URBAN FOREST RESOURCE ANALYSIS OF INVENTORIED PARK TREES

Clark County, Nevada

June 2013

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

Clark County, Nevada
Resource Analysis
of Inventoried Park Trees

June 2013

Prepared for

Nevada Division of Forestry

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Executive Summary

Trees play a vital role in the communities of Clark County, Nevada. They provide numerous benefits both tangible and intangible, to residents, visitors, and neighboring communities. Dedicated to maintaining 24,552 trees in county parks, Clark County has demonstrated that public trees are a valued community resource, an important component of the urban infrastructure, and a part of the County's identity.

The Nevada Division of Forestry (NDF) has an interest in supporting urban forest management across the state. In 2012, NDF contracted with Davey Resource Group (DRG) to collect an inventory of public trees within an area designated as the Clark County Area of Interest (AOI). The AOI encompassed multiple entities, including the unincorporated Clark County, the City of Mesquite, North Las Vegas, Las Vegas, Boulder City, the Clark County School District, and the University of Nevada, Las Vegas (UNLV). During the inventory, a certified arborist briefly inspected each tree and recorded information including species, size, condition, geographic location, and current maintenance needs. Arborists collected this information for nearly 100,000 individual tree sites across the AOI. For Clark County, this included 24,552 individual sites in county parks. Upon completion of the inventory for each entity, DRG performed a detailed and quantified analysis of the current structure, function, and value of this tree resource using the inventory data in conjunction with i-Tree benefit-cost modeling software.

Clark County's park tree populations in the inventoried parks are providing annual benefits of $834,609 ($0.43 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.

Clark County did not provide a maintenance budget for park trees. With that data, the following additional analysis can be provided:

- A Benefit Investment Ratio (BIR - value of benefits vs. cost of maintenance)
- The Overall Net Benefit of the tree population
- An Average Net Benefit per Tree

Clark County's park tree inventory is reducing annual electric energy consumption by 1,221 megawatts (MWh) and annual natural gas consumption by 8,723 therms, for a combined value of $87,592. In addition, these trees are removing 1.66 tons of pollutants from the air, including ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulates ($_{PM10}$) for an overall annual air quality benefit of $43,608. Canopy from this population covers 141.8 acres. This canopy reduces annual stormwater runoff volume by 7.7 million gallons and protects local water resources by reducing sediment and pollution loading.

Trees are a part of the community infrastructure. However, unlike many other public assets, with proper maintenance, trees have the potential to increase in value over time. Clark County's inventoried tree resource is a relatively young population in overall good condition. With more than 119 different species, Clark County is well positioned to realize a significant increase in environmental benefits as tree populations continue to mature. An ongoing commitment to maximizing and maintaining the health of the urban forest will ensure that the community continues to be a healthy, safe, and enjoyable place to live.

Introduction

Clark County is located in Southern Nevada. With an estimated population of 2,036,358, it is the most populous county in the state of Nevada, accounting for nearly three-quarters of its residents. Clark County's arid climate makes it one of the driest places in the country. Despite the challenges imposed by climate, the County has invested in planting and maintaining over 24,500 trees in its regional parks. These trees compose Clark County's urban forest.

A healthy urban forest plays an important role in the quality of life in Clark County.

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

In addition to these direct improvements, healthy urban trees increase the overall attractiveness of a community and the value of local real estate by 7% to 10%. Trees promote shopping, retail sales, and tourism (Wolf, 2007). Trees support a more livable community, fostering psychological health and providing residents with a greater sense of place (Ulrich, 1986; Kaplan, 1989). Community trees, both public and private, soften the urban hardscape by providing a green sanctuary, making Clark County a more enjoyable place to live, work, and play. The County's 24,552 park trees play a prominent role in the overall urban forest benefits afforded to the community. Residents rely on the Clark County Public Works Department to protect and maintain this vital resource.

Clark County participated in a Nevada Division of Forestry (NDF) sponsored project in 2012 to inventory a portion of their public park trees. By participating, Clark County reflects the community's appreciation, concern, and proactive stance on the management of public trees.

A team of International Society of Arboriculture certified arborists from Davey Resource Group (DRG) mapped the location and collected data on publicly owned trees using global positioning system technology. In addition to location, the arborists collected information about the species, size, condition, and current maintenance needs of each tree. An urban forest is a dynamic resource, constantly changing and growing in response to environment and care. It is critical for the County to update the inventory data, using asset management software, as maintenance needs are addressed and trees mature.

The inventory data was analyzed with i-Tree's *Streets*, a STRATUM Analysis Tool (*Streets* v5.0.1; i-Tree v5.0.6), to develop a resource analysis and report of the current condition of the inventoried urban forest. This report, unique to Clark County, effectively quantifies the value of the community's park trees with regard to actual benefits derived from the tree resource. In addition, the report provides baseline values that can be used to develop and update an urban forest management plan.

Management plans help communities determine where to focus available resources and set benchmarks for measuring progress.

This urban forest resource analysis and report provides information on the structure, function, and value of a specific tree resource. With this information, managers and citizens can make informed decisions about tree management strategies. This report provides the following information:

- A description of the current structure of Clark County's inventoried tree resource and an established benchmark for future management decisions.
- The economic value of the benefits from the urban forest, illustrating the relevance and relationship of trees to local quality of life issues such as air quality, environmental health, economic development, and psychological health.
- Data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-governmental organizations, air quality districts, federal and state agencies, legislative initiatives, or local assessment fees.
- Benchmark data for developing a long-term urban forest management plan.

Chapter 1: Urban Forest Resource Summary

Summary of Urban Forest Resource Structure

Clark County's urban forest resource considered 24,552 park trees and 381 available planting sites.

A structural analysis is the first step towards understanding the benefits provided by these trees as well as their management needs. Considering species composition, diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes this urban forest resource:

- There were 119 unique tree species identified in the inventory. The predominant tree species are *Pinus eldarica* (Mondale pine, 15%), *Fraxinus velutina* 'Fan-Tex' (Fan-Tex ash, 10%) and *Fraxinus velutina* (velvet ash, 6%).
- The age structure of the inventoried tree population is young overall, with 60% of trees measuring between 0 to 6 inches DBH (diameter at breast height, measured at 4'6" above the ground) and 88% under 12 inches DBH.
- Half of the inventoried trees (51%) are in fair condition, and 39% are in good condition.
- To date, the inventoried tree population has sequestered 3,804 tons of carbon (CO_2), valued at approximately $57,061.
- Replacement of Clark County's 24,552 inventoried trees with trees of similar size, species, and condition would cost over $61 million.

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Summary of Urban Forest Benefits

Annually, Clark County's inventoried park trees provide cumulative benefits to the community at an average value of $33.99 per tree, for a total gross value of $ 834,609 per year. These annual benefits include:

- Trees reduce electricity and natural gas use in their neighborhoods through shading and climate effects for an overall benefit of $87,592, an average of $3.57 per tree.
- Trees sequester 455 tons of atmospheric CO_2 per year. An additional 610 tons are avoided[1] by reducing energy generation, resulting in a net value of $15,437 and an average of $0.63 per tree.
- Net air quality improvements, including removal and avoidance of pollutants, provided by the inventoried park tree population are valued at $43,608, an average per tree benefit of $1.78.
- Clark County's inventoried park trees intercept an estimated 7.7 million gallons of stormwater annually for a total value of $37,181, an average of $1.51 per tree.
- The benefit contributed by Clark County's inventoried park trees to property value increases, aesthetics, and socioeconomics equals $650,791, an average of $26.51 per tree.

[1] Avoided pollution is a result of reducing energy consumption. The avoided value represents pollution would have resulted from the generation of additional energy.

Urban Forest Resource Management

Clark County's park tree population is a dynamic resource that requires continued investment to maintain and realize its full benefit potential. **These community trees are one of the few assets that have the potential to increase in value with time and proper management.** Appropriate and timely tree care can substantially increase lifespan. When trees live longer, they provide greater benefits. As individual trees continue to mature, and aging trees are replaced, the overall value of the community forest and the amount of benefits provided grow as well. This vital, living resource is, however, vulnerable to a host of stressors and requires ecologically sound and sustainable best management practices to ensure a continued flow of benefits for future generations.

Maintaining an appropriate age distribution by planting new trees and focusing on large-stature trees will help maximize future urban forest benefits to the community.

Clark County has the benefit of a relatively young urban forest in good condition. The County should focus resources on maximizing the flow of benefits from the current tree population and maintaining a forward-thinking approach. Based on the resource analysis, DRG recommends the following:

- Maintain an appropriate age distribution by continuing to plant new trees to improve long-term resource sustainability and greater canopy coverage. To maximize benefits, focus on medium- to large-stature trees where planting sites allow.
- Maximize the condition of the existing tree resource through continuing comprehensive tree maintenance and a cyclical pruning schedule.
- Continue annual tree planting efforts with the goal of achieving a 100% stocking rate, utilizing available planting sites identified by the inventory.
- Implement a structural pruning program for young and establishing trees to promote healthy structure, extend life expectancy, and reduce future costs and liability.
- Maintain and update the inventory database.

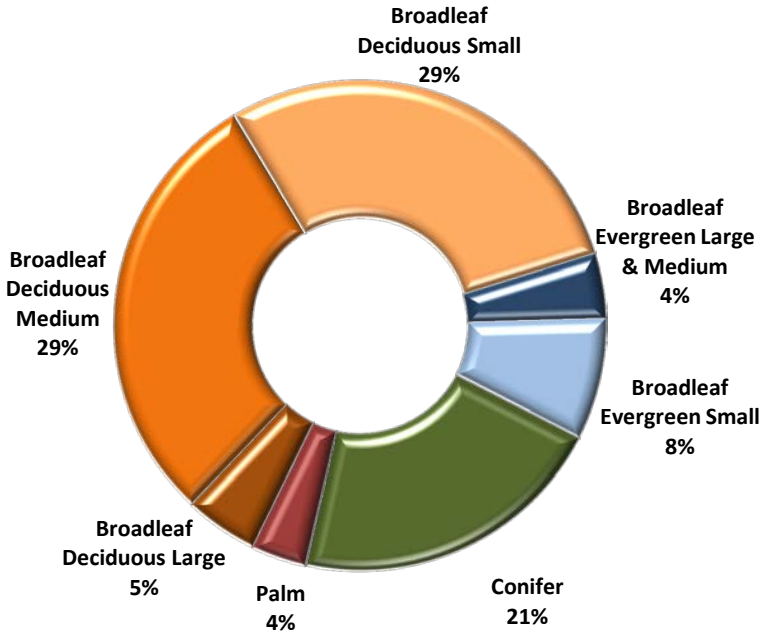
The value of Clark County's inventoried tree resource will continue to increase as existing trees mature and new trees are planted. As the resource grows, continued investment in management is critical to ensuring that residents will continue receiving a high return on investment in the future. It is not as simple as planting more trees to increase canopy cover and benefits. Planning and funding for tree care and tree management must complement planting efforts in order to ensure the long-term success and health of Clark County’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. Managers can take pride in knowing that trees improve the quality of life in the County.

Chapter 2: Clark County's Urban Forest Resource

A county's urban forest resource is more thoroughly understood through examination of composition and species richness (diversity). Inferences based on this data can help managers understand the importance of individual tree species to the overall forest as it exists today. Consideration of stocking level (trees per available space), canopy cover, age distribution, condition, and performance helps to project the potential of the forest resource.

Population Composition

Broadleaf species are the most common among Clark County's inventoried park tree population, comprising 75% of the total inventory. Broadleaf trees typically have larger canopies than coniferous trees of the same size diameter. 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. Deciduous broadleaf species make up 63% of Clark County's park tree population, including 5% large-stature, 29% medium-stature, and 29% small-stature trees. Evergreen broadleaf trees comprise 12% of the population, including 4% large- and medium-stature and 8% small stature. Conifers represent 21% of the overall population, and they are primarily large stature trees. Approximately 4% of the population is comprised of palms. (Figure 1 and Table 1).



Conifer Small, Conifer Medium and Broadleaf Evergreen Large represent <1% each

Figure 1. Overall Composition of Clark County's Inventoried Park Tree Population

Species Richness and Composition

Clark County's inventoried park tree population (Table 1 and Appendix C) includes a mix of 119 unique species, almost twice 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 10 species represent 59% of the total population (Figure 2). The predominant tree species are *Pinus eldarica* (Mondale pine, 15.5%), *Fraxinus velutina* 'Fan-Tex' (Fan-Tex ash, 10.3%) and *Fraxinus velutina* (velvet ash, 5.9%).

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). The genus *Pinus* (20.8%) is slightly over-represented as more than 20% of the population, and both *Pinus eldarica* and *Fraxinus velutina* 'Fan-Tex' exceed the 10% species rule. New plantings in the immediate future should limit these species to reduce overreliance.

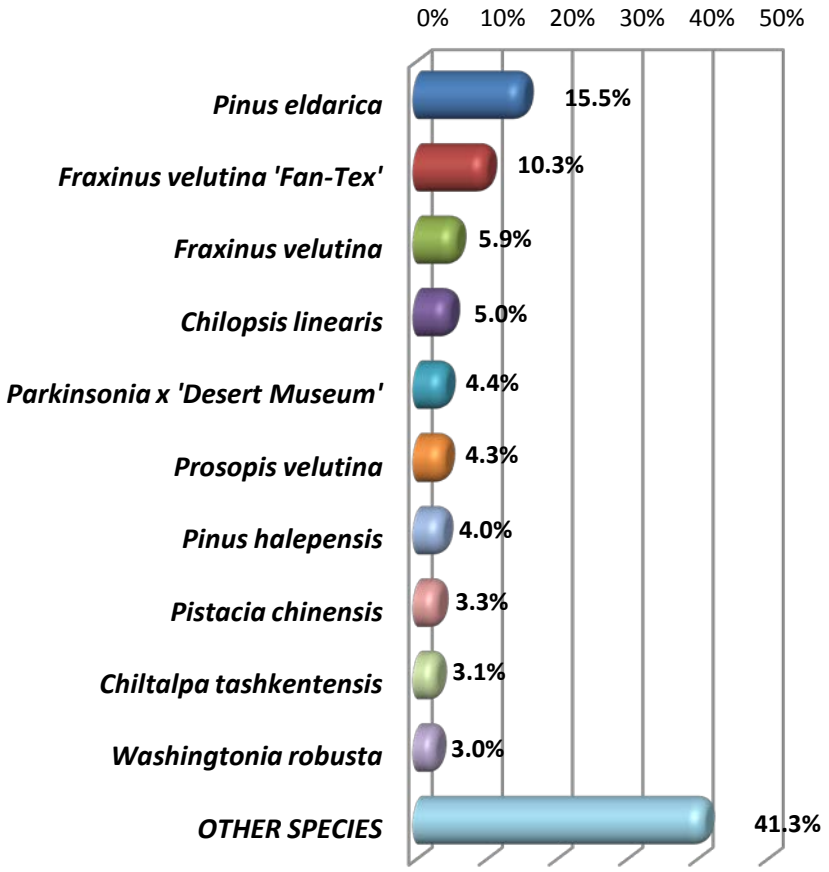


Figure 2. Frequency of Top 10 Species in Clark County's Inventoried Park Tree Population

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

Maintaining a diverse population within an urban forest is important to reduce the risk of unexpected, devastating, and costly, pest and pathogen damage.

Table 1. Population Distribution of Clark County's Park Tree Inventory

Species	DBH Class (in) 0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	% of Pop.
Broadleaf Deciduous Large (BDL)											
Gleditsia triacanthos	78	106	103	20	1	0	0	0	0	308	1.3%
BDL OTHER	44	95	320	202	114	35	9	3	0	822	3.3%
Total	**122**	**201**	**423**	**222**	**115**	**35**	**9**	**3**	**0**	**1,130**	**4.6%**
Broadleaf Deciduous Medium (BDM)											
Fraxinus velutina 'Fan-Tex'	509	1,264	703	48	1	0	0	0	0	2,525	10.3%
Fraxinus velutina	210	489	589	130	19	6	0	0	0	1,443	5.9%
Pistacia chinensis	226	457	133	2	0	0	0	0	0	818	3.3%
Ulmus parvifolia	65	382	153	4	1	0	0	0	0	605	2.5%
Fraxinus angustifolia	72	214	112	4	0	0	0	0	0	402	1.6%
Prosopis chilensis	83	112	77	25	6	5	0	0	0	308	1.3%
Parkinsonia florida	90	165	32	1	0	0	0	0	0	288	1.2%
BDM OTHER	139	213	258	125	49	7	1	0	0	792	3.2%
Total	**1,394**	**3,296**	**2,057**	**339**	**76**	**18**	**1**	**0**	**0**	**7,181**	**29.2%**
Broadleaf Deciduous Small (BDS)											
Chilopsis linearis	767	356	94	8	0	0	0	0	0	1,225	5.0%
Parkinsonia x 'Desert Museum'	706	288	74	1	1	0	0	0	0	1,070	4.4%
Prosopis velutina	517	291	221	22	1	0	0	0	0	1,052	4.3%
ChitalpaChitalpa tashkentensis	110	297	340	8	0	0	0	0	0	755	3.1%
Vitex agnus-castus	537	157	16	1	0	0	0	0	0	711	2.9%
Prosopis glandulosa	227	276	100	1	0	0	0	0	0	604	2.5%
Prosopis torreyana	294	114	40	8	0	0	0	0	0	456	1.9%

Species	DBH Class (in)										
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	% of Pop.
Acacia farnesiana	259	113	23	0	0	0	0	0	0	395	1.6%
BDS OTHER	348	292	148	2	0	0	0	0	0	790	3.2%
Total	**3,765**	**2,184**	**1,056**	**51**	**2**	**0**	**0**	**0**	**0**	**7,058**	**28.7%**
Broadleaf Evergreen Large (BEL)											
BEL OTHER	22	30	23	9	2	0	0	0	0	86	0.4%
Total	**22**	**30**	**23**	**9**	**2**	**0**	**0**	**0**	**0**	**86**	**0.4%**
Broadleaf Evergreen Medium (BEM)											
Quercus virginiana	210	267	149	5	0	0	0	0	0	631	2.6%
BEM OTHER	112	145	34	11	0	0	1	0	0	303	1.2%
Total	**322**	**412**	**183**	**16**	**0**	**0**	**1**	**0**	**0**	**934**	**3.8%**
Broadleaf Evergreen Small (BES)											
Acacia stenophylla	122	491	99	1	0	0	0	0	0	713	2.9%
Rhus lancea	89	130	47	1	1	0	0	0	0	268	1.1%
BES OTHER	310	560	116	3	0	0	0	0	0	989	4.0%
Total	**521**	**1,181**	**262**	**5**	**1**	**0**	**0**	**0**	**0**	**1,970**	**8.0%**
Conifer Evergreen Large (CEL)											
Pinus eldarica	97	829	2,050	727	94	4	0	0	0	3,801	15.5%
Pinus halepensis	29	177	371	285	95	22	8	0	1	988	4.0%
CEL OTHER	13	115	161	37	2	0	0	0	0	328	1.3%
Total	**139**	**1,121**	**2,582**	**1,049**	**191**	**26**	**8**	**0**	**1**	**5,117**	**20.8%**

Species	DBH Class (in)										
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	% of Pop.
Conifer Evergreen Medium (CEM)											
CEM OTHER	0	1	25	0	0	0	0	0	0	26	0.1%
Total	**0**	**1**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**26**	**0.1%**
Conifer Evergreen Small (CES)											
CES OTHER	0	0	3	0	0	0	0	0	0	3	0.0%
Total	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0.0%**
Palm Evergreen Large (PEL)											
PEL OTHER	0	0	2	4	4	6	0	0	0	16	0.1%
Total	**0**	**0**	**2**	**4**	**4**	**6**	**0**	**0**	**0**	**16**	**0.1%**
Palm Evergreen Medium (PEM)											
PEM OTHER	0	0	4	58	68	2	0	0	0	132	0.5%
Total	**0**	**0**	**4**	**58**	**68**	**2**	**0**	**0**	**0**	**132**	**0.5%**
Palm Evergreen Small (PES)											
Washingtonia robusta	14	19	288	355	57	0	6	0	0	739	3.0%
PES OTHER	0	0	17	45	61	22	13	1	1	160	0.7%
Total	**14**	**19**	**305**	**400**	**118**	**22**	**19**	**1**	**1**	**899**	**3.7%**
County-wide Total	**6,299**	**8,445**	**6,925**	**2,153**	**577**	**109**	**38**	**4**	**2**	**24,552**	**100%**

Species Importance

To quantify the significance of any one particular species found in Clark County's urban forest, an *importance value* (IV) is derived for each of the most common species. Importance values are particularly meaningful to urban forest managers because they indicate a community's reliance on the functional capacity of a 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 county's urban forest population. Since importance value goes beyond population numbers alone, it can help managers to better comprehend the resulting loss of benefits from a catastrophic loss of any one species. When importance values are comparatively equal among the 10 to 15 most 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 shorter lifespans and increased long-term management investments.

The 22 most abundant species each represent greater than 1% of the total population. Together, these 22 species represent 82% of the total population, 73% of the total leaf area, and 78% of the total canopy cover for a combined importance value of 78 (Table 2). Of these species, Clark County relies most on *Pinus eldarica* (Mondale pine, IV=17.8), followed by *Fraxinus velutina* 'Fan-Tex' (Fan-Tex ash, IV=10.5) and *Fraxinus velutina* (velvet ash, IV=7.3).

Due to their large stature and high leaf surface area, some species provide more impact than their population numbers alone would suggest. For example, Clark County's *Ulmus parvifolia* (Chinese elm, IV= 3.4) represents just 2.5% of the population while providing 4.6% of the canopy. This species is a large-stature deciduous hardwood that grows vigorously and often has higher maintenance needs. Their maintenance needs may be justified, however, considering the benefits provided by these trees are relatively high.

The low importance value of some species is a function of tree type. Immature and small-stature populations tend to have lower importance values than their percentage in the overall population might suggest. This is due to their relatively small leaf area and canopy coverage. For instance, Clark County's *Chilopsis linearis* (desert willow) represents 5% of the total population, but because of their small stature, its importance value is just 2.5 (Table 2).

Table 2. Importance Value (IV) of Clark County's Most Abundant Park Tree Species

Species	Number of Trees	% of Pop.	Leaf Area (ft^2)	% of Total Leaf Area	Canopy Cover (ft^2)	% of Total Canopy Cover	Importance Value
Pinus eldarica	3801	15.48	3,332,734	19.41	**1,136,708**	18.40	17.76
Fraxinus velutina 'Fan-Tex'	2525	10.28	1,565,109	9.11	**751,331**	12.16	10.52
Fraxinus velutina	1443	5.88	1,439,078	8.38	**472,173**	7.64	7.30
Chilopsis linearis	1225	4.99	192,943	1.12	**96,761**	1.57	2.56
Parkinsonia x 'Desert Museum'	1070	4.36	179,846	1.05	**111,284**	1.80	2.40
Prosopis velutina	1052	4.28	505,704	2.94	**231,855**	3.75	3.66
Pinus halepensis	988	4.02	1,944,322	11.32	**455,836**	7.38	7.58
Pistacia chinensis	818	3.33	304,414	1.77	**137,101**	2.22	2.44
ChitalpaChitalpa tashkentensis	755	3.08	330,871	1.93	**178,720**	2.89	2.63
Washingtonia robusta	739	3.01	204,104	1.19	**56,520**	0.92	1.70
Acacia stenophylla	713	2.90	280,044	1.63	**106,425**	1.72	2.09
Vitex agnus-castus	711	2.90	92,042	0.54	**60,207**	0.97	1.47
Quercus virginiana	631	2.57	263,181	1.53	**118,077**	1.91	2.00
Ulmus parvifolia	605	2.46	549,308	3.20	**282,356**	4.57	3.41
Prosopis glandulosa	604	2.46	260,825	1.52	**125,078**	2.02	2.00
Prosopis torreyana	456	1.86	90,253	0.53	**53,033**	0.86	1.08
Fraxinus angustifolia	402	1.64	242,611	1.41	**117,882**	1.91	1.65
Acacia farnesiana	395	1.61	63,993	0.37	**40,058**	0.65	0.88
Gleditsia triacanthos	308	1.25	262,327	1.53	**75,945**	1.23	1.34
Prosopis chilensis	308	1.25	289,052	1.68	**119,022**	1.93	1.62
Parkinsonia florida	288	1.17	103,690	0.60	**65,899**	1.07	0.95
Rhus lancea	268	1.09	101,677	0.59	**39,113**	0.63	0.77
Other Trees	4447	18.11	4,575,058	26.64	**1,345,512**	21.78	22.18
County-wide Total	**24,552**	**100%**	**17,173,186**	**100%**	**6,176,897**	**100%**	**100%**

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. Overall, the inventoried park trees provide 141.8 acres of tree canopy cover. *Pinus eldarica* (Mondale pine), followed by *Fraxinus velutina* 'Fan-Tex' (Fan-Tex ash) provide the largest proportion of canopy, accounting for 18.4% and 12.2% of the total canopy respectively. According to the Clark County Parks and Recreation website, there is approximately 1,600 acres of parks in the county. Trees therefore shade approximately 8.9% of the parkland.

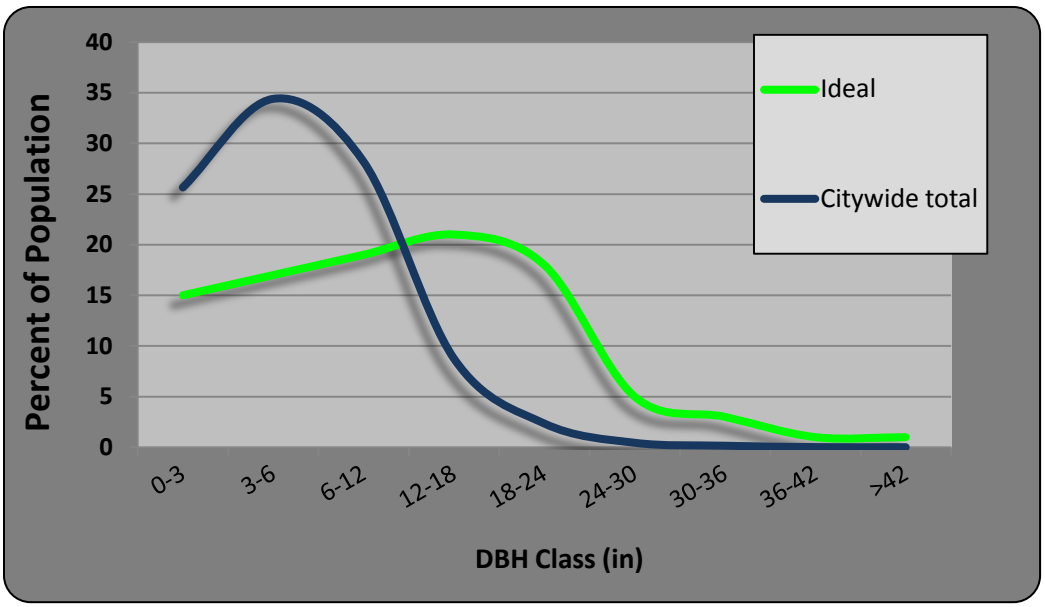


Figure 3. Overall Relative Age Distribution of Clark County's Tree Inventory

Relative Age Distribution

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

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

Overall, the age distribution of Clark County's urban forest is weighted towards young trees, with 60% of the population consisting of trees with a DBH of six inches or smaller. Established trees (6-18 inches DBH) comprise 37%, and mature trees (>18 inches DBH) make up less than 3% of the overall population. With continued, proactive management of this young urban forest, Clark County can expect increasing benefits as this resource matures. Clark County has very few trees in the large diameter classes (>24"). This may be, at least in part, a result of the arid environment rather than the overall age of the street tree population. Trees in the older age classes provide greater benefits due to their high leaf surface area. Emphasis should be placed on preserving older trees.

Of Clark County's nine most common park tree species (Figure 4*),* the youngest population is likely *Parkinsonia x 'Desert Museum'* (desert museum Palo verde, 93% under 6" DBH).

Pistacia chinensis (Chinese pistache, 84% under 6" DBH) is a medium-stature tree well represented in the young age classes. This species has considerable potential to increase in value and benefit with appropriate maintenance.

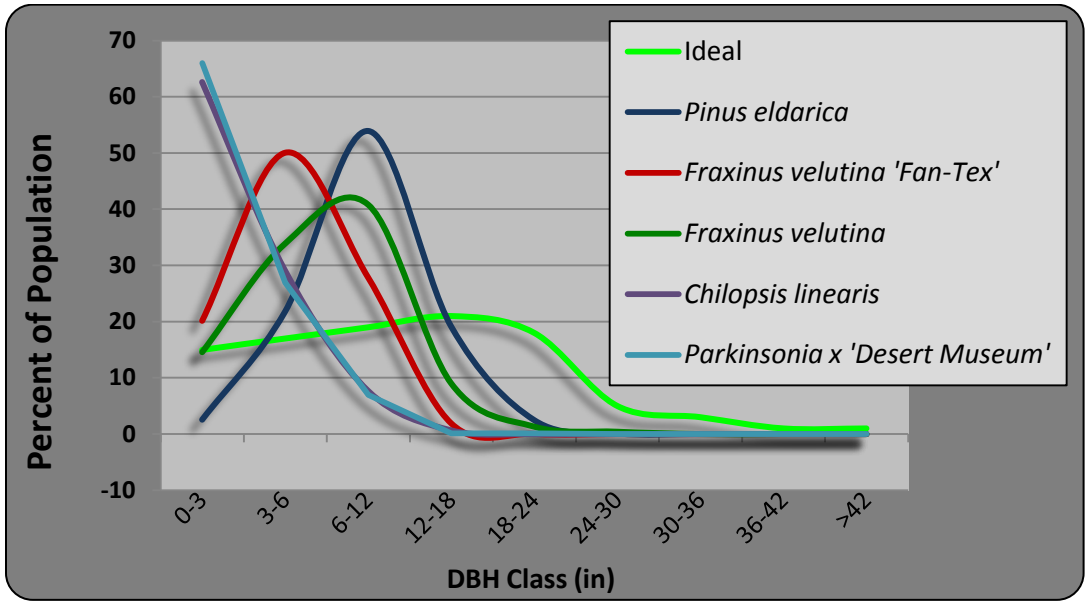
Four of the nine most common species are small-stature trees with significant representation in the small DBH classes. Because these species are smaller at maturity, this is not necessarily an indication of young age. *Parkinsonia x 'Desert Museum'* (desert museum Palo verde, 92.9% under 6" DBH), *Chilopsis linearis* (desert willow, 91.7% under 6" DBH), and *Prosopis velutina* (velvet mesquite, 76.8% under 6" DBH) are small-stature populations that are likely to continue to provide benefits at a flat or declining rate over time.

Pinus eldarica (Mondale pine) and *Pinus halepensis* (Aleppo pine) are the only established populations of large-stature trees. These species will continue to provide increased benefits over time.

As young populations mature and eventually grow old, their maintenance needs are likely to increase. Future plantings should adequately represent long-standing and high-performing species. Sufficient replacements should be planted to ensure the functional capacity and benefit streams from these populations, even as individuals begin to decline.

With a relatively young urban forest and proactive management, Clark County can expect greater benefits as large-stature trees mature. New installations should carefully consider species selection, increasing the use of underused and well-performing species, and focusing on medium and large-statured species.

In addition to planting, it is critical to dedicate resources to ensuring proper maintenance as trees mature. A long-term, sustainable management plan, including regular inspection and pruning cycles, can ensure Clark County'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.



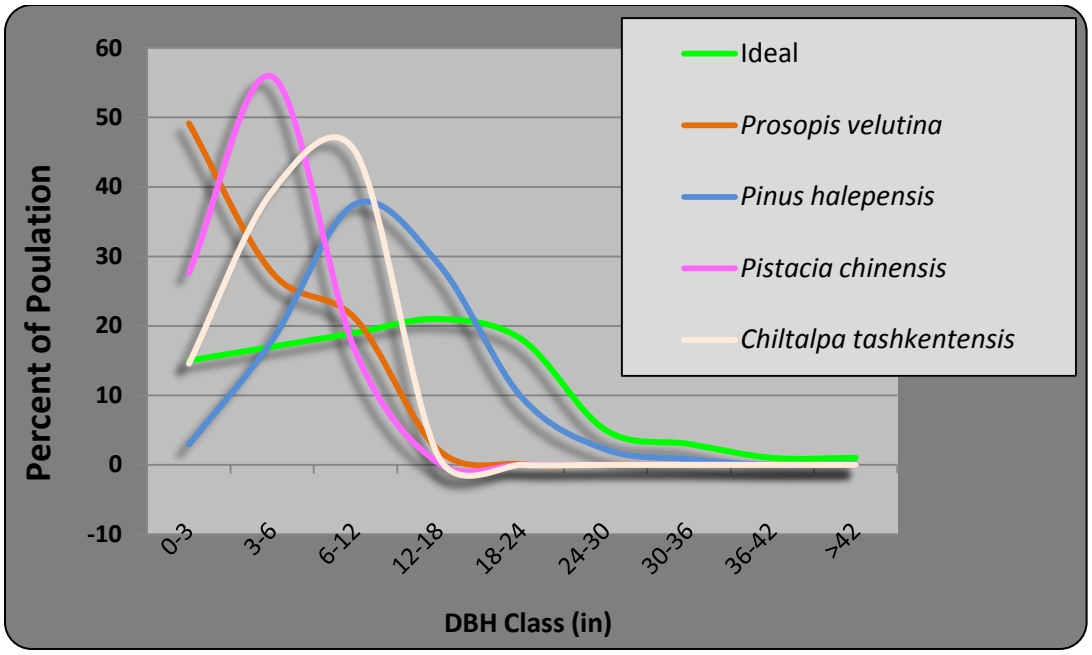


Figure 4. Relative Age Distribution of Clark County's Top Nine Inventoried Tree Species

Urban Forest Condition and Relative Performance

Tree condition is an indication of how well trees are managed and how well they are performing in a given site-specific environment (e.g., street median, parking lot, etc.). Each inventoried tree was rated for overall condition, including consideration for structure, foliage, and the root collar. When trees are performing at their peak, the benefits they provide are maximized.

The inventory found 39% of Clark County's trees in good condition and over 50% in fair condition. Nearly 10% of the population was determined to be in poor condition. Removal or mitigation of dead and failing trees is recommended as soon as possible to reduce liability exposure.

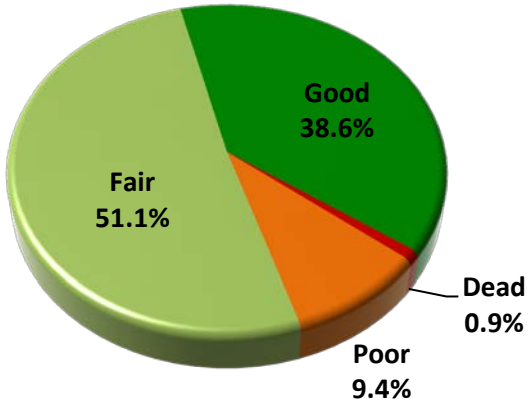


Figure 5. Condition of Clark County's Inventoried Park Trees

The *relative performance index* (RPI) is one way to further analyze the condition and suitability of specific 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 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.

Among the 24 most common species collected by the inventory, 15 have an RPI of 1.0 or greater (Table 3). Of these, *Acacia stenophyla* (shoestring acacia, RPI=1.14), and *Washingtonia robusta* (Mexican fan palm, RPI=1.11) have the highest RPI, while *Populus* spp. (Cottonwood, RPI=0.83) and C*hitalpa tashkentensis* (chitalpa, RPI=0.88) have the lowest (Table 3).

The RPI can be a useful tool for urban forest managers. For example, if a community has been planting two or more new species, the RPI can be used to compare their relative performance. If the RPI indicates that one is performing relatively poorly, managers may decide to reduce or even stop planting that species and subsequently save money on both planting stock and replacement costs. The RPI enables managers to look at the performance of long-standing species as well. Established species with an RPI of 1.00 or greater have performed well when compared to the population as a whole. These top performers should be retained, and planted, as a healthy proportion of the overall population. It is important to keep in mind that, because RPI is based on condition at the time of the inventory, it may not reflect cosmetic or nuisance issues, especially seasonal issues that are not threatening the health or structure of the trees.

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 based on 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 simply be exhibiting signs of population senescence. The individuals of this species may have produced substantial benefits over the years and the species should continue to be considered when making determinations for future planting. A complete table, with RPI values for all species, is included in Appendix C.

Table 3. Relative Performance Index (RPI) for Clark County's Inventoried Park Trees

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Pinus eldarica	0.1	8.7	42.3	48.9	**1.0**	3,801	15.5
Fraxinus velutina 'Fan-Tex'	1.3	12.8	57.7	28.2	**0.9**	2,525	10.3
Fraxinus velutina	0.7	8.5	52.7	38.0	**1.0**	1,443	5.9
Chilopsis linearis	0.6	9.1	46.3	44.0	**1.0**	1,225	5.0
Parkinsonia x 'Desert Museum'	0.1	5.5	77.7	16.7	**0.9**	1,070	4.4
Prosopis velutina	1.3	10.8	62.6	25.2	**0.9**	1,052	4.3
Pinus halepensis	0.1	3.8	53.8	42.2	**1.0**	988	4.0
Pistacia chinensis	1.5	9.8	50.9	37.9	**1.0**	818	3.3
Chiltalpa tashkentensis	0.8	15.2	73.2	10.7	**0.9**	755	3.1
Washingtonia robusta	0.7	2.7	35.6	61.0	**1.1**	739	3.0
Acacia stenophylla	0.3	0.3	35.2	64.2	**1.1**	713	2.9
Vitex agnus-castus	0.4	9.1	44.9	45.6	**1.0**	711	2.9
Quercus virginiana	0.8	6.3	49.0	43.9	**1.0**	631	2.6
Ulmus parvifolia	0.7	14.2	55.7	29.4	**0.9**	605	2.5
Prosopis glandulosa	1.3	7.3	54.3	37.1	**1.0**	604	2.5
Prosopis torreyana	1.8	10.7	40.4	47.1	**1.0**	456	1.9
Fraxinus angustifolia	2.2	17.2	57.2	23.4	**0.9**	402	1.6
Acacia farnesiana	0.3	5.6	57.5	36.7	**1.0**	395	1.6
Gleditsia triacanthos	2.3	19.2	50.0	28.6	**0.9**	308	1.3
Prosopis chilensis	1.9	5.8	59.4	32.8	**1.0**	308	1.3
Parkinsonia florida	2.4	6.3	65.6	25.7	**1.0**	288	1.2
Rhus lancea	0.4	7.1	37.3	55.2	**1.1**	268	1.1
Other Trees	0.0	0.1	0.5	0.4	**1.0**	3,959	18.1
County-wide Total	**0.9**	**9.4**	**51.1**	**38.6**	**1.0**	**24,552**	**100%**

The RPI value can also help to identify underused species that are demonstrating good performance. Trees with an RPI value greater than 1.00 and an established age distribution may be indicating their suitability in the local environment and should receive consideration for additional planting (Table 4). When considering new species, it helps to base the decision on established populations. The greater number of trees of a particular species, the more relevant the RPI becomes. The following species appear to be performing well and should be considered for future tree plantings.

Table 4. Tree Species Which May be Underused, Based on RPI

Species	RPI	# of Trees	% of Pop.
Rhus lancea	**1.08**	268	1.1
Quercus virginiana	**1.03**	631	2.6
Vitex agnus-castus	**1.03**	711	2.9
Prosopis torreyana	**1.02**	456	1.9
Acacia farnesiana	**1.01**	395	1.6

Replacement Value

The current value of Clark County's inventoried tree resource is approximately $61.2 million. The community forest is a public asset which, when properly cared for, has the potential to appreciate in value as the trees mature over time. Replacement value accounts for the historical investment in trees over their lifetime. Replacement value is also a way of describing the value of a tree population (and/or average value per tree) at a given time. The replacement value reflects current population numbers, stature, placement, and condition. There are several methods available for obtaining a fair and reasonable perception of a tree's value (CTLA, 1992; Watson, 2002). The 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).

Replacement of Clark County's park trees would cost $61.2 million.

To replace Clark County's current inventoried tree population of 24,552 trees with trees of similar size, species, and condition would cost more than $61.2 million (Table 5). The average replacement value per tree is $2,491. *Pinus eldarica* (Mondale pine) and *Pinus halepensis* (Aleppo pine) are the most valuable populations, representing 24.9 million and 48.8% of the overall replacement value but just 19.5% of the population. A complete table, listing replacement value for all species, is included in Appendix C.

On a per-tree basis, *Pinus halepensis* (Aleppo pine, $8,946.22/tree) and *Pinus eldarica* (Mondale pine, $4,224.48/tree) have the highest average replacement values. 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 as well. Conversely, smaller statured trees have average values of around $500 per tree, including *Washingtonia robusta* (Mexican fan palm, $256/tree) and *Vitex agnus-castus* (chaste tree, $529/tree).

Clark County's park trees represent vital component of the County's infrastructure and a public asset valued at approximately $61.2 million—an asset that, with proper care and maintenance, will increase in value over time. Distinguishing replacement value from the value of annual benefits produced by Clark County's inventoried park trees is very important. Annual benefits are examined in Chapter 3.

Table 5. Replacement Value of Clark County's Park Trees

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
Pinus eldarica	18,628	695,873	7,073,208	6,637,110	1,533,877	98,550	0	0	0	**16,057,247**	26.3	15.5
Fraxinus velutina 'Fan-Tex'	88,956	1,412,216	3,303,776	646,545	19,066	0	0	0	0	**5,470,559**	8.9	10.3
Fraxinus velutina	31,951	337,550	1,581,695	918,107	231,458	97,041	0	0	0	**3,197,801**	5.2	5.9
Chilopsis linearis	158,269	446,316	435,799	89,470	0	0	0	0	0	**1,129,854**	1.8	5.0
Parkinsonia x 'Desert Museum'	133,100	332,433	305,360	10,129	19,066	0	0	0	0	**800,089**	1.3	4.4
Prosopis velutina	105,257	418,094	1,304,020	345,305	34,681	0	0	0	0	**2,207,358**	3.6	4.3
Pinus halepensis	4,846	202,090	1,743,195	3,566,128	2,097,279	755,239	408,239	0	61,853	**8,838,870**	14.5	4.0
Pistacia chinensis	50,998	671,936	822,917	31,391	0	0	0	0	0	**1,577,243**	2.6	3.3
Chiltalpa tashkentensis	20,596	310,963	1,325,457	76,809	0	0	0	0	0	**1,733,825**	2.8	3.1
Washingtonia robusta	2,058	3,597	70,462	94,629	17,234	0	1,422	0	0	**189,403**	0.3	3.0
Acacia stenophylla	28,289	679,180	455,866	14,349	0	0	0	0	0	**1,177,685**	1.9	2.9
Vitex agnus-castus	114,488	184,198	67,561	10,129	0	0	0	0	0	**376,376**	0.6	2.9
Quercus virginiana	43,327	329,929	720,088	54,864	0	0	0	0	0	**1,148,207**	1.9	2.6
Ulmus parvifolia	11,403	422,162	732,798	44,735	19,066	0	0	0	0	**1,230,164**	2.0	2.5
Prosopis glandulosa	52,219	416,746	560,575	18,402	0	0	0	0	0	**1,047,942**	1.7	2.5
Prosopis torreyana	62,045	145,820	165,557	81,029	0	0	0	0	0	**454,451**	0.7	1.9
Fraxinus angustifolia	11,176	239,037	501,353	48,955	0	0	0	0	0	**800,521**	1.3	1.6
Acacia farnesiana	60,529	161,781	126,471	0	0	0	0	0	0	**348,782**	0.6	1.6
Gleditsia triacanthos	12,156	93,777	303,269	172,609	13,652	0	0	0	0	**595,462**	1.0	1.3
Prosopis chilensis	16,050	99,242	237,782	202,891	81,910	110,258	0	0	0	**748,134**	1.2	1.3
Parkinsonia florida	20,199	233,971	189,707	7,577	0	0	0	0	0	**451,453**	0.7	1.2
Rhus lancea	19,839	164,159	230,442	14,349	19,066	0	0	0	0	**447,854**	0.7	1.1
Other Trees	181,923	1,530,558	4,172,777	2,446,831	1,770,489	682,361	298,978	45,205	819	**11,129,941**	18.2	18.1
County-wide Total	**$1,248,303**	**$9,531,629**	**$26,430,135**	**$15,532,342**	**$5,856,845**	**$1,743,449**	**$708,639**	**$45,205**	**$62,672**	**$61,159,219**	**100%**	**100%**

Chapter 3: Urban Forest Resource Benefits

Trees are important to Clark County. Environmentally, they help conserve and reduce energy use, decrease 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 cost of management? In other words, are trees a good investment for Clark County? To answer this question, the benefits must be quantified in financial terms.

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

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

The *heat island effect* describes the increase in urban temperatures in relation to surrounding suburban and rural areas. Heat islands are associated with an increase in hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger 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.

Trees reduce conductive heat loss from buildings by reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding). Trees can reduce wind speed and the resulting air infiltration by up to 50%, translating into potential annual heating savings of 25% (Heisler, 1986).

Considering Clark County parks may not include many buildings, the actual realized benefits may be significantly below these reported values.

Electricity and Natural Gas Reduction

Electricity and natural gas saved annually in Clark County from both the shading and climate effects of inventoried trees is equal to 1,221 MWh (valued at $81,961) and 8,723 therms ($5,631), for a total retail savings of approximately $87,592 and an average of $3.57 per tree (Table 6). *Pinus halepensis* (Aleppopine), which represents 4.0% of the population, is providing 7.3% of the energy benefits, and provides the highest per-tree benefits ($6.48/tree). Similarly, *Ulmus parvifolia* (Chinese elm), which represents just 2.5% of the population, is providing 4.4% of the total energy benefits and the next highest per-tree benefit of $6.40). Together, the populations of *Pinus halepensis* (Aleppo pine) and *Ulmus parvifolia* (Chinese elm) are providing 12% of the overall energy benefits while comprising just 6.5% of the population.

Small stature trees are less able to provide electricity and natural gas reductions. On a per-tree basis, *Chilopsis linearis* (desert willow, $1.07/tree) and *Washingtonia robusta* (Mexican fan palm, $1.10/tree) provide the lowest benefits. Although these two species account for 8.0% of the urban forest, they are providing only 2.4% of the overall energy benefits.

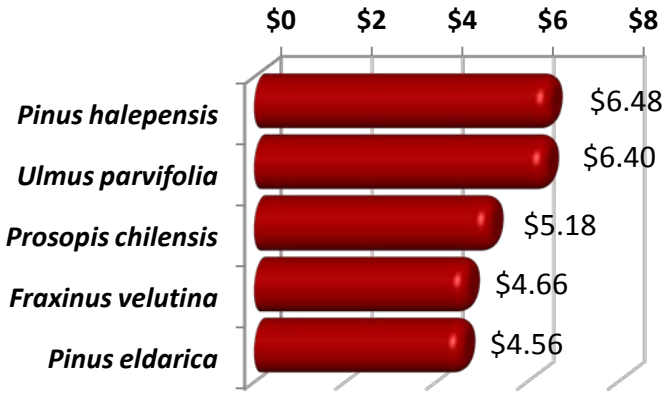


Figure 6. Annual Electricity and Natural Gas Benefits - Top Five Species

Table 6. Annual Electric and Natural Gas Benefits from Clark County's Inventoried Park Trees

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Pinus eldarica	243.5	16,338.09	1,518.7	980.34	**17,318**	15.48	19.77	4.56
Fraxinus velutina 'Fan-Tex'	142.4	9,557.80	1,065.5	687.76	**10,246**	10.28	11.70	4.06
Fraxinus velutina	93.6	6,278.60	683.6	441.25	**6,720**	5.88	7.67	4.66
Chilopsis linearis	18.0	1,209.68	154.2	99.51	**1,309**	4.99	1.49	1.07
Parkinsonia x 'Desert Museum'	20.5	1,377.97	175.8	113.45	**1,491**	4.36	1.70	1.39
Prosopis velutina	43.9	2,943.26	326.8	210.96	**3,154**	4.28	3.60	3.00
Pinus halepensis	90.0	6,035.74	561.0	362.11	**6,398**	4.02	7.30	6.48
Pistacia chinensis	26.5	1,781.44	209.3	135.11	**1,917**	3.33	2.19	2.34
Chiltalpa tashkentensis	34.4	2,307.65	265.5	171.35	**2,479**	3.08	2.83	3.28
Washingtonia robusta	11.2	754.24	92.6	59.79	**814**	3.01	0.93	1.10
Acacia stenophylla	20.0	1,340.35	161.0	103.93	**1,444**	2.90	1.65	2.03
Vitex agnus-castus	10.9	732.96	97.2	62.74	**796**	2.90	0.91	1.12
Quercus virginiana	23.2	1,557.77	170.0	109.76	**1,668**	2.57	1.90	2.64
Ulmus parvifolia	54.1	3,629.49	378.4	244.26	**3,874**	2.46	4.42	6.40
Prosopis glandulosa	23.5	1,574.64	182.9	118.07	**1,693**	2.46	1.93	2.80
Prosopis torreyana	9.9	662.20	82.4	53.18	**715**	1.86	0.82	1.57
Fraxinus angustifolia	22.3	1,497.93	168.5	108.76	**1,607**	1.64	1.83	4.00
Acacia farnesiana	7.3	490.21	63.2	40.78	**531**	1.61	0.61	1.34
Gleditsia triacanthos	15.3	1,024.12	109.8	70.88	**1,095**	1.25	1.25	3.56
Prosopis chilensis	22.3	1,496.82	154.6	99.79	**1,597**	1.25	1.82	5.18
Parkinsonia florida	12.2	821.27	95.7	61.75	**883**	1.17	1.01	3.07
Rhus lancea	7.3	491.69	58.4	37.69	**529**	1.09	0.60	1.98
Other Trees	269.1	18,057.44	1,948.3	1,257.65	**19,315**	18.11	22.05	4.34
County-wide Total	**1,221**	**$81,961**	**8,723**	**$5,631**	**$87,592**	**100%**	**100%**	**$3.57**

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, 2007).

The idea that carbon credits are a commodity that can be exchanged for financial gain is based on the growth of emerging carbon markets. The Center for Urban Forest Research 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 United States.

While Clark County's urban forest resource may or may not qualify for carbon-offset credits or be traded in the open market, the county's inventoried 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:

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

At the same time, vehicles and other combustion engines used to plant and care for trees release CO_2 during operation. 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 net CO_2 benefits of trees. Since Clark County parks may not include many buildings, the actual realized benefits may be significantly below these reported values.

Sequestered Carbon Dioxide

To date, Clark County's inventoried urban forest has sequestered a total of 3,804 tons of carbon dioxide (CO_2) valued at $57,061[2]. Annually, this tree resource directly sequesters 455 tons of CO_2, valued at $6,828, into woody and foliar biomass. Accounting for estimated CO_2 emissions from tree decomposition (-30.4 tons), tree related maintenance activity (-6.1 tons), and avoided CO_2 (610.4 tons), Clark County's trees provide an annual net reduction in atmospheric CO_2 of 1,029 tons, valued at $15,437 with an average of $0.63 per tree, as reflected by the negative numbers in decomposition release and maintenance release in Table 7.

Pinus halepensis (Aleppo pine, $1.22) and *Ulmus parvifolia* (Chinese elm, $0.94) are currently providing the highest per tree benefit (Figure 7). *Pinus eldarica* (Mondale pine) are providing the greatest percentage of overall benefits at 17.6% due to their large size and prevalence in the population (15.5%).

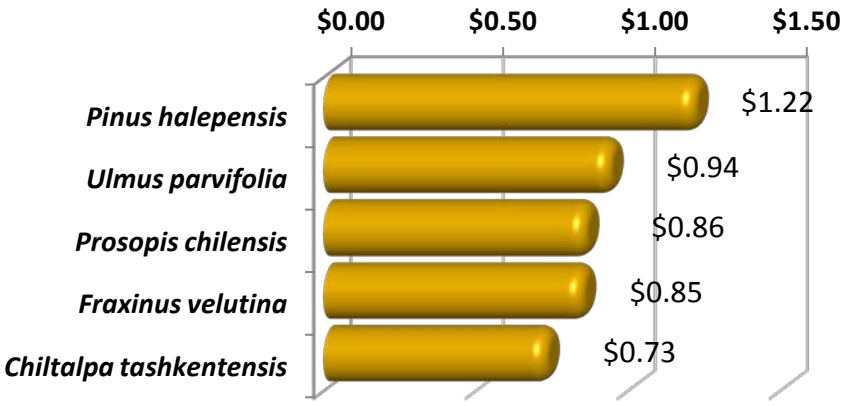


Figure 7. Annual Reduction of CO_2 - Top Five species

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

Table 7. Annual CO_2 Reduction Benefits Provided by Clark County's Inventoried Park Trees

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Pinus eldarica	133,776	1,003.32	- 12,743.10	- 2,766.53	- 116.32	243,365	1,825.24	361,632	**2,712.24**	15.48	17.57	0.71
Fraxinus velutina 'Fan-Tex'	91,882	689.12	- 3,238.34	- 1,059.88	- 32.24	142,369	1,067.76	229,953	**1,724.65**	10.28	11.17	0.68
Fraxinus velutina	75,721	567.90	- 4,415.21	- 809.64	- 39.19	93,523	701.42	164,019	**1,230.14**	5.88	7.97	0.85
Chilopsis linearis	9,074	68.06	- 46.29	- 291.52	- 2.53	18,019	135.14	26,755	**200.66**	4.99	1.30	0.16
Parkinsonia x 'Desert Museum'	21,705	162.79	- 847.36	- 239.19	- 8.15	20,526	153.94	41,144	**308.58**	4.36	2.00	0.29
Prosopis velutina	29,250	219.37	- 1,054.91	- 346.90	- 10.51	43,842	328.81	71,689	**537.67**	4.28	3.48	0.51
Pinus halepensis	78,142	586.07	- 6,256.69	- 889.73	- 53.60	89,906	674.29	160,902	**1,206.76**	4.02	7.82	1.22
Pistacia chinensis	13,717	102.88	- 535.81	- 283.99	- 6.15	26,535	199.02	39,432	**295.74**	3.33	1.92	0.36
Chitalpa tashkentensis	42,109	315.82	- 2,501.79	- 367.01	- 21.52	34,374	257.80	73,614	**552.11**	3.08	3.58	0.73
Washingtonia robusta	18,606	139.55	- 3,943.40	- 703.10	- 34.85	11,235	84.26	25,195	**188.96**	3.01	1.22	0.26
Acacia stenophylla	7,465	55.99	- 269.27	- 258.59	- 3.96	19,965	149.74	26,902	**201.77**	2.90	1.31	0.28
Vitex agnus-castus	10,983	82.37	- 328.58	- 131.00	- 3.45	10,918	81.88	21,441	**160.81**	2.90	1.04	0.23
Quercus virginiana	37,004	277.53	- 1,514.82	- 229.90	- 13.09	23,204	174.03	58,464	**438.48**	2.57	2.84	0.69
Ulmus parvifolia	23,108	173.31	- 1,010.79	- 256.71	- 9.51	54,063	405.47	75,904	**569.28**	2.46	3.69	0.94
Prosopis glandulosa	16,149	121.12	- 455.09	- 195.79	- 4.88	23,455	175.91	38,954	**292.15**	2.46	1.89	0.48
Prosopis torreyana	11,034	82.76	- 546.65	- 112.42	- 4.94	9,864	73.98	20,239	**151.79**	1.86	0.98	0.33
Fraxinus angustifolia	14,470	108.53	- 482.88	- 167.69	- 4.88	22,313	167.34	36,132	**270.99**	1.64	1.76	0.67
Acacia farnesiana	7,761	58.21	- 279.43	- 86.55	- 2.74	7,302	54.76	14,697	**110.23**	1.61	0.71	0.28
Gleditsia triacanthos	11,760	88.20	- 665.87	- 144.41	- 6.08	15,255	114.41	26,204	**196.53**	1.25	1.27	0.64
Prosopis chilensis	13,935	104.51	- 854.74	- 153.46	- 7.56	22,296	167.22	35,223	**264.17**	1.25	1.71	0.86
Parkinsonia florida	6,044	45.33	- 204.96	- 92.55	- 2.23	12,233	91.75	17,980	**134.85**	1.17	0.87	0.47
Rhus lancea	2,731	20.48	- 118.90	- 92.31	- 1.58	7,324	54.93	9,844	**73.83**	1.09	0.48	0.28
Other Trees	233,995	1,754.96	- 18,549.88	- 2,471.01	- 157.66	268,975	2,017.32	481,950	**3,614.62**	18.11	23.42	0.81
County-wide Total	**910,423**	**$6,828**	**- 60,865**	**- 12,150**	**-$547.61**	**1,220,859**	**$9,156**	**2,058,268**	**$15,437**	**100%**	**100%**	**$0.63**

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 ($_{PM10}$), 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

The Clark County Department of Air Quality (CCDAQ) measures air pollution and provides data on the number of days per year that federal pollution standards are exceeded.

$_{PM10}$ is particulate matter in the air that measures less than 10 micrometers, smaller than the width of a single human hair. $_{PM10}$ pollution can cause respiratory problems for local residents. CCDAQ reports that air quality in Clark County exceeded the state 8-hour $_{PM10}$ standard of 150 µg/m^3 for only 1 day in 2012.

Ozone (O_3) is another air pollutant that is harmful to human health. Between 2003 and 2012, the Federal 8-hour standard (0.075 ppm) for ground level (O_3) was exceeded 91 days, an average of 9.1 days per year (Table 8) (CCDAQ, 2013).

Table 8. Number of Days Exceeding Federal Ground-Level Ozone

Year	Ozone > Federal 2012 8-hour Standard
2012	19
2011	9
2010	1
2009	5
2008	10
2007	17
2006	8
2005	8
2004	4
2003	10
Average	**9.1**

In the absence of cooling effects provided by trees, higher temperatures contribute to ozone (O_3) formation. Additionally, short-term increases in ozone concentrations are statistically associated with increased tree mortality for 95 large US cities (Bell 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 isoprene's and monoterpenes, which also contribute to ozone formation. i-Tree *Streets* analysis accounts for these BVOC emissions in the air quality net benefit.

Deposition and Interception

Each year, approximately 3,316 pounds of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), small particulate matter ($_{PM10}$), and ozone (O_3) are intercepted or absorbed by the inventoried trees in Clark County, for a value of $17,335 (Table 9). As a population, *Pinus eldarica* (Mondale pine, 862 lbs.) is the greatest contributor to pollutant deposition and interception, accounting for approximately 26% of benefits.

Avoided Pollutants

The energy savings provided by trees have the additional indirect benefit of reducing air pollutant emissions (NO_2, $_{PM10}$, SO_2, and VOCs) that result from energy production. Altogether, 4,184 pounds of pollutants, valued at $38,808, are avoided annually through the shading effects of Clark County's inventoried trees.

BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered. Approximately 3,134 pounds of BVOCs are emitted annually from Clark County's inventoried trees, offsetting the total air quality benefit by -$12,535. *Quercus virginiana* (southern live oak) are the heaviest per tree emitters of BVOCs (0.87 lbs/tree), accounting for 17.5% of BVOC emissions while comprising just 2.6% of the population. *Pistacia chinensis* (Chinese pistache, -0.34 lbs/tree) and *Washingtonia robusta* (Mexican fan palm, -0.29 lbs/tree) also contribute substantial BVOCs. For these three species, the benefits from interception, deposition, and avoidance of air pollutants (NO_2, $_{PM10}$, SO_2, and VOCs) are not enough to offset their BVOC emissions, and their per tree net impact on air quality is negative.

Net Air Quality Improvement

The net value of air pollutants removed, avoided, and released by Clark County's inventoried park tree population is $43,608 annually. The average net benefit per tree is $1.78. Trees vary dramatically in their ability to produce air quality benefits. Typically, large-canopied trees with large leaf surface areas that are not high emitters of BVOCs produce the greatest benefits. On a per tree basis, *Ulmus parvifolia* (Chinese elm, $3.64) *Prosopis chilensis* (Chilean mesquite, $3.02), and *Pinus halepensis* (Aleppo pine, $2.90) currently produce the greatest per tree net air quality improvements (Figure 8). However, due to its high prevalence in the population (15.5%), *Pinus eldarica* (Mondale pine) account for the greatest air quality improvements (25 %) in terms of total benefits by species, collectively removing 1,333 pounds of pollutants at a net value of $10,855.

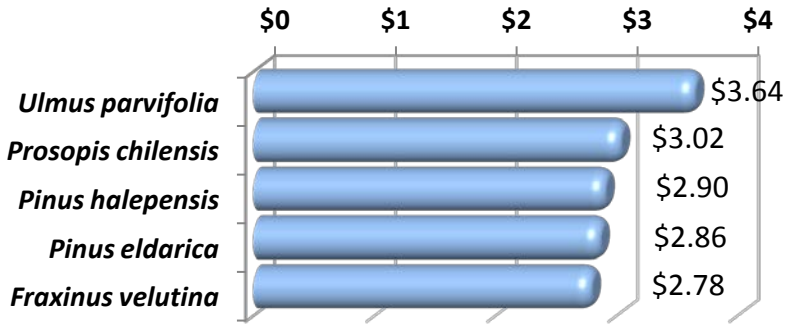


Figure 8. Annual Improvement to Air Quality - Top Five Species

Table 9. Annual Air Quality Improvements Provided by Clark County's Inventoried Park Trees

Species	Deposition O_3 (lb)	Deposition NO_2 (lb)	Deposition $_{PM10}$ (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 Pop.	Avg. $/tree
Pinus eldarica	319.37	174.20	333.02	35.12	4,523.84	439.23	22.39	3.91	376.23	7,813.73	- 370.61	- 1,482.45	1,332.87	**10,855.12**	15.48	2.86
Fraxinus velutina 'Fan-Tex'	105.55	50.72	123.09	10.51	1,528.64	254.81	13.01	2.31	217.56	4,522.15	- 222.02	- 888.07	555.54	**5,162.72**	10.28	2.04
Fraxinus velutina	81.76	31.63	78.93	6.57	1,030.23	168.26	8.59	1.52	143.64	2,985.78	0.00	0.00	520.90	**4,016.01**	5.88	2.78
Chilopsis linearis	9.15	2.50	8.80	0.56	108.13	32.33	1.65	0.30	27.53	572.61	- 128.51	- 514.03	- 45.69	**166.71**	4.99	0.14
Parkinsonia x 'Desert Museum'	19.46	9.35	21.04	1.94	271.91	36.80	1.88	0.34	31.36	652.15	- 74.56	- 298.26	47.60	**625.80**	4.36	0.58
Prosopis velutina	34.80	16.72	39.67	3.47	498.53	78.45	4.00	0.71	66.98	1,392.28	- 71.74	- 286.94	173.07	**1,603.87**	4.28	1.52
Pinus halepensis	65.39	35.68	81.32	7.20	1,005.18	159.73	8.14	1.42	136.78	2,841.00	- 246.00	- 984.00	249.66	**2,862.17**	4.02	2.90
Pistacia chinensis	20.63	7.97	20.73	1.66	264.88	47.75	2.44	0.43	40.72	846.67	- 279.68	- 1,118.71	- 137.34	**- 7.17**	3.33	- 0.01
Chitalpa tashkentensis	54.09	26.00	51.13	5.38	711.59	61.72	3.15	0.56	52.68	1,095.02	- 137.18	- 548.72	117.53	**1,257.89**	3.08	1.67
Washingtonia robusta	30.20	16.47	28.52	3.32	409.97	20.27	1.04	0.18	17.28	359.28	- 210.92	- 843.66	- 93.63	**- 74.41**	3.01	- 0.10
Acacia stenophylla	11.60	6.33	15.93	1.28	187.36	35.71	1.82	0.32	30.46	633.29	0.00	0.00	103.46	**820.66**	2.90	1.15
Vitex agnus-castus	7.92	3.81	9.39	0.79	115.64	19.56	1.00	0.18	16.66	346.51	- 38.16	- 152.64	21.14	**309.51**	2.90	0.44
Quercus virginiana	11.69	6.38	16.69	1.29	192.67	41.74	2.13	0.38	35.67	741.23	- 547.25	- 2,189.02	- 431.29	**- 1,255.12**	2.57	- 1.99
Ulmus parvifolia	36.47	14.10	38.65	2.93	480.25	96.86	4.94	0.87	82.75	1,719.79	0.00	0.00	277.58	**2,200.04**	2.46	3.64
Prosopis glandulosa	14.16	6.80	17.81	1.41	212.93	41.98	2.14	0.38	35.82	744.70	- 37.00	- 148.00	83.52	**809.63**	2.46	1.34
Prosopis torreyana	11.79	5.67	11.96	1.17	159.95	17.69	0.90	0.16	15.08	313.58	- 37.42	- 149.68	27.00	**323.86**	1.86	0.71
Fraxinus angustifolia	15.57	7.48	18.56	1.55	227.86	39.94	2.04	0.36	34.10	708.75	- 34.42	- 137.66	85.17	**798.95**	1.64	1.99
Acacia farnesiana	6.52	3.13	7.21	0.65	92.06	13.22	0.68	0.12	11.26	234.18	- 26.53	- 106.13	16.25	**220.12**	1.61	0.56
Gleditsia triacanthos	12.67	5.54	13.24	1.09	169.41	27.48	1.40	0.25	23.47	487.80	0.00	0.00	85.14	**657.21**	1.25	2.13
Prosopis chilensis	29.05	13.96	28.92	2.89	390.87	39.68	2.02	0.36	33.92	704.82	- 41.00	- 164.01	109.79	**931.68**	1.25	3.02
Parkinsonia florida	8.19	3.93	9.93	0.82	120.83	21.89	1.12	0.20	18.68	388.27	- 30.16	- 120.65	34.58	**388.44**	1.17	1.35
Rhus lancea	5.19	2.83	6.64	0.57	80.90	13.09	0.67	0.12	11.17	232.14	0.00	0.00	40.28	**313.04**	1.09	1.17
Other Trees	361.78	156.39	330.21	31.70	4,551.62	477.30	24.36	4.31	407.62	8,472.33	- 600.63	- 2,402.53	1,193.05	**10,621.43**	18.11	2.39
County-wide Total	**1,273**	**607.61**	**1,311**	**123.86**	**$17,335**	**2,185.49**	**111.53**	**19.70**	**1,867**	**$38,808**	**- 3,134**	**-$12,535**	**4,366**	**$43,608**	**100%**	**$1.78**

Stormwater Runoff Reductions

Rainfall interception by trees reduces the amount of stormwater that enters collection and treatment facilities during large storm events. Trees intercept rainfall in their canopy, acting as mini-reservoirs, controlling runoff at the source. Healthy urban trees 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 bare soil.

Clark County's inventoried trees intercept 7,745,459 list it out gallons of stormwater annually for an average of 315 gallons per tree (Table 10). The total value of this benefit to the County is $37,181, an average of $1.51 per tree. *Pinus halepensis* (Aleppo pine) are currently providing the greatest per tree benefit of $4.31 (Figure 9), while *Pinus eldarica* (Mondale Pine) is currently providing the greatest percentage of overall stormwater benefits (22.6%).

As trees grow, their stormwater benefit will improve, but some species increases will be more substantial benefits than others will. Many of the tree species currently demonstrating very low benefits, including *Chilopsis linearis* (desert willow, $0.22/tree) and *Parkinsonia X 'Desert museum'* (desert museum Palo verde, $0.48) are small-stature trees. As such, their benefits will not increase much over time. However other trees with currently lower benefits, such as *Pistacia chinensis* (Chinese pistache, $0.67/tree), young populations of medium-stature species, will realize increasing benefits as their canopies mature.

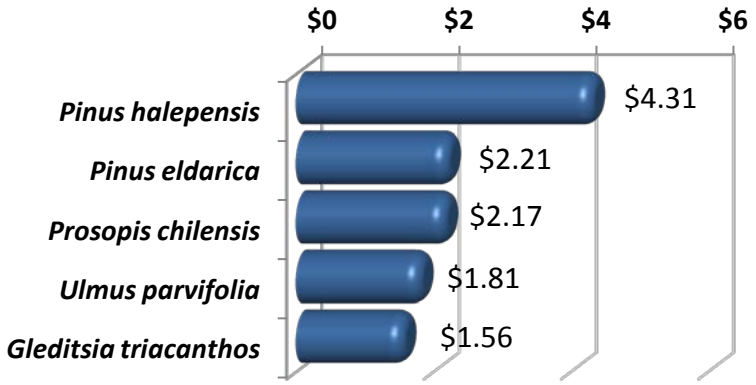


Figure 9. Annual Reduction in Stormwater Runoff - Top Five Species

Table 10. Annual Stormwater Runoff Reduction Benefits Provided by Clark County's Inventoried Park Tree Resource

Species	Total Rainfall Interception (Gal)	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Pinus eldarica	1,753,080	**8,415.37**	15.5	22.6	2.21
Fraxinus velutina 'Fan-Tex'	817,355	**3,923.58**	10.3	10.6	1.55
Fraxinus velutina	438,875	**2,106.75**	5.9	5.7	1.46
Chilopsis linearis	56,939	**273.32**	5.0	0.7	0.22
Parkinsonia x 'Desert Museum'	107,775	**517.36**	4.4	1.4	0.48
Prosopis velutina	257,485	**1,236.01**	4.3	3.3	1.17
Pinus halepensis	886,944	**4,257.63**	4.0	11.5	4.31
Pistacia chinensis	114,709	**550.64**	3.3	1.5	0.67
Chiltalpa tashkentensis	184,193	**884.19**	3.1	2.4	1.17
Washingtonia robusta	96,739	**464.38**	3.0	1.3	0.63
Acacia stenophylla	152,120	**730.23**	2.9	2.0	1.02
Vitex agnus-castus	56,905	**273.16**	2.9	0.7	0.38
Quercus virginiana	154,176	**740.10**	2.6	2.0	1.17
Ulmus parvifolia	227,527	**1,092.20**	2.5	2.9	1.81
Prosopis glandulosa	136,021	**652.95**	2.5	1.8	1.08
Prosopis torreyana	52,511	**252.07**	1.9	0.7	0.55
Fraxinus angustifolia	127,530	**612.19**	1.6	1.7	1.52
Acacia farnesiana	38,606	**185.32**	1.6	0.5	0.47
Gleditsia triacanthos	99,823	**479.18**	1.3	1.3	1.56
Prosopis chilensis	138,994	**667.22**	1.3	1.8	2.17
Parkinsonia florida	63,120	**302.99**	1.2	0.8	1.05
Rhus lancea	55,519	**266.51**	1.1	0.7	0.99
Other Trees	1,728,514	**8,297.44**	18.1	22.3	1.87
County-wide Total	**7,745,459**	**$37,181**	**100%**	**100%**	**$1.51**

Aesthetic, Property Value and Socioeconomic Benefits

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

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

The total annual benefit associated with property value increases and other less tangible benefits is $650,791, an average of $26.51 per tree (Table 11). Tree species that produced the highest average per tree aesthetic benefits are *Pinus halepensis* (Aleppo pine, $57.98) and *Ulmus parvifolia* (Chinese elm, $48.04).

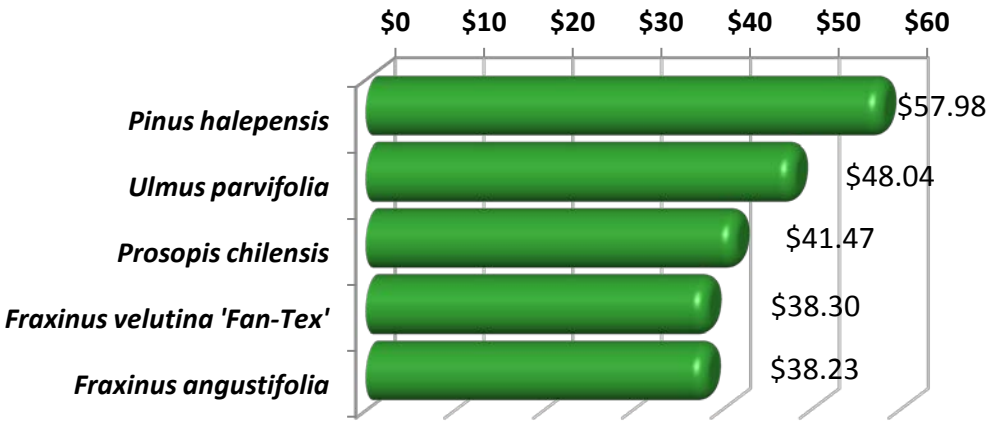


Figure 10. Annual Increase in Property and Socioeconomic Values - Top Five Species

Table 11. Annual Property Value, Aesthetic, and Socioeconomic Benefits Provided by Clark County's Inventoried Park Tree Resource

Species	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Pinus eldarica	**74,206**	15.48	11.40	19.52
Fraxinus velutina 'Fan-Tex'	**96,712**	10.28	14.86	38.30
Fraxinus velutina	**42,751**	5.88	6.57	29.63
Chilopsis linearis	**10,503**	4.99	1.61	8.57
Parkinsonia x 'Desert Museum'	**11,124**	4.36	1.71	10.40
Prosopis velutina	**35,260**	4.28	5.42	33.52
Pinus halepensis	**57,287**	4.02	8.80	57.98
Pistacia chinensis	**17,965**	3.33	2.76	21.96
Chitalpa tashkentensis	**10,891**	3.08	1.67	14.43
Washingtonia robusta	**6,166**	3.01	0.95	8.34
Acacia stenophylla	**12,800**	2.90	1.97	17.95
Vitex agnus-castus	**6,987**	2.90	1.07	9.83
Quercus virginiana	**13,674**	2.57	2.10	21.67
Ulmus parvifolia	**29,062**	2.46	4.47	48.04
Prosopis glandulosa	**20,206**	2.46	3.10	33.45
Prosopis torreyana	**4,915**	1.86	0.76	10.78
Fraxinus angustifolia	**15,367**	1.64	2.36	38.23
Acacia farnesiana	**4,087**	1.61	0.63	10.35
Gleditsia triacanthos	**10,599**	1.25	1.63	34.41
Prosopis chilensis	**12,772**	1.25	1.96	41.47
Parkinsonia florida	**6,354**	1.17	0.98	22.06
Rhus lancea	**4,745**	1.09	0.73	17.71
Other Trees	**146,357**	18.11	22.49	32.91
County-wide Total	**$650,791**	**100%**	**100%**	**$26.51**

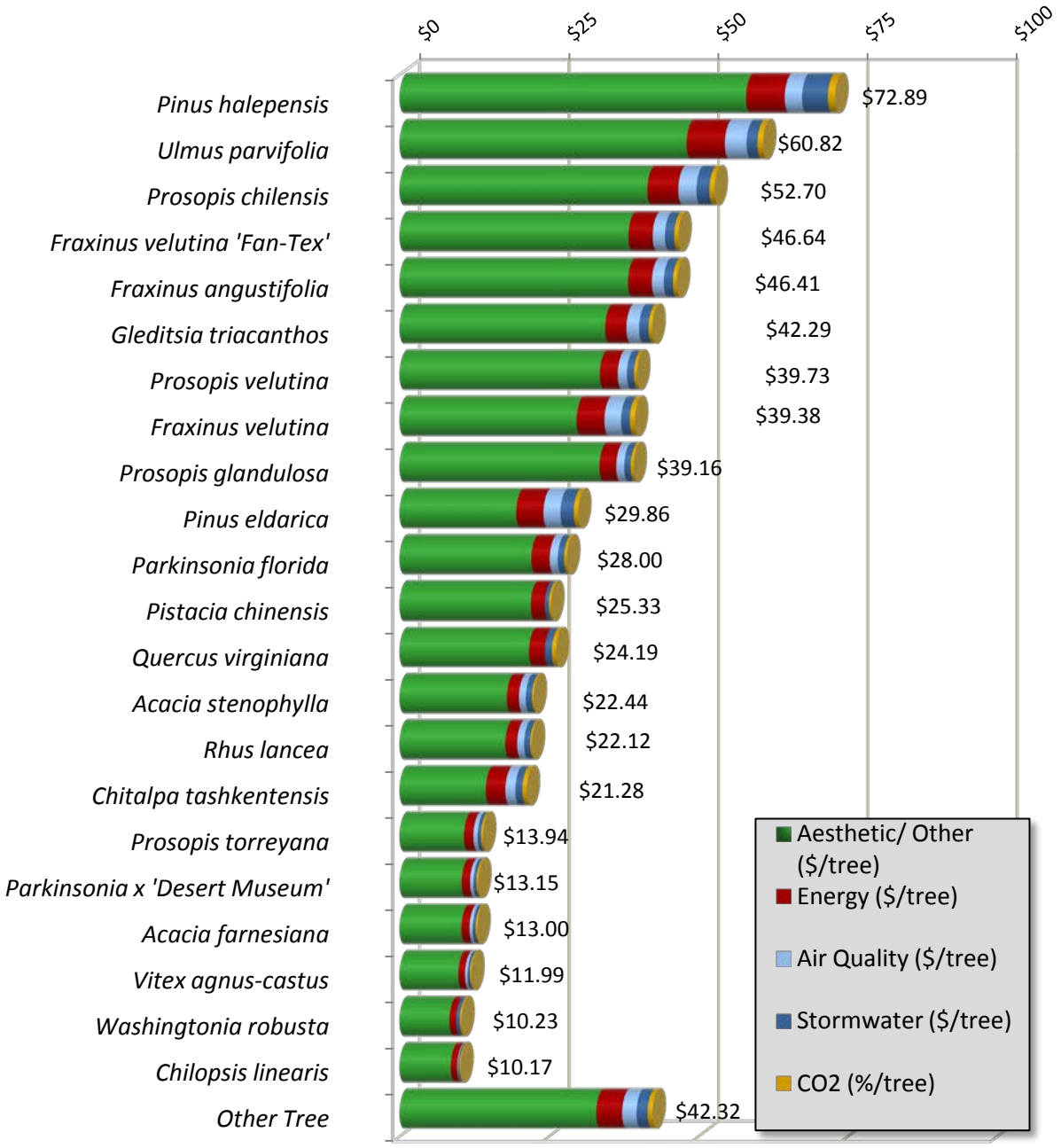


Figure 11. Summary of Annual per Tree Benefits

Table 12. Summary of Current Annual Average per Tree Related Benefits ($/Tree/yr.) from Clark County's Inventoried Park Tree Resource

Species	Energy ($/tree)	CO_2 (%/tree)	Air Quality ($/tree)	Stormwater ($/tree)	Aesthetic/ Other ($/tree)	Total ($/tree)	% of Pop.
Pinus eldarica	4.56	0.71	2.86	2.21	19.52	**29.86**	15.48
Fraxinus velutina 'Fan-Tex'	4.06	0.68	2.04	1.55	38.30	**46.64**	10.28
Fraxinus velutina	4.66	0.85	2.78	1.46	29.63	**39.38**	5.88
Chilopsis linearis	1.07	0.16	0.14	0.22	8.57	**10.17**	4.99
Parkinsonia x 'Desert Museum'	1.39	0.29	0.58	0.48	10.40	**13.15**	4.36
Prosopis velutina	3.00	0.51	1.52	1.17	33.52	**39.73**	4.28
Pinus halepensis	6.48	1.22	2.90	4.31	57.98	**72.89**	4.02
Pistacia chinensis	2.34	0.36	- 0.01	0.67	21.96	**25.33**	3.33
Chitalpa tashkentensis	3.28	0.73	1.67	1.17	14.43	**21.28**	3.08
Washingtonia robusta	1.10	0.26	- 0.10	0.63	8.34	**10.23**	3.01
Acacia stenophylla	2.03	0.28	1.15	1.02	17.95	**22.44**	2.90
Vitex agnus-castus	1.12	0.23	0.44	0.38	9.83	**11.99**	2.90
Quercus virginiana	2.64	0.69	- 1.99	1.17	21.67	**24.19**	2.57
Ulmus parvifolia	6.40	0.94	3.64	1.81	48.04	**60.82**	2.46
Prosopis glandulosa	2.80	0.48	1.34	1.08	33.45	**39.16**	2.46
Prosopis torreyana	1.57	0.33	0.71	0.55	10.78	**13.94**	1.86
Fraxinus angustifolia	4.00	0.67	1.99	1.52	38.23	**46.41**	1.64
Acacia farnesiana	1.34	0.28	0.56	0.47	10.35	**13.00**	1.61
Gleditsia triacanthos	3.56	0.64	2.13	1.56	34.41	**42.29**	1.25
Prosopis chilensis	5.18	0.86	3.02	2.17	41.47	**52.70**	1.25
Parkinsonia florida	3.07	0.47	1.35	1.05	22.06	**28.00**	1.17
Rhus lancea	1.98	0.28	1.17	0.99	17.71	**22.12**	1.09
Other Trees	4.34	0.81	2.39	1.87	32.91	**42.32**	18.11
County-wide Total	**$3.57**	**$0.63**	**$1.78**	**$1.51**	**$26.51**	**$33.99**	**100%**

Benefit Summary

Clark County's park trees have substantial environmental and aesthetic benefits. Annual increases in property value, socioeconomic, and other aesthetic values are substantial benefits, account for 78% of the total benefits.

Approximately 22% ($183,818) of the total annual benefits ($834,609) quantified in this study are environmental services (Table 13). Energy savings ($87,592) account for 48% of the annual environmental benefits and 10% of all annual benefits. Air quality benefits ($43,608) account for 24% of annual environmental benefits and 5% of all annual benefits. Stormwater benefits ($37,181) account for 20% of the annual environmental benefits and 4% of all benefits. Carbon reduction benefits, valued at $15,437, account for 8% of environmental benefits and 2% of all benefits.

The estimated sum of benefits provided by Clark County's public tree resource is $834,609, a value of $33.99 per tree and $0.43 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 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 County, as well as variability in tree growth. In other words, **trees are worth far more than what one can ever quantify!**

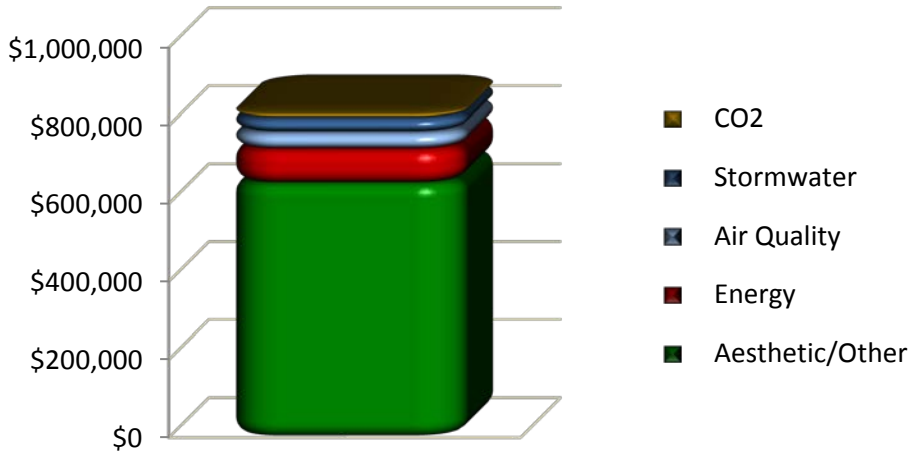


Figure 12. Benefit Summary for Clark County's Tree Resource

Total Annual Benefits from Clark County's Tree Resource: $834,609

Average Annual per Tree Benefits: $33.99

Annual Value of Benefits per Capita: $0.43

Table 13. Annual Benefit Summary for Clark County's Inventoried Tree Resource

Benefits	Total ($)	$/tree	$/capita
Energy	87,592	3.57	0.05
CO_2	15,437	0.63	0.01
Air Quality	43,608	1.78	0.02
Stormwater	37,181	1.51	0.02
Aesthetic/Other	650,791	26.51	0.34
Total Benefits	**$834,609**	**$33.99**	**$0.43**

Conclusion

This analysis describes the current structural characteristics of Clark County's park tree resource using established tree sampling, numerical modeling, and statistical methods to provide a general accounting of the benefits. The analysis provides a "snapshot" of this resource at its current population, structure, and condition. 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.

Clark County's park trees are providing quantifiable benefits including energy savings, stormwater runoff reduction, reduction in atmospheric CO_2, and aesthetic benefits. The county's 24,552 trees are providing $834,609 in annual gross benefits. That is an average of $33.99 per tree and $0.43 per capita.

The park trees inventoried in this project are relatively young and in fair to good condition with more than 119 different species. Although it is critical to maintain an adequate level of resources to protect and nurture this resource, Clark County's public trees can be expected to provide even greater benefits in the future and for many generations to come. The county can focus resources on maximizing the flow of benefits from the current tree population and maintaining a forward-thinking approach. Based on the resource analysis, Davey Resource Group recommends the following:

- Maintain an appropriate age distribution by continuing to plant new trees to improve long-term resource sustainability and greater canopy coverage. To maximize benefits, focus on medium- to large-stature trees where conditions are sustainable.
- Maximize the benefits of the existing tree resource through comprehensive tree maintenance and a cyclical pruning schedule.
- Continue annual tree planting efforts with the goal of achieving a 100% stocking rate, utilizing available planting sites identified by the inventory.
- Implement a structural pruning program for young and establishing trees to promote healthy structure, extend life expectancy, and reduce future costs and liability.
- Maintain and update the inventory database.

Urban forest managers can better anticipate future trends with an understanding of the current status of the County's tree population. Managers can also anticipate challenges and devise plans to 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 referenced in development of 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

Clark County's trees are of vital importance to the environmental, social, and economic well-being of the community.

and outside the organization.

Clark County's trees are of vital importance to the environmental, social, and economic well-being of the community. Clark County has demonstrated that park trees are a valued community resource, a vital component of the urban infrastructure, and an important part of the County's history and identity. The County may use this inventory to take a proactive and forward-looking approach to caring for the community's trees in the future. Updates should be incorporated into the inventory as work is performed. Current and complete inventory data will help staff to more efficiently track maintenance activities and tree health and will provide a strong basis for making informed management decisions. With additional tree planting and proactive management, Clark County's urban forest can be expected to produce an even greater flow of benefits as this resource continues to mature. By maintaining a commitment to planting, maintaining and preserving these trees, the community will continue to be a healthy, safe, and enjoyable place to live.

Appendix A: Methods and Procedures

Certified Arborists collected Clark County's tree inventory using ArcPad software to assist the inventory arborist in locating the sample plots on the ground and inputting 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 5.0.1; i-Tree v 5.0.6). 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 Clark County's trees, i-Tree *Streets* calculates the dollar value of annual resource functionality. This analysis combines the results of the county's tree inventory with benefit modeling data to produce information regarding resource structure, function, and value for use in determining management recommendations. i-Tree *Streets* regionalizes the calculations of its output by incorporating detailed reference County project information for 17 climate zones across the United States (Clark County is located in the Southwest Desert Climate Zone).

An annual resource unit was determined on a per tree basis for each of the modeled benefits. Resource units are measured as MWh of electricity saved per tree; MBtu of natural gas conserved per tree; pounds of atmospheric CO_2 reduced per tree; pounds of NO_2, SO_2, O_3, $_{PM10}$, and VOCs reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values.

Price values assigned to each resource unit (tree) were generated based on economic indicators of society's willingness to pay for the environmental benefits trees provide. **The County's tree care costs were not provided so a cost-benefit ratio cannot be determined.**

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 14. Clark County Benefit Prices Used In This Analysis

Benefits	Price	Unit	Source
Electricity	$0.07	$/Kwh	Residential rates from NV Energy
Natural Gas	$0.65	$/Therm	Residential rates from NV Energy
CO_2	$0.01	$/lb	*Streets* default – Southwest Desert
$_{PM10}$	$6.00	$/lb	*Streets* default – Southwest Desert
NO_2	$4.00	$/lb	*Streets* default – Southwest Desert
SO_2	$15.70	$/lb	*Streets* default – Southwest Desert
VOC	$4.00	$/lb	*Streets* default – Southwest Desert
Stormwater Interception	$0.00	$/gallon	*Streets* default – Southwest Desert
Median Home Value	$133,500	$	Zillow.com – February, 2013

i-Tree *Streets* default values (Table 14) from the Southwest Desert Climate Zone were used for all benefit prices except for median home values and electric and natural gas rates. Electric rates and natural gas rates are residential rates from NV Energy. Median home value for Clark County was estimated to be $133,500 in February, 2013, based on the Zillow Home Value Index (Zillow.com). Using these rates, the magnitude of the benefits provided by the park tree resource was calculated using i-Tree *Streets*. **Program budget values used in benefit versus investment ratio calculations were not supplied by Clark County.**

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Appendix C: Reports

Clark County's Population of Park Trees

	DBH Class (in)										
Species	**0-3**	**3-6**	**6-12**	**12-18**	**18-24**	**24-30**	**30-36**	**36-42**	**>42**	**Total**	**% of Pop.**
Broadleaf Deciduous Large (BDL)											
Gleditsia triacanthos	78	106	103	20	1	0	0	0	0	308	1.3
Populus species	5	41	64	75	40	14	4	1	0	244	1.0
Populus fremontii	1	1	37	78	37	11	1	2	0	168	0.7
Ulmus pumila	15	7	4	24	37	10	4	0	0	101	0.4
Quecus shumardii	6	29	60	0	0	0	0	0	0	95	0.4
Plantanus occidentalis	2	4	42	22	0	0	0	0	0	70	0.3
Platanus x acerfolia	1	1	64	0	0	0	0	0	0	66	0.3
Fraxinus uhdei	0	2	18	0	0	0	0	0	0	20	0.1
Sophora japonica	0	1	13	0	0	0	0	0	0	14	0.1
Quercus lobata	4	3	6	0	0	0	0	0	0	13	0.1
Quercus macrocarpa	0	5	7	0	0	0	0	0	0	12	0.0
Platanus wrightii	5	0	1	2	0	0	0	0	0	8	0.0
Quercus texana Buckley	4	0	0	0	0	0	0	0	0	4	0.0
Celtis sinensis	0	1	1	0	0	0	0	0	0	2	0.0
Populus alba	0	0	2	0	0	0	0	0	0	2	0.0
Zelkova serrata	1	0	1	0	0	0	0	0	0	2	0.0
Populus balsamifera ssp. Balsamifera	0	0	0	1	0	0	0	0	0	1	0.0
Total	**122**	**201**	**423**	**222**	**115**	**35**	**9**	**3**	**0**	**1,130**	**4.6**
Broadleaf Deciduous Medium (BDM)											
Fraxinus velutina 'Fan-Tex'	509	1,264	703	48	1	0	0	0	0	2,525	10.3
Fraxinus velutina	210	489	589	130	19	6	0	0	0	1,443	5.9
Pistacia chinensis	226	457	133	2	0	0	0	0	0	818	3.3
Ulmus parvifolia	65	382	153	4	1	0	0	0	0	605	2.5
Fraxinus angustifolia	72	214	112	4	0	0	0	0	0	402	1.6
Prosopis chilensis	83	112	77	25	6	5	0	0	0	308	1.3
Parkinsonia florida	90	165	32	1	0	0	0	0	0	288	1.2
Morus alba	3	6	59	105	48	7	1	0	0	229	0.9
Fraxinus velutina 'Glabra'	31	52	110	14	1	0	0	0	0	208	0.8
Robinia ambigua 'Purple Rose'	38	38	53	0	0	0	0	0	0	129	0.5
Robinia pseudoacacia	30	64	9	0	0	0	0	0	0	103	0.4
Parkinsonia aculeata	22	18	18	3	0	0	0	0	0	61	0.2

	DBH Class (in)										
Species	**0-3**	**3-6**	**6-12**	**12-18**	**18-24**	**24-30**	**30-36**	**36-42**	**>42**	**Total**	**% of Pop.**
Koelreuteria paniculata	3	10	3	0	0	0	0	0	0	16	0.1
Albizia julibrissin	6	8	0	0	0	0	0	0	0	14	0.1
Jacaranda mimosifolia	1	7	1	0	0	0	0	0	0	9	0.0
Salix gooddingii	0	3	2	0	0	0	0	0	0	5	0.0
Crataegus phaenopyrum	4	0	0	0	0	0	0	0	0	4	0.0
Melia azedarach	0	1	1	2	0	0	0	0	0	4	0.0
Pistacia X atlantica 'Red Push'	1	3	0	0	0	0	0	0	0	4	0.0
Celtis occidentalis	0	2	1	0	0	0	0	0	0	3	0.0
Salix x sepulcralis 'Simonkai'	0	0	1	1	0	0	0	0	0	2	0.0
Betula papyrifera	0	1	0	0	0	0	0	0	0	1	0.0
Total	**1,394**	**3,296**	**2,057**	**339**	**76**	**18**	**1**	**0**	**0**	**7,181**	**29.2**

Broadleaf Deciduous Small (BDS)											
Chilopsis linearis	767	356	94	8	0	0	0	0	0	1,225	5.0
Parkinsonia x 'Desert Museum'	706	288	74	1	1	0	0	0	0	1,070	4.4
Prosopis velutina	517	291	221	22	1	0	0	0	0	1,052	4.3
Chitalpa tashkentensis	110	297	340	8	0	0	0	0	0	755	3.1
Vitex agnus-castus	537	157	16	1	0	0	0	0	0	711	2.9
Prosopis glandulosa	227	276	100	1	0	0	0	0	0	604	2.5
Prosopis torreyana	294	114	40	8	0	0	0	0	0	456	1.9
Acacia farnesiana	259	113	23	0	0	0	0	0	0	395	1.6
Parkonsonia hybrid	107	77	33	1	0	0	0	0	0	218	0.9
Pyrus calleryana	7	110	98	0	0	0	0	0	0	215	0.9
Prunus cerasifera	124	51	0	0	0	0	0	0	0	175	0.7
Prosopis pubescens	34	26	11	0	0	0	0	0	0	71	0.3
Fraxinus cuspidata	17	2	0	0	0	0	0	0	0	19	0.1
Bauhinia variegata	13	5	0	0	0	0	0	0	0	18	0.1
Prosopis spp.	9	9	0	0	0	0	0	0	0	18	0.1
Lagerstroemia indica	12	2	0	0	0	0	0	0	0	14	0.1
Fraxinus sieboldiana	12	0	0	0	0	0	0	0	0	12	0.0
Tamarix chinensis	3	4	1	0	0	0	0	0	0	8	0.0
Prosopis juliflora	6	1	0	0	0	0	0	0	0	7	0.0
Ziziphus jujuba	0	0	3	1	0	0	0	0	0	4	0.0
Punica granatum	1	2	0	0	0	0	0	0	0	3	0.0
Cercis canadensis	2	0	0	0	0	0	0	0	0	2	0.0
Parkinsonia microphylla	0	1	0	0	0	0	0	0	0	1	0.0

	DBH Class (in)										
Species	**0-3**	**3-6**	**6-12**	**12-18**	**18-24**	**24-30**	**30-36**	**36-42**	**>42**	**Total**	**% of Pop.**
Elaeocarpus decipiens	0	1	0	0	0	0	0	0	0	1	0.0
Ficus carica	0	0	1	0	0	0	0	0	0	1	0.0
Prunus dulcis	1	0	0	0	0	0	0	0	0	1	0.0
Salix spp.	0	1	0	0	0	0	0	0	0	1	0.0
Sapium sebiferum	0	0	1	0	0	0	0	0	0	1	0.0
Total	**3,765**	**2,184**	**1,056**	**51**	**2**	**0**	**0**	**0**	**0**	**7,058**	**28.7**
Broadleaf Evergreen Large (BEL)											
Quercus ilex	22	25	11	0	0	0	0	0	0	58	0.2
Eucalyptus camaldulensis	0	0	9	4	2	0	0	0	0	15	0.1
Eucalyptus microtheca	0	1	2	3	0	0	0	0	0	6	0.0
Quercus suber	0	4	0	1	0	0	0	0	0	5	0.0
Eucalyptus sideroxylon	0	0	1	1	0	0	0	0	0	2	0.0
Total	**22**	**30**	**23**	**9**	**2**	**0**	**0**	**0**	**0**	**86**	**0.4**
Broadleaf Evergreen Medium (BEM)											
Quercus virginiana	210	267	149	5	0	0	0	0	0	631	2.6
Prosopis alba	94	109	21	7	0	0	0	0	0	231	0.9
Brachychiton populneum	6	30	4	0	0	0	0	0	0	40	0.2
Schinus molle	1	4	9	4	0	0	1	0	0	19	0.1
Laurus nobillis	7	2	0	0	0	0	0	0	0	9	0.0
Quercus fusiformis	3	0	0	0	0	0	0	0	0	3	0.0
Magnolia grandiflora	1	0	0	0	0	0	0	0	0	1	0.0
Total	**322**	**412**	**183**	**16**	**0**	**0**	**1**	**0**	**0**	**934**	**3.8**
Broadleaf Evergreen Small (BES)											
Acacia stenophylla	122	491	99	1	0	0	0	0	0	713	2.9
Rhus lancea	89	130	47	1	1	0	0	0	0	268	1.1
Yucca brevifolia	2	226	16	0	0	0	0	0	0	244	1.0
Olea europaea 'Swan Hill'	41	112	24	0	0	0	0	0	0	177	0.7
Sophora secundiflora	125	21	0	0	0	0	0	0	0	146	0.6
Pyrus kawakamii	4	62	24	0	0	0	0	0	0	90	0.4
Olea europaea	0	41	32	2	0	0	0	0	0	75	0.3
Chamaerops humilis	3	47	14	1	0	0	0	0	0	65	0.3
Acacia aneura	43	9	0	0	0	0	0	0	0	52	0.2
Acacia greggii	36	14	0	0	0	0	0	0	0	50	0.2
Acacia constricta	21	3	0	0	0	0	0	0	0	24	0.1

	DBH Class (in)										
Species	**0-3**	**3-6**	**6-12**	**12-18**	**18-24**	**24-30**	**30-36**	**36-42**	**>42**	**Total**	**% of Pop.**
Acacia pendula	8	15	0	0	0	0	0	0	0	23	0.1
Ligustrum lucidum	4	4	0	0	0	0	0	0	0	8	0.0
Ebenopsis ebano	6	1	0	0	0	0	0	0	0	7	0.0
Xylosma congestum	1	3	2	0	0	0	0	0	0	6	0.0
Celtis pallida	5	0	0	0	0	0	0	0	0	5	0.0
Nerium oleander	4	0	0	0	0	0	0	0	0	4	0.0
Podocarpus macrophyllus	3	0	0	0	0	0	0	0	0	3	0.0
Myrtus communis	2	0	0	0	0	0	0	0	0	2	0.0
Platycladus orientalis	1	1	0	0	0	0	0	0	0	2	0.0
Acacia saligna	0	0	1	0	0	0	0	0	0	1	0.0
Callistemon viminalis	1	0	0	0	0	0	0	0	0	1	0.0
Geijera parviflora	0	0	1	0	0	0	0	0	0	1	0.0
Lysiloma microphyllum	0	1	0	0	0	0	0	0	0	1	0.0
Prunus caroliniana	0	0	1	0	0	0	0	0	0	1	0.0
Schinus terebinthifolius	0	0	1	0	0	0	0	0	0	1	0.0
Total	**521**	**1,181**	**262**	**5**	**1**	**0**	**0**	**0**	**0**	**1,970**	**8.0**
Conifer Evergreen Large (CEL)											
Pinus eldarica	97	829	2,050	727	94	4	0	0	0	3,801	15.5
Pinus halepensis	29	177	371	285	95	22	8	0	1	988	4.0
Pinus pinea	2	12	117	34	2	0	0	0	0	167	0.7
Pinus roxburghii	7	91	41	3	0	0	0	0	0	142	0.6
Cupressus sempervirens	4	12	3	0	0	0	0	0	0	19	0.1
Total	**139**	**1,121**	**2,582**	**1,049**	**191**	**26**	**8**	**0**	**1**	**5,117**	**20.8**
Conifer Evergreen Medium (CEM)											
Pinus thunbergiana	0	0	19	0	0	0	0	0	0	19	0.1
Cupressus leylandii	0	1	3	0	0	0	0	0	0	4	0.0
Cupressus glabra	0	0	3	0	0	0	0	0	0	3	0.0
Total	**0**	**1**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**26**	**0.1**
Conifer Evergreen Small (CES)											
Juniperus spp.	0	0	2	0	0	0	0	0	0	2	0.0
Pinus contorta 'bolanderi'	0	0	1	0	0	0	0	0	0	1	0.0
Total	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0.0**
Palm Evergreen Large (PEL)											

	DBH Class (in)										
Species	**0-3**	**3-6**	**6-12**	**12-18**	**18-24**	**24-30**	**30-36**	**36-42**	**>42**	**Total**	**% of Pop.**
Phoenix canariensis	0	0	2	4	4	6	0	0	0	16	0.1
Total	**0**	**0**	**2**	**4**	**4**	**6**	**0**	**0**	**0**	**16**	**0.1**
Palm Evergreen Medium (PEM)											
Phoenix dactylifera	0	0	4	58	68	2	0	0	0	132	0.5
Total	**0**	**0**	**4**	**58**	**68**	**2**	**0**	**0**	**0**	**132**	**0.5**
Palm Evergreen Small (PES)											
Washingtonia robusta	14	19	288	355	57	0	6	0	0	739	3.0
Washingtonia filifera	0	0	17	45	61	22	13	1	1	160	0.7
Total	**14**	**19**	**305**	**400**	**118**	**22**	**19**	**1**	**1**	**899**	**3.7**
County-wide Total	**6,299**	**8,445**	**6,925**	**2,153**	**577**	**109**	**38**	**4**	**2**	**24,552**	**100%**

Relative Performance Index (RPI) for Clark County's Park Trees

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Pinus eldarica	0.1	8.7	42.3	48.9	**1.0**	3,801	15.5
Fraxinus velutina 'Fan-Tex'	1.3	12.8	57.7	28.2	**0.9**	2,525	10.3
Fraxinus velutina	0.7	8.5	52.7	38.0	**1.0**	1,443	5.9
Chilopsis linearis	0.6	9.1	46.3	44.0	**1.0**	1,225	5.0
Parkinsonia x 'Desert Museum'	0.1	5.5	77.7	16.7	**0.9**	1,070	4.4
Prosopis velutina	1.3	10.8	62.6	25.2	**0.9**	1,052	4.3
Pinus halepensis	0.1	3.8	53.8	42.2	**1.0**	988	4.0
Pistacia chinensis	1.5	9.8	50.9	37.9	**1.0**	818	3.3
Chitalpa tashkentensis	0.8	15.2	73.2	10.7	**0.9**	755	3.1
Washingtonia robusta	0.7	2.7	35.6	61.0	**1.1**	739	3.0
Acacia stenophylla	0.3	0.3	35.2	64.2	**1.1**	713	2.9
Vitex agnus-castus	0.4	9.1	44.9	45.6	**1.0**	711	2.9
Quercus virginiana	0.8	6.3	49.0	43.9	**1.0**	631	2.6
Ulmus parvifolia	0.7	14.2	55.7	29.4	**0.9**	605	2.5
Prosopis glandulosa	1.3	7.3	54.3	37.1	**1.0**	604	2.5
Prosopis torreyana	1.8	10.7	40.4	47.1	**1.0**	456	1.9
Fraxinus angustifolia	2.2	17.2	57.2	23.4	**0.9**	402	1.6
Acacia farnesiana	0.3	5.6	57.5	36.7	**1.0**	395	1.6
Gleditsia triacanthos	2.3	19.2	50.0	28.6	**0.9**	308	1.3
Prosopis chilensis	1.9	5.8	59.4	32.8	**1.0**	308	1.3
Parkinsonia florida	2.4	6.3	65.6	25.7	**1.0**	288	1.2
Rhus lancea	0.4	7.1	37.3	55.2	**1.1**	268	1.1
Populus species	1.2	23.8	66.8	8.2	**0.8**	244	1.0
Yucca brevifolia	5.3	26.6	29.5	38.5	**0.9**	244	1.0
Prosopis alba	0.0	2.2	18.6	79.2	**1.2**	231	0.9
Morus alba	0.0	5.7	63.3	31.0	**1.0**	229	0.9
Parkonsonia hybrid	0.0	4.1	62.8	33.0	**1.0**	218	0.9
Pyrus calleryana	2.3	8.4	41.9	47.4	**1.0**	215	0.9
Fraxinus velutina 'Glabra'	1.4	13.0	24.5	61.1	**1.1**	208	0.8
Olea europaea	0.0	1.1	45.8	53.1	**1.1**	177	0.7
Prunus cerasifera	5.7	27.4	57.7	9.1	**0.8**	175	0.7
Populus fremontii	0.6	8.3	58.9	32.1	**1.0**	168	0.7
Pinus pinea	0.6	15.6	61.1	22.8	**0.9**	167	0.7
Washingtonia filifera	0.0	0.0	36.3	63.8	**1.1**	160	0.7
Sophora secundiflora	0.0	6.2	43.8	50.0	**1.1**	146	0.6
Pinus roxburghii	4.2	4.9	27.5	63.4	**1.1**	142	0.6
Phoenix dactylifera	0.0	1.5	43.2	55.3	**1.1**	132	0.5
Robinia ambigua 'Purple Rose'	7.8	17.1	28.7	46.5	**1.0**	129	0.5
Robinia pseudoacacia	1.0	15.5	45.6	37.9	**1.0**	103	0.4
Ulmus pumila	0.0	11.9	76.2	11.9	**0.9**	101	0.4

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Quecus shumardii	1.1	11.6	14.7	72.6	**1.1**	95	0.4
Pyrus kawakamii	0.0	14.4	57.8	27.8	**0.9**	90	0.4
Olea europaea	0.0	1.3	61.3	37.3	**1.0**	75	0.3
Prosopis pubescens	0.0	9.9	77.5	12.7	**0.9**	71	0.3
Plantanus occidentalis	0.0	10.0	68.6	21.4	**0.9**	70	0.3
Platanus x acerfolia	0.0	1.5	98.5	0.0	**0.9**	66	0.3
Chamaerops humilis	0.0	1.5	24.6	73.8	**1.2**	65	0.3
Parkinsonia aculeata	0.0	16.4	57.4	26.2	**0.9**	61	0.2
Quercus ilex	3.4	24.1	55.2	17.2	**0.8**	58	0.2
Acacia aneura	7.7	28.8	36.5	26.9	**0.8**	52	0.2
Acacia greggii	2.0	2.0	62.0	34.0	**1.0**	50	0.2
Brachychiton populneum	0.0	0.0	35.0	65.0	**1.1**	40	0.2
Acacia constricta	4.2	8.3	79.2	8.3	**0.9**	24	0.1
Acacia pendula	0.0	0.0	34.8	65.2	**1.1**	23	0.1
Fraxinus uhdei	0.0	0.0	45.0	55.0	**1.1**	20	0.1
Schinus molle	0.0	5.3	31.6	63.2	**1.1**	19	0.1
Fraxinus cuspidata	26.3	42.1	26.3	5.3	**0.6**	19	0.1
Pinus thunbergiana	0.0	0.0	52.6	47.4	**1.1**	19	0.1
Cupressus sempervirens	0.0	0.0	31.6	68.4	**1.2**	19	0.1
Prosopis spp.	0.0	5.6	72.2	22.2	**1.0**	18	0.1
Bauhinia variegata	5.6	33.3	11.1	50.0	**0.9**	18	0.1
Koelreuteria paniculata	6.3	12.5	31.3	50.0	**1.0**	16	0.1
Phoenix canariensis	0.0	0.0	31.3	68.8	**1.2**	16	0.1
Eucalyptus camaldulensis	0.0	0.0	46.7	53.3	**1.1**	15	0.1
Albizia julibrissin	0.0	14.3	71.4	14.3	**0.9**	14	0.1
Lagerstroemia indica	7.1	28.6	42.9	21.4	**0.8**	14	0.1
Sophora japonica	0.0	0.0	7.1	92.9	**1.2**	14	0.1
Quercus lobata	7.7	38.5	30.8	23.1	**0.8**	13	0.1
Fraxinus sieboldiana	8.3	91.7	0.0	0.0	**0.5**	12	0.0
Quercus macrocarpa	0.0	0.0	33.3	66.7	**1.1**	12	0.0
Laurus nobillis	0.0	66.7	33.3	0.0	**0.6**	9	0.0
Jacaranda mimosifolia	11.1	22.2	44.4	22.2	**0.8**	9	0.0
Platanus wrightii	0.0	62.5	25.0	12.5	**0.7**	8	0.0
Tamarix chinensis	0.0	0.0	62.5	37.5	**1.0**	8	0.0
Ligustrum lucidum	0.0	0.0	75.0	25.0	**1.0**	8	0.0
Ebenopsis ebano	0.0	14.3	57.1	28.6	**1.0**	7	0.0
Prosopis juliflora	0.0	14.3	57.1	28.6	**1.0**	7	0.0
Xylosma congestum	0.0	16.7	50.0	33.3	**1.0**	6	0.0
Eucalyptus microtheca	0.0	33.3	16.7	50.0	**1.0**	6	0.0
Celtis pallida	0.0	0.0	100.0	0.0	**0.9**	5	0.0
Salix gooddingii	0.0	20.0	60.0	20.0	**0.9**	5	0.0
Quercus suber	0.0	0.0	40.0	60.0	**1.1**	5	0.0

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Crataegus phaenopyrum	25.0	75.0	0.0	0.0	**0.4**	4	0.0
Quercus texana Buckley	25.0	50.0	25.0	0.0	**0.5**	4	0.0
Ziziphus jujuba	0.0	0.0	25.0	75.0	**1.2**	4	0.0
Melia azedarach	0.0	0.0	75.0	25.0	**1.0**	4	0.0
Pistacia X atlantica 'Red Push'	0.0	0.0	0.0	100.0	**1.3**	4	0.0
Nerium oleander	0.0	0.0	100.0	0.0	**0.9**	4	0.0
Cupressus leylandii	0.0	0.0	100.0	0.0	**0.9**	4	0.0
Punica granatum	0.0	0.0	33.3	66.7	**1.1**	3	0.0
Celtis occidentalis	0.0	33.3	66.7	0.0	**0.8**	3	0.0
Quercus fusiformis	0.0	66.7	33.3	0.0	**0.6**	3	0.0
Podocarpus macrophyllus	0.0	0.0	0.0	100.0	**1.3**	3	0.0
Cupressus glabra	0.0	0.0	33.3	66.7	**1.1**	3	0.0
Platycladus orientalis	0.0	0.0	50.0	50.0	**1.1**	2	0.0
Cercis canadensis	0.0	0.0	50.0	50.0	**1.1**	2	0.0
Populus alba	0.0	0.0	0.0	100.0	**1.3**	2	0.0
Zelkova serrata	0.0	0.0	100.0	0.0	**0.9**	2	0.0
Celtis sinensis	0.0	0.0	50.0	50.0	**1.1**	2	0.0
Salix x sepulcralis 'Simonkai'	0.0	0.0	100.0	0.0	**0.9**	2	0.0
Juniperus spp.	0.0	0.0	100.0	0.0	**0.9**	2	0.0
Eucalyptus sideroxylon	0.0	0.0	0.0	100.0	**1.3**	2	0.0
Myrtus communis	0.0	100.0	0.0	0.0	**0.5**	2	0.0
Acacia saligna	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Lysiloma microphyllum	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Prunus dulcis	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Parkinsonia microphylla	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Populus balsamifera ssp. Balsamifera	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Pinus contorta 'bolanderi'	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Elaeocarpus decipiens	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Salix spp.	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Callistemon viminalis	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Geijera parviflora	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Schinus terebinthifolius	0.0	0.0	0.0	100.0	**1.3**	1	0.0
Prunus caroliniana	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Betula papyrifera	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Ficus carica	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Sapium sebiferum	0.0	0.0	100.0	0.0	**0.9**	1	0.0
Magnolia grandiflora	0.0	0.0	100.0	0.0	**0.9**	1	0.0
County-wide Total	**0.9**	**9.4**	**51.1**	**38.6**	**1.0**	**24,552**	**100%**

Replacement Value of Clark County's Park Trees

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
Pinus eldarica	18,628	695,873	7,073,208	6,637,110	1,533,877	98,550	0	0	0	**16,057,247**	26.3	15.5
Fraxinus velutina 'Fan-Tex'	88,956	1,412,216	3,303,776	646,545	19,066	0	0	0	0	**5,470,559**	8.9	10.3
Fraxinus velutina	31,951	337,550	1,581,695	918,107	231,458	97,041	0	0	0	**3,197,801**	5.2	5.9
Chilopsis linearis	158,269	446,316	435,799	89,470	0	0	0	0	0	**1,129,854**	1.8	5.0
Parkinsonia x 'Desert Museum'	133,100	332,433	305,360	10,129	19,066	0	0	0	0	**800,089**	1.3	4.4
Prosopis velutina	105,257	418,094	1,304,020	345,305	34,681	0	0	0	0	**2,207,358**	3.6	4.3
Pinus halepensis	4,846	202,090	1,743,195	3,566,128	2,097,279	755,239	408,239	0	61,853	**8,838,870**	14.5	4.0
Pistacia chinensis	50,998	671,936	822,917	31,391	0	0	0	0	0	**1,577,243**	2.6	3.3
Chiltalpa tashkentensis	20,596	310,963	1,325,457	76,809	0	0	0	0	0	**1,733,825**	2.8	3.1
Washingtonia robusta	2,058	3,597	70,462	94,629	17,234	0	1,422	0	0	**189,403**	0.3	3.0
Acacia stenophylla	28,289	679,180	455,866	14,349	0	0	0	0	0	**1,177,685**	1.9	2.9
Vitex agnus-castus	114,488	184,198	67,561	10,129	0	0	0	0	0	**376,376**	0.6	2.9
Quercus virginiana	43,327	329,929	720,088	54,864	0	0	0	0	0	**1,148,207**	1.9	2.6
Ulmus parvifolia	11,403	422,162	732,798	44,735	19,066	0	0	0	0	**1,230,164**	2.0	2.5
Prosopis glandulosa	52,219	416,746	560,575	18,402	0	0	0	0	0	**1,047,942**	1.7	2.5
Prosopis torreyana	62,045	145,820	165,557	81,029	0	0	0	0	0	**454,451**	0.7	1.9
Fraxinus angustifolia	11,176	239,037	501,353	48,955	0	0	0	0	0	**800,521**	1.3	1.6
Acacia farnesiana	60,529	161,781	126,471	0	0	0	0	0	0	**348,782**	0.6	1.6
Gleditsia triacanthos	12,156	93,777	303,269	172,609	13,652	0	0	0	0	**595,462**	1.0	1.3
Prosopis chilensis	16,050	99,242	237,782	202,891	81,910	110,258	0	0	0	**748,134**	1.2	1.3
Parkinsonia florida	20,199	233,971	189,707	7,577	0	0	0	0	0	**451,453**	0.7	1.2
Rhus lancea	19,839	164,159	230,442	14,349	19,066	0	0	0	0	**447,854**	0.7	1.1

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
Populus species	845	19,246	103,694	285,775	270,292	158,707	63,764	22,725	0	**925,047**	1.5	1.0
Yucca brevifolia	394	256,840	67,561	0	0	0	0	0	0	**324,794**	0.5	1.0
Prosopis alba	20,188	115,838	77,811	69,044	0	0	0	0	0	**282,880**	0.5	0.9
Morus alba	462	3,167	105,787	480,309	418,953	102,692	25,209	0	0	**1,136,579**	1.9	0.9
Parkonsonia hybrid	22,398	92,949	134,118	10,129	0	0	0	0	0	**259,593**	0.4	0.9
Pyrus calleryana	1,378	125,781	506,035	0	0	0	0	0	0	**633,194**	1.0	0.9
Fraxinus velutina 'Glabra'	5,846	68,347	554,197	154,462	19,066	0	0	0	0	**801,918**	1.3	0.8
Olea europaea 'Swan Hill'	8,965	143,494	129,770	0	0	0	0	0	0	**282,229**	0.5	0.7
Prunus cerasifera	17,963	42,389	0	0	0	0	0	0	0	**60,352**	0.1	0.7
Populus fremontii	180	342	38,450	230,005	186,801	88,924	15,191	21,661	0	**581,556**	1.0	0.7
Pinus pinea	439	9,930	476,268	399,237	46,077	0	0	0	0	**931,952**	1.5	0.7
Washingtonia filifera	0	0	7,762	25,163	42,696	16,475	10,923	819	819	**104,656**	0.2	0.7
Sophora secundiflora	24,353	18,462	0	0	0	0	0	0	0	**42,815**	0.1	0.6
Pinus roxburghii	1,192	71,883	123,923	21,996	0	0	0	0	0	**218,995**	0.4	0.6
Phoenix dactylifera	0	0	2,821	46,899	69,382	1,832	0	0	0	**120,934**	0.2	0.5
Robinia ambigua 'Purple Rose'	6,754	43,478	276,262	0	0	0	0	0	0	**326,494**	0.5	0.5
Robinia pseudoacacia	6,512	73,805	32,777	0	0	0	0	0	0	**113,093**	0.2	0.4
Ulmus pumila	3,180	8,409	16,054	230,427	689,560	295,417	139,758	0	0	**1,382,804**	2.3	0.4
Quecus shumardii	1,242	33,100	327,769	0	0	0	0	0	0	**362,111**	0.6	0.4
Pyrus kawakamii	516	52,254	76,844	0	0	0	0	0	0	**129,613**	0.2	0.4
Olea europaea	0	60,850	198,252	31,391	0	0	0	0	0	**290,494**	0.5	0.3
Prosopis pubescens	5,535	22,128	29,481	0	0	0	0	0	0	**57,144**	0.1	0.3
Plantanus	363	3,399	175,256	248,152	0	0	0	0	0	**427,171**	0.7	0.3

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
occidentalis												
Platanus x acerfolia	148	583	128,196	0	0	0	0	0	0	**128,926**	0.2	0.3
Chamaerops humilis	607	10,220	3,057	210	0	0	0	0	0	**14,095**	0.0	0.3
Parkinsonia aculeata	3,143	8,060	33,634	15,838	0	0	0	0	0	**60,676**	0.1	0.2
Quercus ilex	3,756	24,602	52,510	0	0	0	0	0	0	**80,867**	0.1	0.2
Acacia aneura	7,405	12,345	0	0	0	0	0	0	0	**19,751**	0.0	0.2
Acacia greggii	7,254	18,160	0	0	0	0	0	0	0	**25,414**	0.0	0.2
Brachychiton populneum	1,318	41,599	19,399	0	0	0	0	0	0	**62,315**	0.1	0.2
Acacia constricta	3,847	3,221	0	0	0	0	0	0	0	**7,067**	0.0	0.1
Acacia pendula	1,908	20,129	0	0	0	0	0	0	0	**22,037**	0.0	0.1
Fraxinus uhdei	0	1,193	37,123	0	0	0	0	0	0	**38,316**	0.1	0.1
Cupressus sempervirens	727	18,250	13,713	0	0	0	0	0	0	**32,690**	0.1	0.1
Fraxinus cuspidata	2,215	1,581	0	0	0	0	0	0	0	**3,796**	0.0	0.1
Pinus thunbergiana	0	0	66,478	0	0	0	0	0	0	**66,478**	0.1	0.1
Schinus molle	257	4,741	44,483	57,396	0	0	44,134	0	0	**151,011**	0.2	0.1
Bauhinia variegata	2,475	9,543	0	0	0	0	0	0	0	**12,018**	0.0	0.1
Prosopis spp.	1,737	6,865	0	0	0	0	0	0	0	**8,602**	0.0	0.1
Koelreuteria paniculata	500	13,419	13,713	0	0	0	0	0	0	**27,632**	0.0	0.1
Phoenix canariensis	0	0	2,522	8,649	8,999	18,314	0	0	0	**38,484**	0.1	0.1
Eucalyptus camaldulensis	0	0	17,864	21,691	18,663	0	0	0	0	**58,218**	0.1	0.1
Albizia julibrissin	977	6,398	0	0	0	0	0	0	0	**7,375**	0.0	0.1
Lagerstroemia indica	2,441	2,133	0	0	0	0	0	0	0	**4,574**	0.0	0.1
Sophora japonica	0	1,521	72,243	0	0	0	0	0	0	**73,764**	0.1	0.1
Quercus lobata	606	3,221	24,081	0	0	0	0	0	0	**27,907**	0.0	0.1

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
Fraxinus sieboldiana	1,158	0	0	0	0	0	0	0	0	**1,158**	0.0	0.0
Quercus macrocarpa	0	7,604	33,111	0	0	0	0	0	0	**40,715**	0.1	0.0
Jacaranda mimosifolia	144	3,770	1,786	0	0	0	0	0	0	**5,700**	0.0	0.0
Laurus nobillis	818	2,147	0	0	0	0	0	0	0	**2,965**	0.0	0.0
Ligustrum lucidum	803	4,741	0	0	0	0	0	0	0	**5,544**	0.0	0.0
Platanus wrightii	417	0	2,298	13,867	0	0	0	0	0	**16,583**	0.0	0.0
Tamarix chinensis	686	6,512	5,127	0	0	0	0	0	0	**12,324**	0.0	0.0
Ebenopsis ebano	1,166	1,074	0	0	0	0	0	0	0	**2,240**	0.0	0.0
Prosopis juliflora	1,090	1,521	0	0	0	0	0	0	0	**2,611**	0.0	0.0
Eucalyptus microtheca	0	1,521	8,027	30,386	0	0	0	0	0	**39,934**	0.1	0.0
Xylosma congestum	89	2,236	5,578	0	0	0	0	0	0	**7,903**	0.0	0.0
Celtis pallida	909	0	0	0	0	0	0	0	0	**909**	0.0	0.0
Quercus suber	0	5,189	0	14,349	0	0	0	0	0	**19,538**	0.0	0.0
Salix gooddingii	0	3,480	12,391	0	0	0	0	0	0	**15,871**	0.0	0.0
Crataegus phaenopyrum	431	0	0	0	0	0	0	0	0	**431**	0.0	0.0
Cupressus leylandii	0	796	8,766	0	0	0	0	0	0	**9,562**	0.0	0.0
Melia azedarach	0	800	2,900	17,564	0	0	0	0	0	**21,263**	0.0	0.0
Nerium oleander	500	0	0	0	0	0	0	0	0	**500**	0.0	0.0
Pistacia X atlantica 'Red Push'	209	2,476	0	0	0	0	0	0	0	**2,686**	0.0	0.0
Quercus texana	606	0	0	0	0	0	0	0	0	**606**	0.0	0.0
Ziziphus jujuba	0	0	8,848	8,143	0	0	0	0	0	**16,991**	0.0	0.0
Celtis occidentalis	0	1,700	4,013	0	0	0	0	0	0	**5,713**	0.0	0.0
Cupressus glabra	0	0	15,385	0	0	0	0	0	0	**15,385**	0.0	0.0
Podocarpus	649	0	0	0	0	0	0	0	0	**649**	0.0	0.0

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
macrophyllus												
Punica granatum	257	2,594	0	0	0	0	0	0	0	**2,852**	0.0	0.0
Quercus fusiformis	394	0	0	0	0	0	0	0	0	**394**	0.0	0.0
Cercis canadensis	439	0	0	0	0	0	0	0	0	**439**	0.0	0.0
Celtis sinensis	0	1,074	5,686	0	0	0	0	0	0	**6,759**	0.0	0.0
Eucalyptus sideroxylon	0	0	5,686	14,349	0	0	0	0	0	**20,035**	0.0	0.0
Juniperus spp.	0	0	8,027	0	0	0	0	0	0	**8,027**	0.0	0.0
Myrtus communis	212	0	0	0	0	0	0	0	0	**212**	0.0	0.0
Populus alba	0	0	4,745	0	0	0	0	0	0	**4,745**	0.0	0.0
Salix x sepulcralis Simonkai	0	0	2,900	7,268	0	0	0	0	0	**10,168**	0.0	0.0
Platycladus orientalis	182	1,521	0	0	0	0	0	0	0	**1,703**	0.0	0.0
Zelkova serrata	153	0	2,308	0	0	0	0	0	0	**2,461**	0.0	0.0
Acacia saligna	0	0	2,900	0	0	0	0	0	0	**2,900**	0.0	0.0
Betula papyrifera	0	500	0	0	0	0	0	0	0	**500**	0.0	0.0
Callistemon viminalis	204	0	0	0	0	0	0	0	0	**204**	0.0	0.0
Parkinsonia microphylla	0	1,909	0	0	0	0	0	0	0	**1,909**	0.0	0.0
Elaeocarpus decipiens	0	825	0	0	0	0	0	0	0	**825**	0.0	0.0
Ficus carica	0	0	5,127	0	0	0	0	0	0	**5,127**	0.0	0.0
Geijera parviflora	0	0	12,627	0	0	0	0	0	0	**12,627**	0.0	0.0
Lysiloma microphyllum	0	1,347	0	0	0	0	0	0	0	**1,347**	0.0	0.0
Magnolia grandiflora	182	0	0	0	0	0	0	0	0	**182**	0.0	0.0
Pinus contorta	0	0	12,627	0	0	0	0	0	0	**12,627**	0.0	0.0

Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Total ($)	% of Pop.
'bolanderi'												
Populus balsamifera ssp. Balsamifera	0	0	0	4,132	0	0	0	0	0	**4,132**	0.0	0.0
Prunus caroliniana	0	0	4,013	0	0	0	0	0	0	**4,013**	0.0	0.0
Prunus dulcis	201	0	0	0	0	0	0	0	0	**201**	0.0	0.0
Sapium sebiferum	0	0	2,308	0	0	0	0	0	0	**2,308**	0.0	0.0
Salix spp.	0	1,347	0	0	0	0	0	0	0	**1,347**	0.0	0.0
Schinus terebinthifolius	0	0	5,686	0	0	0	0	0	0	**5,686**	0.0	0.0
Citywide total	**$1,248,303**	**$9,531,629**	**$26,430,135**	**$15,532,342**	**$5,856,845**	**$1,743,449**	**$708,639**	**$45,205**	**$62,672**	**$61,159,219**	**100%**	**100%**