Repairs	800,000	27.44	12.50
Litter Clean-up	90,000	3.09	1.41
Total Investment	**$2,064,000**	**$70.80**	**$32.25**
Net Benefits	**$4,574,513**	**$156.93**	**$71.48**
Benefit-Investment Ratio	**3.22**		

Conclusion

This analysis describes the current structural characteristics of Palo Alto's right-of-way trees using established tree sampling, numerical modeling, and statistical methods to provide a general accounting of the benefits produced by this public tree resource. The analysis provides a "snapshot" of this resource at its current population and condition level. Rather than examining each individual tree, as an inventory does, the resource analysis examines trends and performance measures over the entire urban forest and each of the major species populations within.

When evaluating the bottom line, Palo Alto's right-of-way trees are worth the investment. This public resource gives back more in quantifiable benefits, including energy savings, stormwater runoff reduction, reduction in atmospheric CO_2, and aesthetic benefits, than the community invests in its care. The City's 29,151 right-of-way trees are providing $6,638,513 in annual gross benefits. Taking into consideration the investment necessary to manage this resource ($2,064,000), Palo Alto's trees currently provide $4,574,513, in annual net benefits. That's an average of $156.93 per tree and $71.48 per capita. **For every $1 invested in Palo Alto's right-of-way trees, the community receives $3.22 in net benefits.**

The estimated gross benefits provided by Palo Alto's right-of-way public tree resource amount to $6,638,513; a value of $227.73 per tree and $103.73 per capita.

Palo Alto enjoys a mature right-of-way tree resource in relatively good condition, with more than 230 different species. Although it is critical to maintain an adequate level of resources to protect this investment, this population can be expected to provide a steady flow of benefits for many generations to come. Future changes and improvements to the urban forestry program should be directed towards sustainability and maximizing cost-effectiveness and overall net benefits. Installation of additional trees in vacant planting sites, to raise the current stocking level of 92.5%, will increase the overall canopy cover as well as the overall flow of benefits. Replacing species that emit high levels of biogenic volatile organic compounds (BVOCs) with species that provide positive air quality benefits will improve air quality throughout the community. Based on the resource analysis, Davey Resource Group recommends the following:

- *Continue annual tree planting efforts with the goal of achieving a 100% stocking rate, utilizing available planting sites identified by the inventory.*
- *Maintain a stable age distribution to ensure long-term resource sustainability and optimal canopy coverage. Where possible, establish 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 flow of benefits. Focus on planting large-stature trees, where space allows, to maximize benefits.*
- *Continue to reduce the prevalence of species that emit high levels of BVOCs. As these populations age, install replacement species that provide positive air quality benefits.*

Understanding the current status of the City's tree population allows forest managers to consider 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. Performance data from the analysis can be used to make determinations regarding species selection, distribution, and maintenance policies. Documenting current structure is necessary for establishing goals and

performance objectives and can serve as a benchmark for measuring future success. Information from the urban forest resource analysis can be used to create an urban forest management or master plan. An urban forest master 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.

As a Tree City, USA, and a pioneer in urban forest protection and management, Palo Alto, California is a community that recognizes the vital importance of trees to the environmental, social, and economic well-being of the City. Palo Alto 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 City of Palo Alto takes a proactive and forwarding-looking approach to caring for the community's trees, as evidenced by the condition and structure of the current public resource. Up-to-date, geo-coded inventory data will help staff to more efficiently track maintenance activities and tree health and provide a strong basis for making informed management decisions. Though the current resource is already producing a significant net benefit, with additional tree planting and continued proactive management, Palo Alto's right-of-way urban forest can be expected to produce an even greater flow of benefits. With a demonstrated commitment to maintaining and maximizing the benefits from its community forest, Palo Alto will continue to be a great place to live, work, and play for many generations to come.

Appendix A: Methods and Procedures

The City of Palo Alto contracted with Davey Resource Group in 2010 to update their inventory of public right-of-way trees. The update included geo-coding the GIS location of individual trees in the inventory. City staff maintain the inventory data using TreeKeeper® 7.7, a software management system developed by Davey to provide accurate and dependable inventory data specific to tree characteristics, health, and performed maintenance.

Palo Alto's right-of-way tree inventory was collected by Certified Arborists, using ArcPad software to assist the inventory arborist in locating the sample plots on the ground and updating tree 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* v 3.0.15; i-Tree v 3.0.19). i-*Tree 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 Palo Alto's right-of-way trees, *i-Tree 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 right-of-way tree inventory with benefit-cost modeling data to produce information regarding resource structure, function, and value for use in determining management recommendations. *i-Tree Streets* regionalizes the calculations of its output by incorporating detailed reference City project information for 17 climate zones across the United States. Palo Alto is located in the Northern California Coast 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, based on current research. It is intended to be a general accounting of the benefits produced by urban trees.

Table 15. Palo Alto Benefit Prices Used In This Analysis.

Benefits	Price	Unit	Source
Electricity	$.13020	$/Kwh	*City of Palo Alto (Tier 2 Residential)*
Natural Gas	$1.3872	$/Therm	*City of Palo Alto (Tier 1)*
CO_2	$0.0075	$/lb	*Streets* default – Northern California Coast
PM_{10}	$9.41	$/lb	*Streets* default – Northern California Coast
NO_2	$12.79	$/lb	*Streets* default – Northern California Coast
SO_2	$3.72	$/lb	*Streets* default – Northern California Coast
VOC	$4.69	$/lb	*Streets* default – Northern California Coast
Stormwater Interception	$0.0078	$/gallon	*Streets* default – Northern California Coast
Median Home Value	$1,233,300	$	www.zillow.com

i-Tree Streets default values (Table 14) from the Northern California Coast Climate Zone were used for all benefit prices except for median home values and electric and natural gas rates. Electric and natural gas rates are 2010 rates obtained from City of Palo Alto website (www.cityofpaloalto.org). Median home value (2010) for Palo Alto was verified at Zillow.com (www.zillow.com). Using these rates, the magnitude of the benefits provided by the right-of-way tree resource was calculated using *i-Tree Streets***.** Program budget values used in benefit versus investment ratio calculations were supplied by City of Palo Alto Urban Forester, Eric Krebs.

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Appendix C: Reports

Palo Alto Complete Population of Public Right-of-Way Trees

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total	% of Pop.
Broadleaf Deciduous Large (BDL)												
Platanus acerifolia	51	66	420	846	963	385	81	13	6	1	2,832	9.7
Ulmus parvifolia	26	14	53	303	345	75	3	0	1	0	820	2.8
Quercus rubra	151	190	325	95	12	4	1	0	0	0	778	2.7
Platanus acerifolia 'Yarwood'	64	185	244	22	1	0	0	1	0	0	517	1.8
Liriodendron tulipifera	1	9	37	56	111	70	32	21	7	2	346	1.2
Celtis australis	20	27	112	115	26	9	6	2	1	0	318	1.1
Celtis sinensis	10	34	161	69	27	1	0	0	0	0	302	1.0
Quercus lobata	11	57	69	29	19	6	9	3	5	7	215	0.7
Fraxinus uhdei	1	4	8	18	46	41	39	23	10	6	196	0.7
Quercus shumardii	62	45	46	4	0	0	0	0	0	0	157	0.5
Platanus acerifolia 'Columbia'	68	46	18	0	0	0	0	0	0	0	132	0.5
Acer saccharinum	0	0	10	12	23	28	22	4	1	1	101	0.3
Catalpa speciosa	9	5	14	27	24	12	9	0	0	0	100	0.3
Acer macrophyllum	13	13	43	27	2	0	0	0	0	0	98	0.3
Zelkova serrata	9	2	0	6	29	9	0	0	0	0	55	0.2
Acer nigrum 'Green Column'	17	30	2	0	0	0	0	0	0	0	49	0.2
Acer x freemanii	23	20	5	0	0	0	0	0	0	0	48	0.2
Ulmus americana	1	2	9	4	9	8	8	6	0	0	47	0.2
Quercus coccinea	1	2	25	10	4	2	0	0	0	0	44	0.2
Quercus palustris	1	3	20	18	2	0	0	0	0	0	44	0.2
Ulmus parvifolia 'Athena'	9	6	16	2	0	0	0	0	0	0	33	0.1
Quercus species	16	5	9	3	0	0	0	0	0	0	33	0.1
Betula jacquemontii	21	7	0	0	0	0	0	0	0	0	28	0.1
Platanus acerifolia 'Bloodgood'	3	16	9	0	0	0	0	0	0	0	28	0.1
Fagus sylvatica	2	4	13	6	2	0	0	0	0	0	27	0.1
Ulmus species	1	1	5	0	3	4	5	1	0	0	20	0.1
Juglans hindsii	0	2	5	5	1	3	1	1	0	0	18	0.1
Acer platanoides	1	8	3	1	1	0	1	0	0	0	15	0.1
Juglans nigra	0	4	7	3	1	0	0	0	0	0	15	0.1
Platanus species	1	1	4	4	2	1	0	0	0	0	13	0.0
BDL Other	3	1	2	3	5	4	2	0	0	0	20	0.1
BDL Total	**596**	**809**	**1,694**	**,688**	**1,658**	**662**	**219**	**75**	**31**	**17**	**7,449**	**25.6%**
Broadleaf Deciduous Medium (BDM)												
Liquidambar styraciflua	39	62	425	1,080	779	241	41	2	0	0	2,669	9.2
Fraxinus velutina 'Modesto'	20	4	25	158	445	538	259	31	1	0	1,481	5.1
Pistacia chinensis	135	243	434	180	34	1	0	0	0	0	1,027	3.5
Ginkgo biloba	140	160	224	73	21	10	4	1	0	0	633	2.2
Acer rubrum	56	124	213	24	1	0	0	0	0	0	418	1.4

Species	DBH Class (in)										Total	% of Pop.
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48		
Tilia cordata	16	58	187	115	25	13	1	1	0	0	416	1.4
Betula pendula	26	69	183	84	11	1	0	0	0	0	374	1.3
Fraxinus oxycarpa	13	41	134	126	42	10	5	1	1	0	373	1.3
Fraxinus holotricha 'Moraine'	8	57	164	89	6	5	3	1	1	0	334	1.1
Pyrus calleryana	16	49	105	93	34	4	0	0	0	0	301	1.0
Fraxinus americana 'Junginger'	113	107	16	1	0	1	0	0	0	0	238	0.8
Sapium sebiferum	16	38	121	49	2	0	0	0	0	0	226	0.8
Aesculus carnea	9	26	51	59	38	3	1	0	0	0	187	0.6
Acer rubrum 'October glory'	64	71	5	0	0	0	0	0	0	0	140	0.5
Pyrus calleryana 'Chanticleer'	33	69	32	0	0	0	1	0	0	0	135	0.5
Ginkgo biloba 'Autumn Gold'	87	33	1	0	0	0	0	0	0	0	121	0.4
Ulmus 'Frontier'	25	50	41	3	0	0	0	0	0	0	119	0.4
Sophora japonica	0	5	60	28	11	5	0	0	0	0	109	0.4
Pyrus calleryana 'Bradford'	4	16	57	25	2	0	0	0	0	0	104	0.4
Morus alba	1	2	11	36	40	12	2	0	0	0	104	0.4
Juglans regia	1	8	38	32	9	2	0	0	0	0	90	0.3
Tilia cordata 'Greenspire'	51	24	9	0	0	0	0	0	0	0	84	0.3
Nyssa sylvatica	44	17	21	0	0	0	0	0	0	0	82	0.3
Fraxinus species	21	19	18	15	0	1	0	0	0	0	74	0.3
Gleditsia triacanthos	19	17	27	5	1	0	0	0	0	0	69	0.2
Robinia ambigua 'Purple Robe'	3	18	43	1	0	0	0	0	0	0	65	0.2
Robinia ambigua 'Idahoensis'	1	13	34	5	0	0	0	0	0	0	53	0.2
Tilia tomentosa 'Green Mountain'	35	5	10	0	0	0	0	0	0	0	50	0.2
Robinia pseudoacacia	5	4	10	2	8	14	1	4	0	1	49	0.2
Albizia julibrissin	5	2	14	17	3	1	0	0	0	0	42	0.1
Pyrus calleryana 'Aristocrat'	0	8	17	14	0	0	0	0	0	0	39	0.1
Acer rubrum 'Franksred'	1	29	7	0	0	0	0	0	0	0	37	0.1
Fraxinus velutina	0	0	5	13	12	3	3	0	1	0	37	0.1
Morus rubra	1	0	3	12	12	6	0	0	0	0	34	0.1
Ailanthus altissima	3	2	10	12	2	2	0	0	0	0	31	0.1
Acer species	3	6	4	9	3	4	0	1	0	0	30	0.1
Tilia tomentosa	4	7	14	4	0	0	0	1	0	0	30	0.1
Carpinus betulus 'Fastigiata'	5	13	9	2	1	0	0	0	0	0	30	0.1
Tilia tomentosa 'Sterling'	17	9	3	0	0	0	0	0	0	0	29	0.1
Jacaranda mimosifolia	3	9	8	3	1	0	0	0	0	0	24	0.1
Aesculus carnea 'Briotii'	13	7	0	0	0	0	0	0	0	0	20	0.1

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total	% of Pop.
Carpinus betulus	4	16	0	0	0	0	0	0	0	0	20	0.1
Betula nigra	5	5	1	1	0	0	0	0	0	0	12	0.0
Alnus rhombifolia	0	1	2	2	2	0	1	0	0	0	8	0.0
Koelreuteria species	0	4	2	0	1	0	0	0	0	0	7	0.0
Tilia species	0	1	2	0	1	2	0	0	0	0	6	0.0
Salix species	0	0	1	0	0	0	1	0	0	0	2	0.0
BDM Other	18	16	9	4	4	1	2	0	0	0	54	0.2
BDM Total	**1,083**	**1,544**	**2,810**	**2,376**	**1,551**	**880**	**325**	**43**	**4**	**1**	**10,617**	**36.4%**
Broadleaf Deciduous Small (BDS)												
Prunus cerasifera	35	75	115	15	1	1	0	0	0	0	242	0.8
Lagerstroemia indica	70	74	45	0	0	0	0	0	0	0	189	0.6
Acer palmatum	77	46	13	2	0	0	0	0	0	0	138	0.5
Crataegus laevigata	23	47	57	2	0	0	0	0	0	0	129	0.4
Prunus caroliniana	4	12	34	30	10	1	0	0	0	0	91	0.3
Prunus serrulata	28	19	18	3	0	0	0	0	0	0	68	0.2
Lagerstroemia 'Natchez'	25	38	0	0	0	0	0	0	0	0	63	0.2
Prunus domestica	18	23	15	6	1	0	0	0	0	0	63	0.2
Cercis canadensis	19	26	14	1	0	0	0	0	0	0	60	0.2
Prunus blieriana	3	22	22	0	0	0	0	0	0	0	47	0.2
Malus species	20	10	7	3	0	0	0	0	0	0	40	0.1
Prunus dulces	6	10	16	6	0	0	0	0	0	0	38	0.1
Prunus species	10	19	5	2	0	0	0	0	0	0	36	0.1
Magnolia x soulangiana	19	9	4	1	0	0	0	0	0	0	33	0.1
Prunus armeniaca	9	13	9	1	0	0	0	0	0	0	32	0.1
Acer capillipes	1	15	5	2	1	0	0	0	0	0	24	0.1
Chionanthus retusus	3	13	7	0	0	0	0	0	0	0	23	0.1
Malus sylvestris	8	5	7	1	0	0	0	0	0	0	21	0.1
Acer campestre	0	2	13	3	0	0	0	0	0	0	18	0.1
Prunus yedoensis	4	4	8	0	1	0	0	0	0	0	17	0.1
Pyrus communis	8	5	4	0	0	0	0	0	0	0	17	0.1
Crataegus laevigata 'Paul's Scarlet'	14	2	0	0	0	0	0	0	0	0	16	0.1
Magnolia species	5	4	6	1	0	0	0	0	0	0	16	0.1
Chitalpa 'Pink Dawn'	2	6	7	0	0	0	0	0	0	0	15	0.1
Prunus yedoensis 'Akebono'	5	6	3	0	0	0	0	0	0	0	14	0.0
Cercis occidentalis	12	1	0	0	0	0	0	0	0	0	13	0.0
Cornus species	8	4	1	0	0	0	0	0	0	0	13	0.0
Prunus persica	10	2	1	0	0	0	0	0	0	0	13	0.0
Acer griseum	10	1	1	0	0	0	0	0	0	0	12	0.0
Lagerstroemia 'Tuscarora'	6	5	1	0	0	0	0	0	0	0	12	0.0
Diospyros kaki	1	3	6	1	0	0	0	0	0	0	11	0.0
Ficus carica	5	1	2	0	0	0	0	0	0	0	8	0.0
Celtis reticulata	0	0	1	0	0	0	0	0	0	0	1	0.0
BDS Other	6	5	6	2	0	0	0	0	0	0	19	0.1
BDS Total	**474**	**527**	**453**	**82**	**14**	**2**	**0**	**0**	**0**	**0**	**1,552**	**5.3%**
Broadleaf Evergreen Large (BEL)												
Quercus agrifolia	28	78	121	126	97	38	24	12	8	2	534	1.8
Quercus ilex	16	50	124	163	113	40	8	1	0	0	515	1.8

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total	% of Pop.
Quercus suber	1	23	56	28	20	11	3	1	3	1	147	0.5
Quercus virginiana	65	4	13	4	0	1	0	0	0	0	87	0.3
Podocarpus gracilior	1	2	27	38	10	1	0	0	0	0	79	0.3
Eucalyptus polyanthemos	0	0	2	7	8	8	5	4	1	1	36	0.1
Eucalyptus species	2	0	2	3	2	4	5	0	2	0	20	0.1
Tristaniopsis conferta	6	9	3	1	0	0	0	0	0	0	19	0.1
Eucalyptus globulus	0	0	2	0	3	0	2	2	2	5	16	0.1
Umbellularia californica	1	8	3	1	1	0	0	0	0	0	14	0.0
Eucalyptus sideroxylon	0	0	0	0	9	1	1	1	1	0	13	0.0
Grevillea robusta	1	0	0	3	5	1	1	0	0	0	11	0.0
Quercus kelloggii	0	3	4	1	0	0	0	0	0	0	8	0.0
Quercus wislizenii	0	2	1	0	0	0	0	0	0	0	3	0.0
BEL Other	0	1	0	1	0	0	0	0	0	0	2	0.0
BEL Total	**121**	**180**	**358**	**376**	**268**	**105**	**49**	**21**	**17**	**9**	**1,504**	**5.2%**
Broadleaf Evergreen Medium (BEM)												
Magnolia grandiflora	71	102	601	1,421	1,061	527	198	58	19	3	4,061	13.9
Cinnamomum camphora	31	32	106	238	311	255	108	40	10	2	1,133	3.9
Ligustrum lucidum	11	55	113	114	50	17	1	0	0	0	361	1.2
Ceratonia siliqua	3	2	15	49	37	20	8	5	1	0	140	0.5
Acacia melanoxylon	10	21	33	17	15	1	2	1	0	0	100	0.3
Geijera parviflora	1	4	28	21	8	1	0	0	0	0	63	0.2
Schinus molle	3	3	8	7	18	9	9	1	2	0	60	0.2
Maytenus boaria	4	21	16	8	4	0	0	0	0	0	53	0.2
Olea europaea	6	11	14	9	3	0	0	0	0	0	43	0.1
Brachychiton populneus	0	0	0	5	3	3	0	0	0	0	11	0.0
Eucalyptus cinerea	0	0	0	3	5	1	0	0	0	0	9	0.0
Pittosporum undulatum	1	0	6	2	0	0	0	0	0	0	9	0.0
Persea americana	2	2	0	4	0	0	0	0	0	0	8	0.0
Ficus species	2	3	2	0	0	0	0	0	0	0	7	0.0
Lyonothamnus floribundus	0	1	5	1	0	0	0	0	0	0	7	0.0
Laurus nobilis	0	2	0	0	0	0	0	0	0	0	2	0.0
Melaleuca quinquenervia	0	0	1	0	1	0	0	0	0	0	2	0.0
Arbutus menziesii	0	0	0	1	0	0	0	0	0	0	1	0.0
Eucalyptus ficifolia	0	1	0	0	0	0	0	0	0	0	1	0.0
BEM Other	5	4	3	0	1	0	0	0	0	0	13	0.0
BEM Total	**150**	**264**	**951**	**1,900**	**1,517**	**834**	**326**	**105**	**32**	**5**	**6,084**	**20.9%**
Broadleaf Evergreen Small (BES)												
Eriobotrya japonica	16	26	17	5	0	0	0	0	0	0	64	0.2
Pyrus kawakamii	3	6	21	17	7	0	0	0	0	0	54	0.2
Xylosma congestum	5	23	18	2	0	0	0	0	0	0	48	0.2
Callistemon viminalis	3	10	16	9	4	2	0	0	0	0	44	0.2

Species	DBH Class (in)										Total	% of Pop.
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48		
Tristaniopsis laurina	3	20	17	0	0	0	0	0	0	0	40	0.1
Callistemon citrinus	0	18	18	0	1	0	0	0	0	0	37	0.1
Citrus limon	21	11	2	0	0	0	0	0	0	0	34	0.1
Schinus terebinthifolius	2	2	6	7	6	7	3	1	0	0	34	0.1
Acer oblongum	2	0	0	8	18	4	0	0	0	0	32	0.1
Tristaniopsis laurina 'Elegant'	11	15	4	0	0	0	0	0	0	0	30	0.1
Aesculus hippocastanum	7	7	2	1	0	2	0	0	0	1	20	0.1
Nerium oleander	3	12	2	2	0	0	0	0	0	0	19	0.1
Citrus sinensis	5	8	3	1	0	0	0	0	0	0	17	0.1
Quillaja saponaria	0	0	2	0	5	6	2	0	0	0	15	0.1
Arbutus unedo	4	5	6	0	0	0	0	0	0	0	15	0.1
Pittosporum species	1	9	5	0	0	0	0	0	0	0	15	0.1
Podocarpus macrophyllus	0	2	5	7	1	0	0	0	0	0	15	0.1
Crinodendron patagua	0	0	1	6	3	0	0	0	0	0	10	0.0
Pittosporum tobira	0	7	2	0	0	0	0	0	0	0	9	0.0
Photinia x fraseri	5	0	3	0	0	0	0	0	0	0	8	0.0
Rhus lancea	0	0	4	2	0	0	0	0	0	0	6	0.0
Eucalyptus lehmannii	1	0	1	0	2	0	1	0	0	0	5	0.0
Ilex altaclarensis	0	0	5	0	0	0	0	0	0	0	5	0.0
Melaleuca linariifolia	0	1	0	2	2	0	0	0	0	0	5	0.0
Myoporum laetum	0	0	1	1	2	0	0	0	0	0	4	0.0
Pittosporum crassifolium	0	3	1	0	0	0	0	0	0	0	4	0.0
Ficus elastica	1	2	0	0	0	0	0	0	0	0	3	0.0
Pittosporum viridiflorum	0	1	2	0	0	0	0	0	0	0	3	0.0
Taxus baccata	1	1	1	0	0	0	0	0	0	0	3	0.0
Citrus x paradisi	0	2	0	0	0	0	0	0	0	0	2	0.0
Cupaniopsis anacardioides	0	0	1	1	0	0	0	0	0	0	2	0.0
Hymenosporum flavum	0	0	0	1	1	0	0	0	0	0	2	0.0
Lycianthes rantonnei	2	0	0	0	0	0	0	0	0	0	2	
Pittosporum eugenioides	0	0	2	0	0	0	0	0	0	0	2	0.0
Pyracantha species	0	1	1	0	0	0	0	0	0	0	2	0.0
Viburnum japonicum	2	0	0	0	0	0	0	0	0	0	2	0.0
Dodonaea viscosa	1	0	0	0	0	0	0	0	0	0	1	0.0
Feijoa sellowiana	0	0	1	0	0	0	0	0	0	0	1	0.0
Heteromeles arbutifolia	0	1	0	0	0	0	0	0	0	0	1	0.0
Ilex cornuta	0	0	1	0	0	0	0	0	0	0	1	0.0
Leptospermum laevigata	0	0	1	0	0	0	0	0	0	0	1	0.0
BES Other	4	10	3	2	1	2	1	0	0	0	23	0.1
BES Total	**103**	**203**	**175**	**74**	**53**	**23**	**7**	**1**	**0**	**1**	**640**	**2.2%**
Conifer Evergreen Large (CEL)												
Sequoia	7	3	23	52	49	42	32	14	8	13	243	0.8

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total	% of Pop.
sempervirens												
Cedrus deodara	4	2	7	23	38	37	23	9	2	3	148	0.5
Pinus radiata	1	3	5	15	37	27	16	3	2	1	110	0.4
Pinus pinea	0	1	2	5	14	18	27	17	5	3	92	0.3
Casuarina equisetifolia	5	3	20	31	12	1	2	0	0	0	74	0.3
Pinus canariensis	9	0	7	15	20	6	0	0	0	0	57	0.2
Calocedrus decurrens	1	1	5	12	9	2	2	1	0	0	33	0.1
Casuarina cunninghaminana	0	0	0	8	8	7	1	0	0	0	24	0.1
Pinus halepensis	3	0	2	3	5	3	1	2	1	1	21	0.1
Picea pungens	0	4	6	8	1	0	0	0	0	0	19	0.1
Pinus thunbergiana	1	5	7	2	0	0	0	0	0	0	15	0.1
Pseudotsuga menziesii	0	0	1	1	2	4	3	2	1	0	14	0.0
Pinus patula	0	0	4	3	0	0	0	0	0	0	7	0.0
Thuja occidentalis	2	1	3	1	0	0	0	0	0	0	7	0.0
Cedrus atlantica	1	1	0	1	2	0	0	0	0	0	5	0.0
Cupressus macrocarpa	0	0	1	3	0	0	0	0	0	1	5	0.0
Chamaecyparis lawsoniana	0	0	1	0	0	0	0	0	0	0	1	0.0
Sequoiadendron giganteum	0	0	0	0	0	0	1	0	0	0	1	0.0
Thuja plicata	0	1	0	0	0	0	0	0	0	0	1	0.0
CEL Other	0	0	0	1	0	0	0	0	0	0	1	0.0
CEL Total	**34**	**25**	**94**	**184**	**197**	**147**	**108**	**48**	**19**	**22**	**878**	**3.0%**
Conifer Evergreen Medium (CEM)												
Cupressus sempervirens	32	27	64	19	3	0	1	0	0	1	147	0.5
Pinus species	5	3	0	2	1	0	0	0	0	0	11	0.0
Cupressus glabra	0	0	1	2	0	0	0	0	0	0	3	0.0
x Cupressocyparis leylandii	0	0	3	0	0	0	0	0	0	0	3	0.0
Juniperus californica	0	0	1	1	0	0	0	0	0	0	2	0.0
CEM Other	0	0	0	1	1	0	0	0	0	0	2	0.0
CEM Total	**37**	**30**	**69**	**25**	**5**	**0**	**1**	**0**	**0**	**1**	**168**	**0.6%**
Conifer Evergreen Small (CES)												
Juniperus chinensis 'Torulosa'	0	7	21	1	0	0	0	0	0	0	29	0.1
Juniperus species	6	2	1	0	0	0	0	0	0	0	9	0.0
Juniperus chinensis	0	0	1	2	0	0	0	0	0	0	3	0.0
CES Other	1	2	0	0	0	0	0	0	0	0	3	0.0
CES Total	**7**	**11**	**23**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**44**	**0.2%**
Palm Evergreen Large (PEL)												
Phoenix canariensis	0	1	0	0	0	10	15	7	0	0	33	0.1
Phoenix dactylifera	0	0	1	0	0	0	0	0	0	0	1	0.0
PEL Total	**0**	**1**	**1**	**0**	**0**	**10**	**15**	**7**	**0**	**0**	**34**	**0.1%**
Palm Evergreen Medium (PEM)												

Species	DBH Class (in)										Total	% of Pop.
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48		
PEM Other	0	0	3	1	1	1	2	0	0	0	8	0.0
PEM Total	**0**	**0**	**3**	**1**	**1**	**1**	**2**	**0**	**0**	**0**	**8**	**0.0%**
Palm Evergreen Small (PES)												
Washingtonia robusta	3	1	5	35	8	3	0	0	0	0	55	0.2
Washingtonia filifera	2	1	2	2	13	5	5	0	0	0	30	0.1
Trachycarpus fortunei	0	0	24	2	0	0	0	0	0	0	26	0.1
Cordyline australis	3	6	6	6	0	0	1	0	0	0	22	0.1
Yucca gloriosa	0	5	9	4	2	0	0	0	0	0	20	0.1
Arecastrum romanzoffianum	1	1	9	3	0	0	0	0	0	0	14	0.0
Brahea edulis	0	0	0	2	0	0	0	0	0	0	2	0.0
Chamaerops humilis	0	0	2	0	0	0	0	0	0	0	2	0.0
Yucca recurvifolia	1	1	0	0	0	0	0	0	0	0	2	0.0
PES Other	**10**	**15**	**57**	**54**	**23**	**8**	**6**	**0**	**0**	**0**	**173**	**0.6%**
Total	**2,615**	**3,609**	**6,688**	**6,763**	**5,287**	**2,672**	**1,058**	**300**	**103**	**56**	**29,151**	**100%**

Relative Performance Index (RPI) for Palo Alto's Public Right-of-Way Trees

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Magnolia grandiflora	0.11	0.94	6.45	34.87	57.56	0.07	**0.95**	4061	13.9
Platanus acerifolia	0.00	0.23	3.00	41.03	55.72	0.02	**0.96**	2832	9.7
Liquidambar styraciflua	0.04	0.21	3.37	31.51	64.80	0.07	**0.99**	2669	9.2
Fraxinus velutina 'Modesto'	0.14	0.34	14.21	54.02	31.23	0.07	**0.84**	1481	5.1
Cinnamomum camphora	0.09	0.09	3.71	30.19	65.84	0.09	**0.99**	1133	3.9
Pistacia chinensis	0.29	0.05	0.58	9.54	89.44	0.10	**1.08**	1027	3.5
Ulmus parvifolia	0.00	0.00	1.10	17.74	81.10	0.06	**1.05**	820	2.8
Quercus rubra	0.26	0.13	0.51	6.56	92.54	0.00	**1.09**	778	2.7
Ginkgo biloba	0.47	0.00	0.55	12.16	86.33	0.47	**1.07**	633	2.2
Quercus agrifolia	0.56	0.00	1.78	19.76	77.81	0.09	**1.03**	534	1.8
Platanus acerifolia 'Yarwood'	0.00	0.00	0.39	19.73	79.69	0.19	**1.05**	517	1.8
Quercus ilex	0.00	0.68	4.37	30.10	64.85	0.00	**0.98**	515	1.8
Acer rubrum	0.24	0.00	0.84	12.44	86.36	0.12	**1.07**	418	1.4
Tilia cordata	0.00	0.12	0.72	23.44	75.72	0.00	**1.03**	416	1.4
Betula pendula	0.53	0.40	2.54	21.26	75.27	0.00	**1.02**	374	1.3
Fraxinus oxycarpa	0.00	0.00	1.74	28.95	69.17	0.13	**1.01**	373	1.3
Ligustrum lucidum	0.00	1.11	6.65	35.60	56.37	0.28	**0.95**	361	1.2
Liriodendron tulipifera	0.00	0.29	4.62	24.71	70.38	0.00	**1.00**	346	1.2
Fraxinus holotricha 'Moraine'	0.00	0.00	1.20	13.77	85.03	0.00	**1.06**	334	1.1
Celtis australis	0.00	0.16	2.20	18.40	79.25	0.00	**1.04**	318	1.1
Celtis sinensis	0.00	0.17	1.32	12.58	85.76	0.17	**1.06**	302	1.0
Pyrus calleryana	0.00	0.00	2.16	28.57	69.27	0.00	**1.01**	301	1.0
Sequoia sempervirens	0.00	0.00	0.41	11.32	88.07	0.21	**1.08**	243	0.8
Prunus cerasifera	1.65	0.83	7.85	29.55	59.50	0.62	**0.94**	242	0.8
Fraxinus americana 'Junginger'	0.00	0.00	0.00	3.15	96.85	0.00	**1.11**	238	0.8
Sapium sebiferum	0.00	0.22	0.22	12.61	86.73	0.22	**1.07**	226	0.8
Quercus lobata	0.47	0.23	1.40	15.58	82.09	0.23	**1.05**	215	0.7
Fraxinus uhdei	0.00	0.26	9.44	39.29	51.02	0.00	**0.92**	196	0.7
Lagerstroemia indica	0.00	0.00	0.00	5.82	94.18	0.00	**1.10**	189	0.6
Aesculus carnea	0.00	0.80	5.08	22.73	71.39	0.00	**1.00**	187	0.6
Quercus shumardii	0.00	0.00	0.64	5.41	93.95	0.00	**1.09**	157	0.5
Cedrus deodara	0.68	0.00	1.01	14.86	83.45	0.00	**1.05**	148	0.5
Cupressus sempervirens	0.00	0.00	0.34	5.44	94.22	0.00	**1.10**	147	0.5
Quercus suber	0.00	0.00	4.08	21.77	74.15	0.00	**1.02**	147	0.5
Ceratonia siliqua	0.71	0.36	7.86	46.43	44.64	0.00	**0.90**	140	0.5
Acer rubrum 'October glory'	0.00	0.00	0.36	2.50	96.07	1.07	**1.11**	140	0.5
Acer palmatum	0.00	0.00	0.72	7.97	91.30	0.00	**1.09**	138	0.5
Pyrus calleryana	0.00	0.00	0.00	5.56	94.07	0.37	**1.10**	135	0.5

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
'Chanticleer'									
Platanus acerifolia 'Columbia'	0.00	0.00	0.00	3.41	96.59	0.00	**1.10**	132	0.5
Crataegus laevigata	0.00	0.00	8.14	29.84	62.02	0.00	**0.96**	129	0.4
Ginkgo biloba 'Autumn Gold'	0.00	0.00	1.24	3.72	95.04	0.00	**1.10**	121	0.4
Ulmus 'Frontier'	0.00	0.00	0.84	7.14	92.02	0.00	**1.09**	119	0.4
Pinus radiata	0.00	0.91	1.36	25.91	71.82	0.00	**1.01**	110	0.4
Sophora japonica	0.00	0.00	3.67	24.77	71.56	0.00	**1.01**	109	0.4
Pyrus calleryana 'Bradford'	0.00	0.00	0.96	21.63	77.40	0.00	**1.04**	104	0.4
Morus alba	0.00	0.00	7.69	36.06	56.25	0.00	**0.95**	104	0.4
Acer saccharinum	0.99	0.50	9.90	36.63	51.98	0.00	**0.91**	101	0.3
Catalpa speciosa	0.00	0.00	21.00	21.50	57.50	0.00	**0.91**	100	0.3
Acacia melanoxylon	1.00	0.00	1.50	20.00	77.00	0.50	**1.03**	100	0.3
Acer macrophyllum	0.00	0.00	0.00	15.82	84.18	0.00	**1.06**	98	0.3
Pinus pinea	0.00	0.00	0.54	9.24	90.22	0.00	**1.08**	92	0.3
Prunus caroliniana	0.00	1.65	7.69	46.70	43.96	0.00	**0.90**	91	0.3
Juglans regia	1.11	2.78	16.11	44.44	35.56	0.00	**0.82**	90	0.3
Quercus virginiana	0.00	0.00	0.57	12.64	86.78	0.00	**1.07**	87	0.3
Tilia cordata 'Greenspire'	0.00	0.00	0.00	1.79	98.21	0.00	**1.11**	84	0.3
Nyssa sylvatica	0.00	0.00	0.00	5.49	94.51	0.00	**1.10**	82	0.3
Podocarpus gracilior	0.00	0.00	0.63	25.95	73.42	0.00	**1.03**	79	0.3
Casuarina equisetifolia	0.00	0.68	5.41	31.76	62.16	0.00	**0.97**	74	0.3
Fraxinus species	0.00	0.00	4.05	17.57	78.38	0.00	**1.03**	74	0.3
Gleditsia triacanthos	0.00	0.00	0.72	16.67	82.61	0.00	**1.06**	69	0.2
Prunus serrulata	0.00	0.00	3.68	18.38	77.94	0.00	**1.03**	68	0.2
Robinia ambigua 'Purple Robe'	0.00	0.00	1.54	23.08	75.38	0.00	**1.03**	65	0.2
Eriobotrya japonica	0.00	0.00	1.56	18.75	79.69	0.00	**1.04**	64	0.2
Prunus domestica	0.00	0.79	3.17	33.33	62.70	0.00	**0.98**	63	0.2
Geijera parviflora	0.00	0.00	4.76	38.89	56.35	0.00	**0.96**	63	0.2
Lagerstroemia 'Natchez'	0.00	0.00	0.00	9.52	90.48	0.00	**1.08**	63	0.2
Schinus molle	0.00	0.83	9.17	31.67	58.33	0.00	**0.94**	60	0.2
Cercis canadensis	0.00	0.83	0.00	21.67	77.50	0.00	**1.04**	60	0.2
Pinus canariensis	0.00	0.00	0.00	6.14	93.86	0.00	**1.10**	57	0.2
Washingtonia robusta	0.00	0.00	0.00	12.73	87.27	0.00	**1.07**	55	0.2
Zelkova serrata	0.00	0.00	1.82	21.82	76.36	0.00	**1.03**	55	0.2
Pyrus kawakamii	0.00	0.00	1.85	46.30	51.85	0.00	**0.95**	54	0.2
Broadleaf Deciduous Medium	1.85	0.00	2.78	25.93	68.52	0.93	**0.99**	54	0.2
Maytenus boaria	1.89	0.00	2.83	35.85	59.43	0.00	**0.96**	53	0.2
Robinia ambigua 'Idahoensis'	0.00	0.00	2.83	25.47	71.70	0.00	**1.01**	53	0.2

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Tilia tomentosa 'Green Mountain'	0.00	0.00	0.00	7.00	93.00	0.00	**1.09**	50	0.2
Robinia pseudoacacia	0.00	0.00	9.18	33.67	57.14	0.00	**0.95**	49	0.2
Acer nigrum 'Green Column'	0.00	0.00	0.00	12.24	87.76	0.00	**1.08**	49	0.2
Xylosma congestum	4.17	0.00	0.00	11.46	84.38	0.00	**1.03**	48	0.2
Acer x freemanii	0.00	0.00	0.00	2.08	96.88	1.04	**1.11**	48	0.2
Ulmus americana	0.00	0.00	6.38	31.91	61.70	0.00	**0.97**	47	0.2
Prunus blieriana	0.00	0.00	2.13	36.17	61.70	0.00	**0.98**	47	0.2
Quercus coccinea	0.00	0.00	1.14	7.95	90.91	0.00	**1.08**	44	0.2
Quercus palustris	0.00	0.00	1.14	14.77	84.09	0.00	**1.06**	44	0.2
Callistemon viminalis	2.27	0.00	6.82	21.59	69.32	0.00	**0.98**	44	0.2
Olea europaea	0.00	0.00	13.95	22.09	62.79	1.16	**0.95**	43	0.1
Albizia julibrissin	0.00	0.00	3.57	33.33	61.90	1.19	**0.98**	42	0.1
Tristaniopsis laurina	0.00	0.00	1.25	10.00	88.75	0.00	**1.08**	40	0.1
Malus species	2.50	0.00	3.75	11.25	82.50	0.00	**1.03**	40	0.1
Pyrus calleryana 'Aristocrat'	0.00	0.00	1.28	19.23	79.49	0.00	**1.04**	39	0.1
Prunus dulces	7.89	0.00	9.21	30.26	51.32	1.32	**0.87**	38	0.1
Callistemon citrinus	0.00	0.00	0.00	16.22	83.78	0.00	**1.06**	37	0.1
Fraxinus velutina	0.00	0.00	0.00	24.32	75.68	0.00	**1.04**	37	0.1
Acer rubrum 'Franksred'	0.00	0.00	0.00	9.46	85.14	5.41	**1.09**	37	0.1
Prunus species	0.00	0.00	2.78	12.50	83.33	1.39	**1.06**	36	0.1
Eucalyptus polyanthemos	0.00	0.00	1.39	22.22	76.39	0.00	**1.03**	36	0.1
Schinus terebinthifolius	0.00	0.00	5.88	30.88	63.24	0.00	**0.98**	34	0.1
Citrus limon	0.00	0.00	5.88	10.29	83.82	0.00	**1.04**	34	0.1
Morus rubra	0.00	17.65	14.71	25.00	42.65	0.00	**0.76**	34	0.1
Ulmus parvifolia 'Athena'	0.00	0.00	0.00	1.52	98.48	0.00	**1.11**	33	0.1
Calocedrus decurrens	0.00	0.00	0.00	18.18	81.82	0.00	**1.06**	33	0.1
Phoenix canariensis	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	33	0.1
Quercus species	1.52	0.00	1.52	19.70	77.27	0.00	**1.02**	33	0.1
Magnolia x soulangiana	0.00	0.00	1.52	13.64	84.85	0.00	**1.06**	33	0.1
Prunus armeniaca	0.00	0.00	6.25	21.88	71.88	0.00	**1.00**	32	0.1
Acer oblongum	0.00	0.00	3.13	15.63	81.25	0.00	**1.04**	32	0.1
Ailanthus altissima	0.00	0.00	1.61	35.48	62.90	0.00	**0.99**	31	0.1
Acer species	6.67	0.00	5.00	26.67	61.67	0.00	**0.92**	30	0.1
Washingtonia filifera	0.00	0.00	1.67	8.33	90.00	0.00	**1.08**	30	0.1
Tristaniopsis laurina 'Elegant'	0.00	0.00	0.00	10.00	90.00	0.00	**1.08**	30	0.1
Carpinus betulus 'Fastigiata'	0.00	0.00	0.00	16.67	83.33	0.00	**1.06**	30	0.1
Tilia tomentosa	0.00	0.00	1.67	11.67	86.67	0.00	**1.07**	30	0.1
Tilia tomentosa 'Sterling'	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	29	0.1

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Juniperus chinensis 'Torulosa'	0.00	0.00	0.00	12.07	86.21	1.72	**1.08**	29	0.1
Betula jacquemontii	0.00	0.00	0.00	3.57	96.43	0.00	**1.10**	28	0.1
Platanus acerifolia 'Bloodgood'	0.00	0.00	0.00	55.36	44.64	0.00	**0.93**	28	0.1
Fagus sylvatica	3.70	0.00	1.85	7.41	87.04	0.00	**1.04**	27	0.1
Trachycarpus fortunei	3.85	0.00	0.00	3.85	92.31	0.00	**1.06**	26	0.1
Acer capillipes	0.00	0.00	2.08	20.83	77.08	0.00	**1.03**	24	0.1
Jacaranda mimosifolia	0.00	0.00	0.00	20.83	79.17	0.00	**1.05**	24	0.1
Casuarina cunninghaminana	0.00	2.08	16.67	27.08	54.17	0.00	**0.90**	24	0.1
Chionanthus retusus	0.00	0.00	0.00	6.52	93.48	0.00	**1.09**	23	0.1
Broadleaf Evergreen Small	0.00	0.00	8.70	17.39	71.74	2.17	**1.00**	23	0.1
Cordyline australis	0.00	0.00	11.36	22.73	65.91	0.00	**0.97**	22	0.1
Pinus halepensis	0.00	0.00	0.00	38.10	61.90	0.00	**0.99**	21	0.1
Malus sylvestris	0.00	0.00	0.00	14.29	85.71	0.00	**1.07**	21	0.1
Aesculus hippocastanum	0.00	0.00	2.50	10.00	87.50	0.00	**1.07**	20	0.1
Aesculus carnea 'Briotii'	0.00	0.00	0.00	0.00	95.00	5.00	**1.12**	20	0.1
Yucca gloriosa	0.00	0.00	0.00	15.00	85.00	0.00	**1.07**	20	0.1
Eucalyptus species	5.00	0.00	5.00	37.50	52.50	0.00	**0.90**	20	0.1
Ulmus species	0.00	0.00	10.00	30.00	60.00	0.00	**0.95**	20	0.1
Carpinus betulus	0.00	0.00	0.00	20.00	80.00	0.00	**1.05**	20	0.1
Broadleaf Deciduous Large	0.00	0.00	0.00	30.00	70.00	0.00	**1.02**	20	0.1
Picea pungens	0.00	0.00	0.00	18.42	81.58	0.00	**1.06**	19	0.1
Broadleaf Deciduous Small	0.00	0.00	0.00	39.47	60.53	0.00	**0.99**	19	0.1
Nerium oleander	0.00	0.00	0.00	34.21	65.79	0.00	**1.00**	19	0.1
Tristaniopsis conferta	0.00	0.00	0.00	5.26	94.74	0.00	**1.10**	19	0.1
Acer campestre	0.00	0.00	8.33	47.22	44.44	0.00	**0.91**	18	0.1
Juglans hindsii	0.00	2.78	11.11	33.33	52.78	0.00	**0.91**	18	0.1
Citrus sinensis	0.00	0.00	0.00	20.59	79.41	0.00	**1.05**	17	0.1
Pyrus communis	0.00	0.00	0.00	20.59	79.41	0.00	**1.05**	17	0.1
Prunus yedoensis	0.00	0.00	8.82	29.41	61.76	0.00	**0.96**	17	0.1
Magnolia species	0.00	0.00	0.00	9.38	90.63	0.00	**1.09**	16	0.1
Eucalyptus globulus	0.00	0.00	3.13	43.75	53.13	0.00	**0.95**	16	0.1
Crataegus laevigata 'Paul's Scarlet'	0.00	0.00	0.00	12.50	87.50	0.00	**1.08**	16	0.1
Arbutus unedo	0.00	0.00	0.00	10.00	90.00	0.00	**1.08**	15	0.1
Juglans nigra	0.00	0.00	6.67	20.00	73.33	0.00	**1.01**	15	0.1
Quillaja saponaria	0.00	3.33	3.33	26.67	66.67	0.00	**0.97**	15	0.1
Podocarpus macrophyllus	0.00	0.00	0.00	26.67	73.33	0.00	**1.03**	15	0.1
Acer platanoides	0.00	0.00	0.00	20.00	80.00	0.00	**1.05**	15	0.1

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Pinus thunbergiana	0.00	3.33	3.33	26.67	66.67	0.00	**0.97**	15	0.1
Chitalpa 'Pink Dawn'	0.00	0.00	0.00	10.00	90.00	0.00	**1.08**	15	0.1
Pittosporum species	0.00	0.00	0.00	13.33	86.67	0.00	**1.07**	15	0.1
Arecastrum romanzoffianum	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	14	0.0
Umbellularia californica	0.00	0.00	7.14	17.86	75.00	0.00	**1.01**	14	0.0
Prunus yedoensis 'Akebono'	0.00	0.00	0.00	14.29	85.71	0.00	**1.07**	14	0.0
Pseudotsuga menziesii	0.00	0.00	0.00	14.29	85.71	0.00	**1.07**	14	0.0
Eucalyptus sideroxylon	0.00	0.00	7.69	19.23	73.08	0.00	**1.00**	13	0.0
Platanus species	0.00	0.00	0.00	34.62	65.38	0.00	**1.00**	13	0.0
Cornus species	0.00	0.00	0.00	3.85	96.15	0.00	**1.10**	13	0.0
Broadleaf Evergreen Medium	0.00	0.00	0.00	46.15	53.85	0.00	**0.96**	13	0.0
Prunus persica	0.00	0.00	0.00	30.77	69.23	0.00	**1.02**	13	0.0
Cercis occidentalis	0.00	0.00	0.00	3.85	96.15	0.00	**1.10**	13	0.0
Acer griseum	0.00	0.00	0.00	8.33	91.67	0.00	**1.09**	12	0.0
Lagerstroemia 'Tuscarora'	0.00	0.00	0.00	4.17	95.83	0.00	**1.10**	12	0.0
Betula nigra	16.67	0.00	0.00	4.17	79.17	0.00	**0.92**	12	0.0
Grevillea robusta	0.00	0.00	13.64	45.45	40.91	0.00	**0.88**	11	0.0
Brachychiton populneus	0.00	0.00	4.55	18.18	77.27	0.00	**1.03**	11	0.0
Pinus species	0.00	0.00	0.00	9.09	90.91	0.00	**1.09**	11	0.0
Diospyros kaki	0.00	0.00	0.00	31.82	68.18	0.00	**1.01**	11	0.0
Crinodendron patagua	0.00	0.00	0.00	60.00	40.00	0.00	**0.92**	10	0.0
Pittosporum undulatum	0.00	0.00	0.00	27.78	72.22	0.00	**1.02**	9	0.0
Eucalyptus cinerea	0.00	0.00	0.00	27.78	72.22	0.00	**1.02**	9	0.0
Pittosporum tobira	0.00	0.00	0.00	16.67	83.33	0.00	**1.06**	9	0.0
Juniperus species	0.00	0.00	5.56	0.00	94.44	0.00	**1.08**	9	0.0
Persea americana	0.00	0.00	0.00	25.00	75.00	0.00	**1.03**	8	0.0
Ficus carica	0.00	0.00	0.00	12.50	87.50	0.00	**1.08**	8	0.0
Alnus rhombifolia	0.00	0.00	6.25	12.50	81.25	0.00	**1.03**	8	0.0
Quercus kelloggii	0.00	0.00	0.00	6.25	93.75	0.00	**1.10**	8	0.0
Photinia x fraseri	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	8	0.0
Palm Evergreen Medium	0.00	0.00	0.00	18.75	81.25	0.00	**1.05**	8	0.0
Lyonothamnus floribundus	0.00	0.00	0.00	14.29	85.71	0.00	**1.07**	7	0.0
Ficus species	0.00	0.00	0.00	7.14	92.86	0.00	**1.09**	7	0.0
Koelreuteria species	0.00	0.00	0.00	14.29	85.71	0.00	**1.07**	7	0.0
Thuja occidentalis	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	7	0.0
Pinus patula	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	7	0.0
Tilia species	0.00	0.00	8.33	16.67	75.00	0.00	**1.01**	6	0.0

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Rhus lancea	0.00	0.00	0.00	33.33	66.67	0.00	**1.01**	6	0.0
Ilex altaclarensis	20.00	0.00	0.00	20.00	60.00	0.00	**0.83**	5	0.0
Cupressus macrocarpa	0.00	0.00	0.00	10.00	90.00	0.00	**1.08**	5	0.0
Cedrus atlantica	0.00	0.00	0.00	10.00	90.00	0.00	**1.08**	5	0.0
Melaleuca linariifolia	0.00	0.00	0.00	40.00	60.00	0.00	**0.98**	5	0.0
Eucalyptus lehmannii	0.00	0.00	0.00	60.00	40.00	0.00	**0.92**	5	0.0
Pittosporum crassifolium	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	4	0.0
Myoporum laetum	0.00	0.00	37.50	50.00	12.50	0.00	**0.71**	4	0.0
Cupressus glabra	0.00	0.00	0.00	33.33	66.67	0.00	**1.01**	3	0.0
Pittosporum viridiflorum	0.00	0.00	0.00	33.33	50.00	16.67	**1.03**	3	0.0
Juniperus chinensis	0.00	0.00	0.00	16.67	83.33	0.00	**1.06**	3	0.0
Conifer Evergreen Small	0.00	0.00	0.00	33.33	66.67	0.00	**1.01**	3	0.0
x Cupressocyparis leylandii	0.00	0.00	66.67	33.33	0.00	0.00	**0.57**	3	0.0
Taxus baccata	0.00	0.00	0.00	33.33	66.67	0.00	**1.01**	3	0.0
Ficus elastica	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	3	0.0
Quercus wislizenii	0.00	0.00	0.00	16.67	83.33	0.00	**1.06**	3	0.0
Lycianthes rantonnei	0.00	0.00	0.00	25.00	75.00	0.00	**1.03**	2	0.0
Pyracantha species	0.00	0.00	0.00	25.00	75.00	0.00	**1.03**	2	0.0
Viburnum japonicum	0.00	0.00	0.00	100.00	0.00	0.00	**0.79**	2	0.0
Cupaniopsis anacardioides	0.00	0.00	25.00	25.00	50.00	0.00	**0.87**	2	0.0
Laurus nobilis	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Brahea edulis	0.00	0.00	0.00	0.00	00.00	0.00	**1.12**	2	0.0
Juniperus californica	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Pittosporum eugenioides	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	2	0.0
Citrus x paradisi	0.00	0.00	0.00	25.00	75.00	0.00	**1.03**	2	0.0
Salix species	0.00	0.00	0.00	25.00	75.00	0.00	**1.03**	2	0.0
Chamaerops humilis	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Broadleaf Evergreen Large	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Melaleuca quinquenervia	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Yucca recurvifolia	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	2	0.0
Hymenosporum flavum	0.00	0.00	25.00	25.00	50.00	0.00	**0.87**	2	0.0
Conifer Evergreen Medium	0.00	0.00	25.00	0.00	75.00	0.00	**0.95**	2	0.0
Heteromeles arbutifolia	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Ilex cornuta	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Chamaecyparis lawsoniana	0.00	0.00	0.00	100.00	0.00	0.00	**0.79**	1	0.0
Arbutus menziesii	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0

Species	Dead	Critical	Poor	Fair	Good	Excellent	RPI	# of Trees	% of Pop
Celtis reticulata	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Eucalyptus ficifolia	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Conifer Evergreen Large	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	1	0.0
Feijoa sellowiana	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	1	0.0
Dodonaea viscosa	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	1	0.0
Leptospermum laevigata	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Sequoiadendron giganteum	0.00	0.00	0.00	50.00	50.00	0.00	**0.95**	1	0.0
Phoenix dactylifera	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
Thuja plicata	0.00	0.00	0.00	0.00	100.00	0.00	**1.12**	1	0.0
All trees	**0.17**	**0.31**	**3.74**	**26.43**	**69.25**	**0.10**	**1.00**	**29151**	**100%**

Replacement Value of Palo Alto's Public Right-of-Way Tree Species

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
Magnolia grandiflora	9,564	47,193	863,935	5,321,542	7,651,544	6,222,804	3,449,371	1,223,223	545,379	97,221	**25,431,776**	13.9	21.20
Platanus acerifolia	6,581	29,178	611,374	3,219,246	7,012,513	4,577,571	1,473,657	315,747	174,016	35,929	**17,455,813**	9.7	14.55
Liquidambar styraciflua	6,339	30,014	615,466	3,998,164	5,586,103	2,807,814	688,003	43,512	0	0	**13,775,415**	9.2	11.48
Fraxinus velutina 'Modesto'	2,820	1,071	12,197	161,947	821,903	1,544,796	1,085,586	169,575	6,322	0	**3,806,217**	5.1	3.17
Cinnamomum camphora	5,565	19,369	208,058	1,221,466	3,077,268	4,161,607	2,593,039	1,267,915	371,470	87,723	**13,013,480**	3.9	10.85
Pistacia chinensis	24,723	153,683	910,623	993,859	354,116	18,496	0	0	0	0	**2,455,500**	3.5	2.05
Ulmus parvifolia	4,641	8,728	105,628	1,652,793	3,688,953	1,267,522	78,003	0	43,552	0	**6,849,820**	2.8	5.71
Quercus rubra	27,217	141,937	871,200	684,480	164,272	91,399	24,974	0	0	0	**2,005,479**	2.7	1.67
Ginkgo biloba	26,846	60,737	227,355	176,434	94,207	66,247	43,437	13,124	0	0	**708,388**	2.2	0.59
Quercus agrifolia	3,598	35,692	191,693	518,371	767,641	502,698	452,307	296,659	225,540	61,291	**3,055,492**	1.8	2.55
Platanus acerifolia 'Yarwood'	9,537	88,385	377,767	84,751	6,029	0	0	19,088	0	0	**585,557**	1.8	0.49
Quercus ilex	2,794	28,590	238,557	824,434	1,124,838	636,481	185,189	30,388	0	0	**3,071,271**	1.8	2.56
Acer rubrum	8,721	44,525	222,921	62,446	4,586	0	0	0	0	0	**343,198**	1.4	0.29
Tilia cordata	2,730	42,789	480,307	760,655	330,238	273,499	35,381	45,748	0	0	**1,971,346**	1.4	1.64
Betula pendula	4,387	19,750	116,664	119,036	28,873	4,110	0	0	0	0	**292,820**	1.3	0.24
Fraxinus oxycarpa	2,212	10,494	72,752	149,746	85,324	36,029	26,328	6,273	5,005	0	**394,163**	1.3	0.33
Ligustrum lucidum	1,968	14,649	63,218	158,904	123,304	69,867	6,066	0	0	0	**437,976**	1.2	0.37
Liriodendron tulipifera	161	2,510	23,930	82,952	286,451	303,986	200,114	176,019	74,803	18,883	**1,169,808**	1.2	0.98
Fraxinus holotricha 'Moraine'	1,407	15,104	92,274	110,775	13,817	19,444	15,961	6,273	7,640	0	**282,695**	1.1	0.24
Celtis australis	3,267	11,158	142,328	374,378	156,191	76,137	72,222	29,757	18,179	0	**883,619**	1.1	0.74
Celtis sinensis	1,676	12,193	158,051	163,119	119,906	6,733	0	0	0	0	**461,677**	1.0	0.38
Pyrus calleryana	3,185	18,464	101,211	208,826	142,400	27,445	0	0	0	0	**501,531**	1.0	0.42
Sequoia sempervirens	1,032	1,268	30,678	181,052	322,722	450,220	493,785	296,745	200,002	352,731	**2,330,236**	0.8	1.94
Prunus cerasifera	6,527	25,290	99,175	29,482	4,210	3,312	0	0	0	0	**167,996**	0.8	0.14
Fraxinus americana 'Junginger'	20,820	29,571	9,312	933	0	3,889	0	0	0	0	**64,524**	0.8	0.05
Sapium sebiferum	2,924	10,356	68,432	60,069	4,843	0	0	0	0	0	**146,625**	0.8	0.12
Quercus lobata	1,855	42,314	180,356	203,712	260,803	117,912	286,481	117,061	238,551	327,302	**1,776,348**	0.7	1.48
Fraxinus uhdei	131	1,030	4,008	19,505	88,600	127,418	187,531	146,431	79,031	44,042	**697,728**	0.7	0.58
Lagerstroemia indica	13,598	39,581	76,420	0	0	0	0	0	0	0	**129,599**	0.6	0.11
Aesculus carnea	1,618	7,584	30,248	82,573	106,366	12,329	5,020	0	0	0	**245,738**	0.6	0.20
Quercus shumardii	10,234	18,981	60,149	13,911	0	0	0	0	0	0	**103,275**	0.5	0.09
Cedrus deodara	624	1,000	11,382	91,241	309,468	492,785	446,825	227,465	61,246	102,504	**1,744,541**	0.5	1.45
Cupressus	5,645	9,967	62,815	47,567	14,508	0	11,448	0	0	20,052	**172,002**	0.5	0.14

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
sempervirens													
Quercus suber	186	15,989	140,358	195,224	277,315	226,056	83,361	32,293	118,453	33,982	**1,123,217**	0.5	0.94
Acer rubrum 'October glory'	12,351	36,511	8,058	0	0	0	0	0	0	0	**56,921**	0.5	0.05
Ceratonia siliqua	456	315	12,527	104,782	144,087	121,888	66,670	62,235	15,740	0	**528,700**	0.5	0.44
Acer palmatum	14,405	28,571	26,663	10,749	0	0	0	0	0	0	**80,387**	0.5	0.07
Pyrus calleryana 'Chanticleer'	6,492	26,678	32,955	0	0	0	11,931	0	0	0	**78,056**	0.5	0.07
Platanus acerifolia 'Columbia'	10,473	22,780	29,897	0	0	0	0	0	0	0	**63,150**	0.5	0.05
Crataegus laevigata	4,285	15,768	50,544	4,441	0	0	0	0	0	0	**75,039**	0.4	0.06
Ginkgo biloba 'Autumn Gold'	16,965	12,807	1,049	0	0	0	0	0	0	0	**30,821**	0.4	0.03
Ulmus 'Frontier'	4,204	16,114	33,035	6,194	0	0	0	0	0	0	**59,548**	0.4	0.05
Pinus radiata	131	793	2,419	17,679	81,407	94,133	86,590	20,981	16,597	8,294	**329,023**	0.4	0.27
Sophora japonica	0	1,267	32,221	34,076	22,364	16,585	0	0	0	0	**106,512**	0.4	0.09
Pyrus calleryana 'Bradford'	767	5,946	56,407	57,816	9,145	0	0	0	0	0	**130,081**	0.4	0.11
Morus alba	133	563	6,379	49,847	100,047	50,027	10,949	0	0	0	**217,944**	0.4	0.18
Acer saccharinum	0	0	10,983	26,547	95,264	190,978	224,550	61,249	17,211	18,701	**645,482**	0.3	0.54
Acacia melanoxylon	1,668	6,074	21,878	25,207	39,229	4,110	9,813	6,459	0	0	**114,439**	0.3	0.10
Catalpa speciosa	1,445	1,683	12,557	55,570	88,330	73,829	78,276	0	0	0	**311,689**	0.3	0.26
Acer macrophyllum	2,430	3,770	28,684	40,104	5,090	0	0	0	0	0	**80,077**	0.3	0.07
Pinus pinea	0	319	2,032	14,042	74,476	153,223	333,915	282,084	100,093	60,651	**1,020,836**	0.3	0.85
Prunus caroliniana	677	6,494	61,446	128,818	90,926	15,776	0	0	0	0	**304,137**	0.3	0.25
Juglans regia	189	2,117	19,948	36,368	17,201	6,094	0	0	0	0	**81,918**	0.3	0.07
Quercus virginiana	11,653	2,737	34,365	28,511	0	20,233	0	0	0	0	**97,499**	0.3	0.08
Tilia cordata 'Greenspire'	9,413	6,669	5,287	0	0	0	0	0	0	0	**21,369**	0.3	0.02
Nyssa sylvatica	8,263	10,849	44,374	0	0	0	0	0	0	0	**63,486**	0.3	0.05
Podocarpus gracilior	190	1,287	53,581	201,672	104,152	18,496	0	0	0	0	**379,379**	0.3	0.32
Casuarina equisetifolia	751	911	13,204	41,570	28,347	4,110	14,223	0	0	0	**103,116**	0.3	0.09
Fraxinus species	3,910	4,953	8,759	18,067	0	3,889	0	0	0	0	**39,578**	0.3	0.03
Gleditsia triacanthos	3,625	4,282	12,713	4,433	1,782	0	0	0	0	0	**26,836**	0.2	0.02
Prunus serrulata	5,165	9,090	25,453	12,607	0	0	0	0	0	0	**52,315**	0.2	0.04
Robinia ambigua 'Purple Robe'	550	4,629	18,997	1,005	0	0	0	0	0	0	**25,182**	0.2	0.02
Eriobotrya japonica	3,058	12,720	24,552	18,540	0	0	0	0	0	0	**58,869**	0.2	0.05
Geijera parviflora	109	1,617	39,672	75,271	56,382	11,319	0	0	0	0	**184,370**	0.2	0.15
Lagerstroemia	4,859	14,484	0	0	0	0	0	0	0	0	**19,343**	0.2	0.02

Species	DBH Class (in)										Total	% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48			
'Natchez'													
Prunus domestica	3,319	7,832	13,114	13,707	4,210	0	0	0	0	0	**42,183**	0.2	0.04
Cercis canadensis	3,436	16,223	31,206	5,310	0	0	0	0	0	0	**56,175**	0.2	0.05
Schinus molle	429	836	7,069	15,930	74,959	60,596	83,326	12,892	28,767	0	**284,805**	0.2	0.24
Pinus canariensis	1,404	0	11,382	64,245	168,298	82,200	0	0	0	0	**327,529**	0.2	0.27
Washingtonia robusta	584	234	1,273	9,316	2,358	881	0	0	0	0	**14,647**	0.2	0.01
Zelkova serrata	1,638	1,037	0	22,742	216,726	109,674	0	0	0	0	**351,817**	0.2	0.29
Broadleaf Deciduous Medium	2,782	4,217	4,423	5,090	8,974	3,889	10,367	0	0	0	**39,741**	0.2	0.03
Pyrus kawakamii	476	2,713	31,074	65,998	51,847	0	0	0	0	0	**152,108**	0.2	0.13
Robinia ambigua 'Idahoensis'	203	3,170	15,189	4,138	0	0	0	0	0	0	**22,701**	0.2	0.02
Maytenus boaria	645	10,818	23,989	23,590	28,350	0	0	0	0	0	**87,391**	0.2	0.07
Tilia tomentosa 'Green Mountain'	6,455	3,732	25,754	0	0	0	0	0	0	0	**35,941**	0.2	0.03
Acer nigrum 'Green Column'	3,028	8,092	1,088	0	0	0	0	0	0	0	**12,208**	0.2	0.01
Robinia pseudoacacia	1,017	994	4,366	1,714	11,112	31,169	4,023	16,417	0	4,898	**75,711**	0.2	0.06
Acer x freemanii	3,793	8,717	6,688	0	0	0	0	0	0	0	**19,198**	0.2	0.02
Xylosma congestum	593	12,311	29,202	8,349	0	0	0	0	0	0	**50,454**	0.2	0.04
Prunus blieriana	539	7,844	19,687	0	0	0	0	0	0	0	**28,069**	0.2	0.02
Ulmus americana	173	652	7,330	7,348	28,210	43,291	59,988	60,242	0	0	**207,235**	0.2	0.17
Callistemon viminalis	564	4,895	24,293	35,915	25,796	22,220	0	0	0	0	**113,682**	0.2	0.09
Quercus coccinea	156	1,000	39,814	42,830	34,162	28,088	0	0	0	0	**146,050**	0.2	0.12
Quercus palustris	195	1,403	29,861	74,406	14,988	0	0	0	0	0	**120,853**	0.2	0.10
Olea europaea	830	4,525	15,382	26,186	15,540	0	0	0	0	0	**62,463**	0.1	0.05
Albizia julibrissin	812	684	12,259	38,742	12,659	5,572	0	0	0	0	**70,727**	0.1	0.06
Malus species	3,864	5,056	9,565	10,867	0	0	0	0	0	0	**29,353**	0.1	0.02
Tristaniopsis laurina	545	16,117	46,839	0	0	0	0	0	0	0	**63,502**	0.1	0.05
Pyrus calleryana 'Aristocrat'	0	3,031	17,064	32,622	0	0	0	0	0	0	**52,717**	0.1	0.04
Prunus dulces	1,147	3,644	11,757	8,806	0	0	0	0	0	0	**25,355**	0.1	0.02
Callistemon citrinus	0	9,662	28,696	0	7,407	0	0	0	0	0	**45,765**	0.1	0.04
Acer rubrum 'Franksred'	186	7,961	3,853	0	0	0	0	0	0	0	**12,000**	0.1	0.01
Fraxinus velutina	0	0	2,678	16,980	26,566	10,523	13,584	0	7,640	0	**77,969**	0.1	0.06
Eucalyptus polyanthemos	0	0	4,028	34,636	84,975	139,808	124,576	142,509	43,552	40,380	**614,464**	0.1	0.51
Prunus species	1,903	7,381	4,937	2,910	0	0	0	0	0	0	**17,131**	0.1	0.01
Citrus limon	4,060	4,789	2,749	0	0	0	0	0	0	0	**11,598**	0.1	0.01
Morus rubra	53	0	1,913	20,523	42,531	37,619	0	0	0	0	**102,639**	0.1	0.09

Species	DBH Class (in)										Total	% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48			
Schinus terebinthifolius	366	1,011	9,059	27,566	48,271	80,913	53,459	23,378	0	0	**244,023**	0.1	0.20
Calocedrus decurrens	142	435	6,491	39,177	59,211	18,712	29,865	17,978	0	0	**172,011**	0.1	0.14
Ulmus parvifolia 'Athena'	1,713	3,862	34,463	11,602	0	0	0	0	0	0	**51,641**	0.1	0.04
Magnolia x soulangiana	3,397	6,581	10,543	5,223	0	0	0	0	0	0	**25,745**	0.1	0.02
Phoenix canariensis	0	1,749	0	0	0	29,794	51,993	28,144	0	0	**111,680**	0.1	0.09
Quercus species	2,212	2,206	14,704	12,589	0	0	0	0	0	0	**31,712**	0.1	0.03
Acer oblongum	325	0	0	46,409	185,820	68,544	0	0	0	0	**301,097**	0.1	0.25
Prunus armeniaca	1,609	5,978	12,845	4,202	0	0	0	0	0	0	**24,635**	0.1	0.02
Ailanthus altissima	597	426	2,888	6,080	1,750	2,234	0	0	0	0	**13,974**	0.1	0.01
Acer species	372	1,185	2,263	10,724	6,196	12,696	0	5,191	0	0	**38,628**	0.1	0.03
Tilia tomentosa	744	5,383	36,297	27,423	0	0	0	32,293	0	0	**102,139**	0.1	0.09
Carpinus betulus 'Fastigiata'	931	3,613	4,596	2,254	2,422	0	0	0	0	0	**13,814**	0.1	0.01
Tristaniopsis laurina 'Elegant'	2,173	7,704	6,883	0	0	0	0	0	0	0	**16,760**	0.1	0.01
Washingtonia filifera	628	415	863	1,041	7,537	3,215	3,136	0	0	0	**16,835**	0.1	0.01
Tilia tomentosa 'Sterling'	3,162	6,920	8,209	0	0	0	0	0	0	0	**18,291**	0.1	0.02
Juniperus chinensis 'Torulosa'	0	2,367	21,058	2,169	0	0	0	0	0	0	**25,593**	0.1	0.02
Betula jacquemontii	3,855	1,945	0	0	0	0	0	0	0	0	**5,800**	0.1	0.00
Platanus acerifolia 'Bloodgood'	399	6,456	13,239	0	0	0	0	0	0	0	**20,094**	0.1	0.02
Fagus sylvatica	167	1,738	16,798	19,844	12,393	0	0	0	0	0	**50,940**	0.1	0.04
Trachycarpus fortunei	0	0	15,219	1,736	0	0	0	0	0	0	**16,955**	0.1	0.01
Acer capillipes	199	5,784	4,166	4,441	4,210	0	0	0	0	0	**18,800**	0.1	0.02
Casuarina cunninghaminana	0	0	0	24,238	43,742	60,581	11,557	0	0	0	**140,118**	0.1	0.12
Jacaranda mimosifolia	568	3,367	8,085	6,279	4,935	0	0	0	0	0	**23,234**	0.1	0.02
Broadleaf Evergreen Small	732	5,168	4,656	6,361	7,407	22,220	21,217	0	0	0	**67,761**	0.1	0.06
Chionanthus retusus	539	5,056	7,344	0	0	0	0	0	0	0	**12,938**	0.1	0.01
Cordyline australis	945	1,995	1,706	2,224	0	0	537	0	0	0	**7,406**	0.1	0.01
Malus sylvestris	1,534	1,851	7,035	2,604	0	0	0	0	0	0	**13,024**	0.1	0.01
Pinus halepensis	456	0	1,879	6,507	22,047	21,359	8,081	28,006	18,454	17,103	**123,892**	0.1	0.10
Aesculus carnea 'Briotii'	2,440	5,383	0	0	0	0	0	0	0	0	**7,822**	0.1	0.01
Aesculus	1,276	4,506	4,348	4,948	0	31,552	0	0	0	40,380	**87,011**	0.1	0.07

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
hippocastanum													
Broadleaf Deciduous Large	494	278	1,684	5,891	17,201	22,579	15,673	0	0	0	**63,799**	0.1	0.05
Carpinus betulus	761	9,542	0	0	0	0	0	0	0	0	**10,304**	0.1	0.01
Eucalyptus species	281	0	284	1,393	1,750	5,523	8,310	0	5,327	0	**22,866**	0.1	0.02
Ulmus species	171	238	1,728	0	2,729	5,435	9,782	3,187	0	0	**23,270**	0.1	0.02
Yucca gloriosa	0	1,552	3,348	1,784	1,011	0	0	0	0	0	**7,695**	0.1	0.01
Broadleaf Deciduous Small	1,048	1,909	5,061	4,824	0	0	0	0	0	0	**12,842**	0.1	0.01
Nerium oleander	535	5,826	3,188	8,349	0	0	0	0	0	0	**17,899**	0.1	0.01
Picea pungens	0	1,422	5,786	19,595	3,414	0	0	0	0	0	**30,218**	0.1	0.03
Tristaniopsis conferta	936	4,427	4,739	4,413	0	0	0	0	0	0	**14,514**	0.1	0.01
Acer campestre	0	885	16,447	11,371	0	0	0	0	0	0	**28,703**	0.1	0.02
Juglans hindsii	0	845	6,159	14,626	2,822	23,835	11,557	15,283	0	0	**75,128**	0.1	0.06
Citrus sinensis	952	4,771	5,882	4,948	0	0	0	0	0	0	**16,553**	0.1	0.01
Prunus yedoensis	761	1,818	14,834	0	11,242	0	0	0	0	0	**28,655**	0.1	0.02
Pyrus communis	1,563	1,793	3,734	0	0	0	0	0	0	0	**7,090**	0.1	0.01
Crataegus laevigata 'Paul's Scarlet'	2,636	1,263	0	0	0	0	0	0	0	0	**3,899**	0.1	0.00
Eucalyptus globulus	0	0	519	0	2,277	0	3,415	4,796	5,786	14,407	**31,201**	0.1	0.03
Magnolia species	972	2,727	13,619	4,395	0	0	0	0	0	0	**21,712**	0.1	0.02
Acer platanoides	195	3,996	4,124	4,202	6,899	0	19,294	0	0	0	**38,709**	0.1	0.03
Quillaja saponaria	0	0	2,986	0	36,874	64,009	35,750	0	0	0	**139,620**	0.1	0.12
Arbutus unedo	749	3,409	13,276	0	0	0	0	0	0	0	**17,434**	0.1	0.01
Chitalpa 'Pink Dawn'	398	2,360	6,881	0	0	0	0	0	0	0	**9,639**	0.1	0.01
Juglans nigra	0	1,304	4,903	5,891	3,326	0	0	0	0	0	**15,424**	0.1	0.01
Pittosporum species	194	5,936	10,950	0	0	0	0	0	0	0	**17,080**	0.1	0.01
Pinus thunbergiana	137	3,208	14,919	7,874	0	0	0	0	0	0	**26,139**	0.1	0.02
Podocarpus macrophyllus	0	1,163	11,292	39,920	10,299	0	0	0	0	0	**62,674**	0.1	0.05
Arecastrum romanzoffianum	294	340	3,520	1,338	0	0	0	0	0	0	**5,493**	0.0	0.00
Prunus yedoensis 'Akebono'	966	2,244	2,993	0	0	0	0	0	0	0	**6,203**	0.0	0.01
Pseudotsuga menziesii	0	0	842	1,761	7,798	23,512	26,394	24,239	14,791	0	**99,336**	0.0	0.08
Umbellularia californica	190	5,055	4,923	3,242	11,242	0	0	0	0	0	**24,652**	0.0	0.02
Broadleaf Evergreen Medium	700	2,386	6,202	0	11,242	0	0	0	0	0	**20,529**	0.0	0.02
Cercis occidentalis	2,359	393	0	0	0	0	0	0	0	0	**2,752**	0.0	0.00

Species	DBH Class (in)										Total	% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48			
Eucalyptus sideroxylon	0	0	0	0	13,943	2,404	4,114	5,266	6,398	0	**32,124**	0.0	0.03
Cornus species	1,592	1,516	1,049	0	0	0	0	0	0	0	**4,157**	0.0	0.00
Platanus species	142	435	4,760	12,377	12,393	9,356	0	0	0	0	**39,463**	0.0	0.03
Prunus persica	1,890	639	951	0	0	0	0	0	0	0	**3,479**	0.0	0.00
Betula nigra	534	1,846	1,014	2,169	0	0	0	0	0	0	**5,563**	0.0	0.00
Acer griseum	1,990	335	895	0	0	0	0	0	0	0	**3,221**	0.0	0.00
Lagerstroemia 'Tuscarora'	1,165	1,967	1,049	0	0	0	0	0	0	0	**4,181**	0.0	0.00
Diospyros kaki	190	1,837	11,445	4,948	0	0	0	0	0	0	**18,420**	0.0	0.02
Brachychiton populneus	0	0	0	26,446	32,072	50,048	0	0	0	0	**108,566**	0.0	0.09
Grevillea robusta	144	0	0	2,867	6,814	1,161	3,509	0	0	0	**14,494**	0.0	0.01
Pinus species	876	834	0	2,642	2,422	0	0	0	0	0	**6,774**	0.0	0.01
Crinodendron patagua	0	0	2,334	34,605	38,951	0	0	0	0	0	**75,890**	0.0	0.06
Eucalyptus cinerea	0	0	0	11,989	36,874	11,319	0	0	0	0	**60,182**	0.0	0.05
Juniperus species	1,016	738	1,014	0	0	0	0	0	0	0	**2,768**	0.0	0.00
Pittosporum tobira	0	4,672	3,969	0	0	0	0	0	0	0	**8,641**	0.0	0.01
Pittosporum undulatum	137	0	13,276	11,537	0	0	0	0	0	0	**24,950**	0.0	0.02
Alnus rhombifolia	0	238	735	1,346	2,097	0	1,371	0	0	0	**5,787**	0.0	0.00
Ficus carica	945	442	3,223	0	0	0	0	0	0	0	**4,610**	0.0	0.00
Persea americana	350	563	0	5,959	0	0	0	0	0	0	**6,872**	0.0	0.01
Palm Evergreen Medium	0	0	2,308	606	911	966	2,051	0	0	0	**6,843**	0.0	0.01
Photinia x fraseri	1,004	0	3,344	0	0	0	0	0	0	0	**4,348**	0.0	0.00
Quercus kelloggii	0	2,194	10,945	7,400	0	0	0	0	0	0	**20,539**	0.0	0.02
Ficus species	400	680	735	0	0	0	0	0	0	0	**1,814**	0.0	0.00
Koelreuteria species	0	1,674	2,675	0	5,705	0	0	0	0	0	**10,054**	0.0	0.01
Lyonothamnus floribundus	0	519	7,584	4,202	0	0	0	0	0	0	**12,305**	0.0	0.01
Pinus patula	0	0	7,097	15,697	0	0	0	0	0	0	**22,794**	0.0	0.02
Thuja occidentalis	332	519	4,124	2,966	0	0	0	0	0	0	**7,941**	0.0	0.01
Tilia species	0	769	5,473	0	10,161	40,467	0	0	0	0	**56,870**	0.0	0.05
Rhus lancea	0	0	7,417	11,602	0	0	0	0	0	0	**19,019**	0.0	0.02
Cedrus atlantica	156	500	0	4,413	15,825	0	0	0	0	0	**20,894**	0.0	0.02
Cupressus macrocarpa	0	0	1,612	12,607	0	0	0	0	0	28,893	**43,112**	0.0	0.04
Eucalyptus lehmannii	137	0	1,138	0	13,798	0	19,294	0	0	0	**34,367**	0.0	0.03
Ilex altaclarensis	0	0	5,972	0	0	0	0	0	0	0	**5,972**	0.0	0.00
Melaleuca linariifolia	0	582	0	10,621	22,374	0	0	0	0	0	**33,577**	0.0	0.03

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
Myoporum laetum	0	0	589	662	3,774	0	0	0	0	0	**5,025**	0.0	0.00
Pittosporum crassifolium	0	988	1,115	0	0	0	0	0	0	0	**2,103**	0.0	0.00
Conifer Evergreen Small	169	1,011	0	0	0	0	0	0	0	0	**1,180**	0.0	0.00
Cupressus glabra	0	0	1,612	7,169	0	0	0	0	0	0	**8,780**	0.0	0.01
x Cupressocyparis leylandii	0	0	562	0	0	0	0	0	0	0	**562**	0.0	0.00
Ficus elastica	190	1,287	0	0	0	0	0	0	0	0	**1,478**	0.0	0.00
Juniperus chinensis	0	0	1,014	4,712	0	0	0	0	0	0	**5,726**	0.0	0.00
Pittosporum viridiflorum	0	374	2,065	0	0	0	0	0	0	0	**2,439**	0.0	0.00
Quercus wislizenii	0	1,425	2,736	0	0	0	0	0	0	0	**4,161**	0.0	0.00
Taxus baccata	131	769	2,736	0	0	0	0	0	0	0	**3,637**	0.0	0.00
Broadleaf Evergreen Large	0	500	0	4,413	0	0	0	0	0	0	**4,913**	0.0	0.00
Brahea edulis	0	0	0	4,192	0	0	0	0	0	0	**4,192**	0.0	0.00
Conifer Evergreen Medium	0	0	0	2,455	6,688	0	0	0	0	0	**9,143**	0.0	0.01
Chamaerops humilis	0	0	1,895	0	0	0	0	0	0	0	**1,895**	0.0	0.00
Citrus x paradisi	0	961	0	0	0	0	0	0	0	0	**961**	0.0	0.00
Cupaniopsis anacardioides	0	0	865	1,795	0	0	0	0	0	0	**2,660**	0.0	0.00
Hymenosporum flavum	0	0	0	4,202	4,520	0	0	0	0	0	**8,722**	0.0	0.01
Juniperus californica	0	0	1,014	2,543	0	0	0	0	0	0	**3,557**	0.0	0.00
Laurus nobilis	0	1,287	0	0	0	0	0	0	0	0	**1,287**	0.0	0.00
Lycianthes rantonnei	366	0	0	0	0	0	0	0	0	0	**366**	0.0	0.00
Melaleuca quinquenervia	0	0	2,174	0	11,242	0	0	0	0	0	**13,416**	0.0	0.01
Pittosporum eugenioides	0	0	2,749	0	0	0	0	0	0	0	**2,749**	0.0	0.00
Pyracantha species	0	465	1,721	0	0	0	0	0	0	0	**2,186**	0.0	0.00
Salix species	0	0	587	0	0	0	4,772	0	0	0	**5,359**	0.0	0.00
Viburnum japonicum	275	0	0	0	0	0	0	0	0	0	**275**	0.0	0.00
Yucca recurvifolia	294	340	0	0	0	0	0	0	0	0	**634**	0.0	0.00
Arbutus menziesii	0	0	0	4,202	0	0	0	0	0	0	**4,202**	0.0	0.00
Conifer Evergreen Large	0	0	0	3,030	0	0	0	0	0	0	**3,030**	0.0	0.00
Celtis reticulata	0	0	1,612	0	0	0	0	0	0	0	**1,612**	0.0	0.00
Chamaecyparis lawsoniana	0	0	1,535	0	0	0	0	0	0	0	**1,535**	0.0	0.00

Species	DBH Class (in)											% of Pop	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	>48	Total		
Dodonaea viscosa	169	0	0	0	0	0	0	0	0	0	**169**	0.0	0.00
Eucalyptus ficifolia	0	519	0	0	0	0	0	0	0	0	**519**	0.0	0.00
Feijoa sellowiana	0	0	1,985	0	0	0	0	0	0	0	**1,985**	0.0	0.00
Heteromeles arbutifolia	0	410	0	0	0	0	0	0	0	0	**410**	0.0	0.00
Ilex cornuta	0	0	1,721	0	0	0	0	0	0	0	**1,721**	0.0	0.00
Leptospermum laevigata	0	0	2,174	0	0	0	0	0	0	0	**2,174**	0.0	0.00
Phoenix dactylifera	0	0	741	0	0	0	0	0	0	0	**741**	0.0	0.00
Sequoiadendron giganteum	0	0	0	0	0	0	4,772	0	0	0	**4,772**	0.0	0.00
Thuja plicata	0	435	0	0	0	0	0	0	0	0	**435**	0.0	0.00
All trees	**461,950**	**1,659,957**	**9,269,799**	**24,228,244**	**35,623,837**	**26,121,259**	**13,426,773**	**5,316,124**	**2,449,545**	**1,415,370**	**119,972,858**	**100%**	**100%**