URBAN FOREST RESOURCE ANALYSIS OF INVENTORIED PUBLIC TREES

City of Las Vegas, Nevada

June 2013

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

City of Las Vegas, Nevada

Resource Analysis

Of Inventoried Public trees

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Prepared for

Nevada Division of Forestry

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Executive Summary

Trees play a vital role in the community of Las Vegas, Nevada. They provide numerous benefits both tangible and intangible, to residents, visitors, and neighboring communities. Dedicated to maintaining 22,731 trees, Las Vegas has demonstrated that public trees are a valued community resource, an important component of the urban infrastructure, and a part of the city'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 City of Las Vegas, North Las Vegas, Mesquite, Boulder City, unincorporated Clark County, 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 Las Vegas, this included 23,053 trees and vacant planting sites in public areas. 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.

Las Vegas' public trees in the inventoried areas are providing annual benefits of $713,520 ($1.20 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.

Las Vegas' public tree resource is reducing annual electric energy consumption by 1,067 megawatts (MWh) and annual natural gas consumption by 7,536 therms, for a combined value of $76,486 annually. In addition, these trees are removing 1,877 pounds of pollutants from the air, including ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulates ($_{PM10}$) for an overall annual air quality benefit of $39,524. Canopy from this population covers 125.11 acres. This canopy reduces annual stormwater runoff by 7 million gallons and protects local water resources by reducing sediment and pollution loading.

Las Vegas' tree population is young and comprised of many small-stature trees. Therefore, the benefits provided to the City do not currently outweigh the cost of maintenance and planting. However, as existing populations of medium and large-stature trees grow in the landscape, the benefits can be expected to increase. The total investment in maintenance for the inventoried trees is $804,961. For every $1 invested in this resource, Las Vegas is receiving $0.89 in benefits.

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. Las Vegas' inventoried tree resource is a relatively young population in overall good condition. With more than 100 different species, Las Vegas 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

Las Vegas is located in Southern Nevada. With an estimated population of 594,294, it is the largest city in the state and one of the fastest growing. Las Vegas' arid climate makes it one of the driest places in the country. Despite the challenges imposed by climate, the City has invested in planting and maintaining over 31,000 trees in public areas. These trees compose Las Vegas' urban forest. **This analysis takes a closer look at a subset of that population, including 22,731 inventoried trees.** Considering this subset was not a random sample, this data cannot be extrapolated to the entire tree inventory, but it does provide a snapshot of the status of the inventoried trees.

A healthy urban forest plays an important role in the quality of life in Las Vegas.

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 City 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 Las Vegas a more enjoyable place to live, work, and play. The City's 31,207 public trees play a prominent role in the overall urban forest benefits afforded to the community. Residents rely on the City of Las Vegas to protect and maintain this vital resource.

The City of Las Vegas participated in a Nevada Division of Forestry (NDF) sponsored project in 2012 to inventory a portion of their public trees. By participating, Las Vegas 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 City 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 Las Vegas, effectively quantifies the value of the community's

public 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 analysis describes the structure, function, and value of a subset of the public urban forest, including 22,731 trees and 322 vacant sites. 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 Las Vegas' 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

Las Vegas' urban forest resource considered 22,731 public trees and 322 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 112 unique tree species identified in the inventory. The predominant tree species are Mondale pine (*Pinus eldarica,* 18.4%) and Fan-Tex ash (*Fraxinus velutina* Fan-Tex, 9.0%).
- The age structure of the inventoried tree population is young overall, with 69% of trees measuring between 0 to 6 inches DBH (diameter at breast height, measured at 4'6" above the ground) and 90% under 12 inches DBH.

Replacement of Las Vegas' 22,731 inventoried trees with trees of similar size, species, and condition would cost nearly $47.3 million.

- Half of the inventoried trees (50%) are in fair condition and 43% are in good condition.
- To date, the inventoried tree population has sequestered 3,499 tons of carbon (CO_2), valued at approximately $52,493.
- Replacement of Las Vegas' 22,731 inventoried trees with trees of similar size, species, and condition would cost nearly $47.3 million.

Summary of Urban Forest Benefits

Annually, Las Vegas' inventoried public trees provide cumulative benefits to the community at an average value of $31.39 per tree, for a total gross value of $804,961 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 $76,486, an average of $3.36 per tree.
- Trees sequester 392 tons of atmospheric CO_2 per year. An additional 533 tons are avoided[1] by reducing energy generation, resulting in a net value of $13,377 and an average of $0.59 per tree.
- Net air quality improvements, including removal and avoidance of pollutants, provided by the city tree population are valued at $39,524, an average per tree benefit of $1.74.
- Las Vegas' inventoried public trees intercept an estimated 7 million gallons of stormwater annually for a total value of $33,718, an average of $1.48 per tree.

For every $1 invested in public trees, Las Vegas receives $0.89 in benefits.

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

- The benefit contributed by Las Vegas' inventoried public trees to property value increases, aesthetics, and socioeconomics equals $550,415, an average of $24.21 per tree.
- When the City's annual investment of $804,961 for maintenance of this resource is considered, the annual net benefit (benefits minus investment) to the City is -$91,441, and average of -$4.02 per tree. In other words**, for every $1 invested in public trees, Las Vegas receives $0.89 in benefits.**

Urban Forest Resource Management

Las Vegas' public 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.

Las Vegas has the benefit of a relatively young urban forest in good condition. The City 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 Las Vegas' inventoried tree resource will continue to increase as existing trees mature and new trees are planted. As the resource grows, investment in management is critical to ensuring that residents will continue receiving a high return on the 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 Las Vegas' 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 City.

Chapter 2: Las Vegas' Urban Forest Resource

A city'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 Las Vegas' inventoried public tree population, comprising 85% 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 59% of Las Vegas' public tree population, including 3% large-stature, 30% medium-stature, and 26% small-stature trees. Evergreen broadleaf trees comprise 15% of the population, including 3% large and medium-stature and 12% small-stature. Conifers represent 21% of the overall population, and they are primarily large stature trees. Approximately 5% of the population is comprised of palms. (Figure 1 and Table 1).

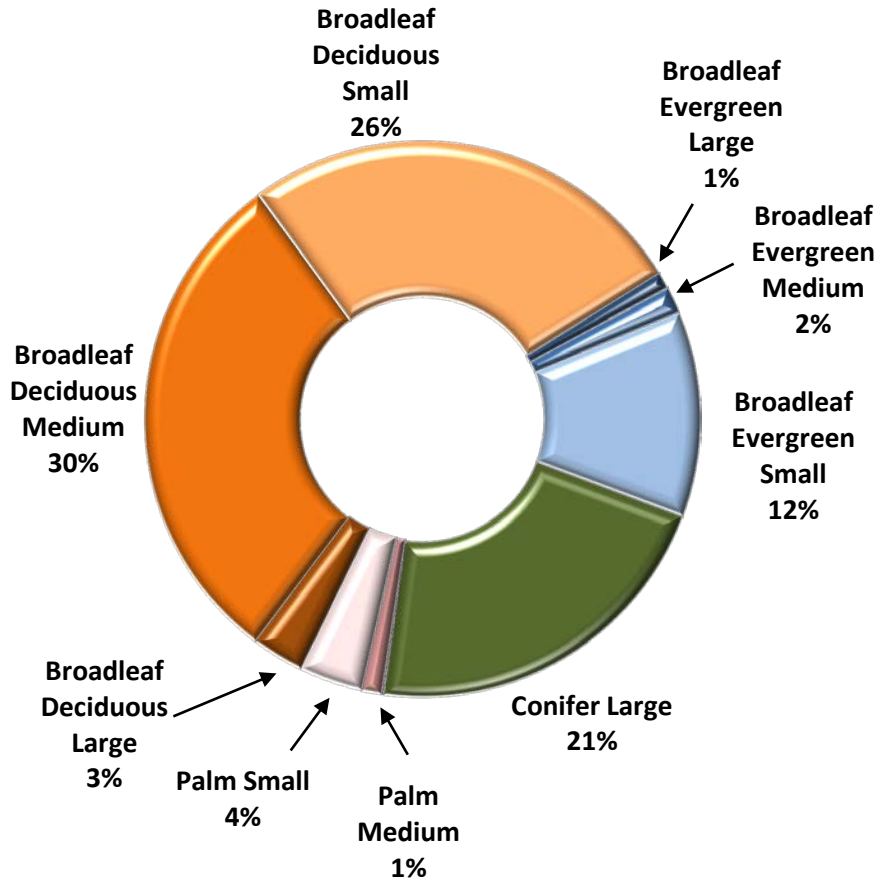


Figure 1. Overall Composition of Las Vegas' Inventoried Public Tree Population

Species Richness and Composition

Las Vegas' inventoried public tree population (Table 1 and Appendix C) includes a mix of 112 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 63% of the total population (Figure 2). The predominant tree species are Mondale pine (*Pinus eldarica*, 18.4%) and Fan-Tex ash (*Fraxinus velutina 'Fan Tex'*, 9.0%).

There is a widely accepted rule that no single species should represent greater than 10% of the total population, and no single genus more than 20% (Clark Et al, 1997). The genus *Pinus* (21%) and the species *P. eldarica* (18.4%) are each exceeding this rule. New plantings in the immediate future should limit these species to reduce overreliance.

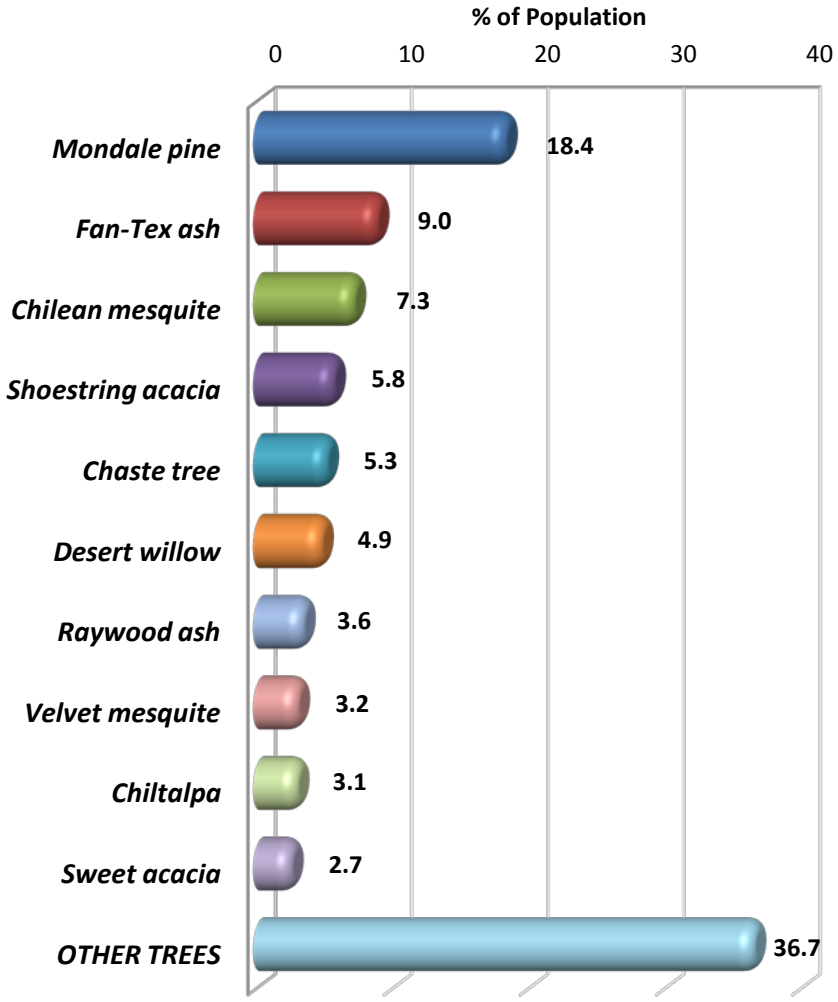


Figure 2. Frequency of Top 10 Species in Las Vegas' Inventoried Public Tree Population

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.

Table 1. Population Distribution of Las Vegas' Public Tree Inventory

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Broadleaf Deciduous Large (BDL)											
Fremont cottonwood	20	42	30	58	57	33	9	3	1	253	1.1
BDL OTHER	56	126	132	86	31	9	3	3	1	447	2.0
Total	**76**	**168**	**162**	**144**	**88**	**42**	**12**	**6**	**2**	**700**	**3.1**
Broadleaf Deciduous Medium (BDM)											
Fan-Tex ash	840	806	324	73	4	0	0	0	0	2,047	9.0
Chilean mesquite	909	449	239	60	2	0	0	0	0	1,659	7.3
Raywood ash	85	542	178	10	0	0	0	0	0	815	3.6
Chinese pistache	68	289	162	10	0	0	0	0	0	529	2.3
Velvet ash	101	174	144	45	2	0	0	0	0	466	2.1
Chinese elm	77	245	60	3	0	0	0	0	0	385	1.7
BDM OTHER	265	341	166	42	21	1	0	0	0	836	3.7
Total	**2,345**	**2,846**	**1,273**	**243**	**29**	**1**	**0**	**0**	**0**	**6,737**	**29.6**
Broadleaf Deciduous Small (BDS)											
Chaste tree	1,073	128	4	0	0	0	0	0	0	1,205	5.3
Desert willow	793	275	49	1	0	0	0	0	0	1,118	4.9
Velvet mesquite	259	364	85	11	1	0	0	0	0	720	3.2
Chiltalpa	124	380	205	0	0	0	0	0	0	709	3.1
Sweet acacia	486	90	35	2	0	0	0	0	0	613	2.7
Desert Museum paloverde	238	252	28	1	0	0	0	0	0	519	2.3
Honey mesquite	113	181	137	6	0	0	0	0	0	437	1.9
Western honey mesquite	97	120	29	2	0	0	0	0	0	248	1.1
BDS OTHER	222	136	38	1	2	0	0	0	0	399	1.8
Total	**3,405**	**1,926**	**610**	**24**	**3**	**0**	**0**	**0**	**0**	**5,968**	**26.3**
Broadleaf Evergreen Large (BEL)											
BEL OTHER	10	148	53	12	3	0	0	0	0	226	1.0
Total	**10**	**148**	**53**	**12**	**3**	**0**	**0**	**0**	**0**	**226**	**1.0**
Broadleaf Evergreen Medium (BEM)											
Southern live oak	89	150	55	11	0	0	0	0	0	305	1.3
BEM OTHER	6	9	30	0	0	0	0	0	0	45	0.2
Total	**95**	**159**	**85**	**11**	**0**	**0**	**0**	**0**	**0**	**350**	**1.5**
Broadleaf Evergreen Small (BES)											
Shoestring acacia	436	743	132	10	0	0	0	0	0	1,321	5.8
African sumac	187	218	35	4	1	1	0	0	0	446	2.0
BES OTHER	632	278	43	0	1	0	0	0	0	954	4.2

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Total	**1,255**	**1,239**	**210**	**14**	**2**	**1**	**0**	**0**	**0**	**2,721**	**12.0**
Conifer Evergreen Large (CEL)											
Mondale pine	111	1,544	1,757	704	71	2	0	0	0	4,189	18.4
Aleppo pine	9	13	172	158	7	0	0	0	0	359	1.6
Stone pine	2	29	132	72	4	1	0	0	0	240	1.1
CEL OTHER	15	8	52	20	1	0	0	0	0	96	0.4
Total	**137**	**1,594**	**2,113**	**954**	**83**	**3**	**0**	**0**	**0**	**4,884**	**21.5**
Conifer Evergreen Medium (CEM)											
CEM OTHER	0	2	5	1	0	0	0	0	0	8	0.0
Total	**0**	**2**	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**8**	**0.0**
Conifer Evergreen Small (CES)											
CES OTHER	2	5	5	0	0	0	0	0	0	12	0.1
Total	**2**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0.1**
Palm Evergreen Large (PEL)											
PEL OTHER	0	4	1	4	6	4	1	0	0	20	0.1
Total	**0**	**4**	**1**	**4**	**6**	**4**	**1**	**0**	**0**	**20**	**0.1**
Palm Evergreen Medium (PEM)											
Date palm	1	0	3	127	138	0	0	0	0	269	1.2
PEM OTHER	0	0	0	0	0	0	0	0	0	0	0.0
Total	**1**	**0**	**3**	**127**	**138**	**0**	**0**	**0**	**0**	**269**	**1.2**
Palm Evergreen Small (PES)											
Mexican fan palm	9	15	211	271	22	14	1	0	0	543	2.4
PES OTHER	162	21	52	26	18	9	5	0	0	293	1.3
Total	**171**	**36**	**263**	**297**	**40**	**23**	**6**	**0**	**0**	**836**	**3.7**
Citywide	**7,497**	**8,127**	**4,783**	**1,831**	**392**	**74**	**19**	**6**	**2**	**22,731**	**100%**

Species Importance

To quantify the significance of any one particular species to Las Vegas' 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 City'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 23 most abundant species each represent greater than 1% of the total population. Together, these 23 species represent 85% of the total population, 84% of the total leaf area, and 85% of the total canopy cover for a combined importance value of 85 (Table 2). Of these species, Las Vegas relies most on Mondale pine (*Pinus eldarica*, IV=22.12) and Fan-Tex ash (*Fraxinus velutina 'Fan-Tex'*, IV= 9.0).

Due to their large stature and high leaf surface area, some species provide more impact than their population numbers alone would suggest. For example, Las Vegas' Fremont cottonwood (*Populus fremontii*, IV=4.4) represents just 1.1% of the tree population but is providing 4.1% of the canopy cover. Chinese elm (*Ulmus parvifolia*, IV=2.4) represents just 1.7% of the population while providing 3.2% of the canopy. Both of these species are large-stature deciduous hardwoods that grow vigorously and often have 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, desert willow (*Chilopsis linearis*) and chaste tree (*Vitex agnus-castus*) represent 4.9% and 5.3% of the population, but because of their small-stature, their importance values are just 2.5 each (Table 2).

Table 2. Importance Value (IV) of Las Vegas' Most Abundant Public Tree Species

Species	Number of Trees	% of Total Trees	Leaf Area (ft^2)	% of Total Leaf Area	Canopy Cover (ft^2)	% of Total Canopy Cover	Importance Value
Mondale pine	4,189	18.4	3,784,950	25.0	1,249,834	22.9	**22.12**
Fan-Tex ash	2,047	9.0	1,223,593	8.1	540,099	9.9	**9.00**
Chilean mesquite	1,659	7.3	871,919	5.8	374,785	6.9	**6.65**
Shoestring acacia	1,321	5.8	507,976	3.4	195,885	3.6	**4.25**
Chaste tree	1,205	5.3	119,191	0.8	82,890	1.5	**2.54**
Desert willow	1,118	4.9	158,685	1.0	77,959	1.4	**2.47**
Raywood ash	815	3.6	576,553	3.8	272,387	5.0	**4.13**
Velvet mesquite	720	3.2	375,454	2.5	172,007	3.2	**2.93**
Chiltalpa	709	3.1	294,658	1.9	156,564	2.9	**2.65**
Sweet acacia	613	2.7	94,059	0.6	57,720	1.1	**1.46**
Mexican fan palm	543	2.4	157,220	1.0	43,086	0.8	**1.41**
Chinese pistache	529	2.3	370,964	2.5	161,779	3.0	**2.58**
Desert Museum paloverde	519	2.3	119,665	0.8	69,924	1.3	**1.45**
Velvet ash	466	2.1	455,171	3.0	147,513	2.7	**2.59**
African sumac	446	2.0	160,393	1.1	61,046	1.1	**1.38**
Honey mesquite	437	1.9	323,712	2.1	148,541	2.7	**2.26**
Chinese elm	385	1.7	349,402	2.3	175,722	3.2	**2.41**
Aleppo pine	359	1.6	743,405	4.9	174,078	3.2	**3.23**
Live oak	305	1.3	161,476	1.1	70,827	1.3	**1.24**
Date palm	269	1.2	83,126	0.5	59,730	1.1	**0.94**
Fremont cottonwood	253	1.1	1,221,331	8.1	223,123	4.1	**4.43**
Western honey mesquite	248	1.1	70,899	0.5	39,572	0.7	**0.76**
Stone pine	240	1.1	430,694	2.8	101,437	1.9	**1.92**
Other Trees	3,336	14.7	2,478,857	16.4	793,314	14.6	**15.20**
Citywide Total	**22,731**	**100%**	**15,133,354**	**100%**	**5,449,822**	**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 trees provide 347.4 acres of tree canopy cover. Mondale pine (*Pinus eldarica*) and Fan-Tex ash (*Fraxinus velutina* 'Fan-Tex') provide the largest proportion of canopy, accounting for 22.9% and 9.0% of the total canopy respectively.

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 Las Vegas' urban forest is weighted towards young trees (Figure 3), with 69% of the population consisting of trees with a DBH of six inches or smaller. Established trees (6-18 inches DBH) comprise 29%, and mature trees (>18 inches DBH) make up less than 2% of the overall population. With continued, proactive management of this young urban forest, Las Vegas can expect increasing benefits as this resource matures. Las Vegas 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.

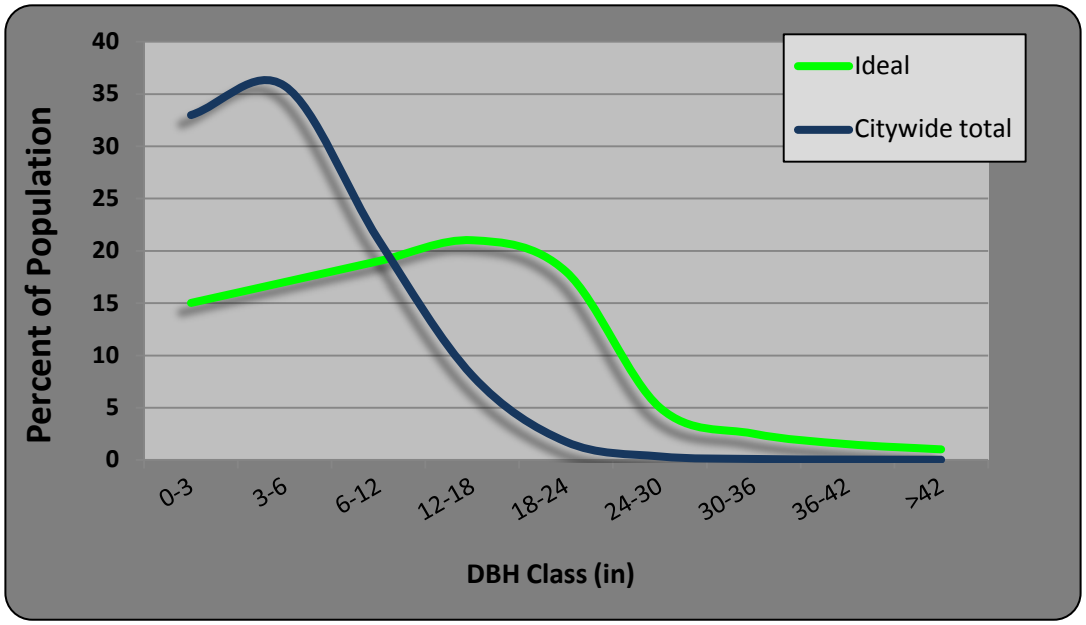


Figure 3. Overall Relative Age Distribution of Las Vegas' Tree Inventory

Of Las Vegas' ten most common species (Figure 4*),* the youngest population is likely chaste tree (*Vitex agnus-castus,* 99.7% under 6" DBH).

Chilean mesquite (*Prosopis chilensis*, 82% 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.

Six of the ten 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. Chaste tree (*Vitex agnus-castus*, 99.7% under 6" DBH), desert willow (*Chilopsis linearis*, 95.5% under 6" DBH), and sweet acacia (*Acacia farnesiana*, 94.0% under 6" DBH) are small-stature populations that are likely to continue to provide benefits at a flat or declining rate over time.

Mondale pine (*Pinus eldarica*) is the only established population of a large-stature tree. This 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, Las Vegas 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 Las Vegas' 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.

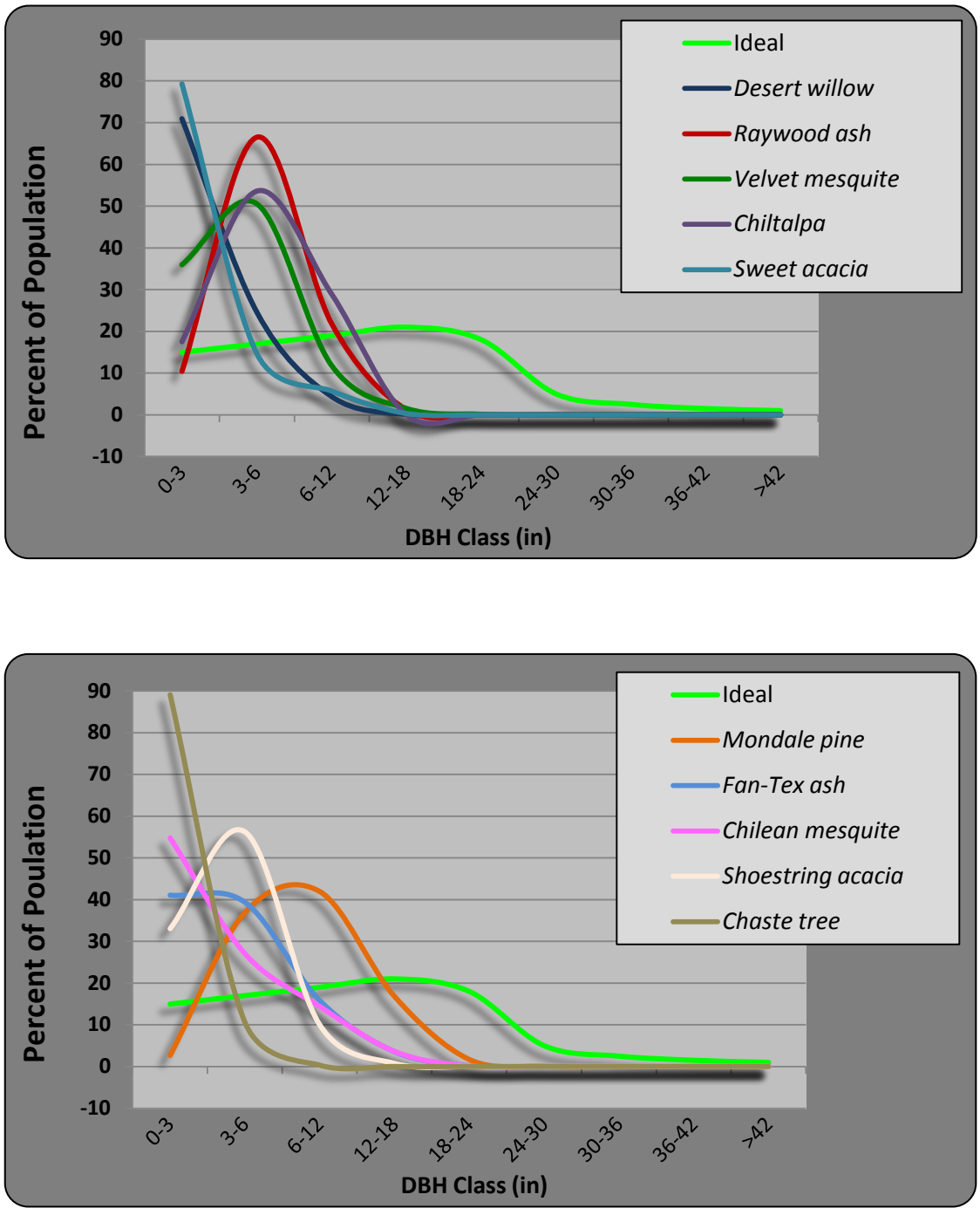


Figure 4. Relative Age Distribution of Las Vegas' Top 10 Inventoried Tree Species

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 43% of Las Vegas' trees in good condition and 50% in fair condition. Nearly 7% of the population was determined to be in poor condition. Removal or mitigation of failing trees is recommended as soon as possible to reduce liability exposure.

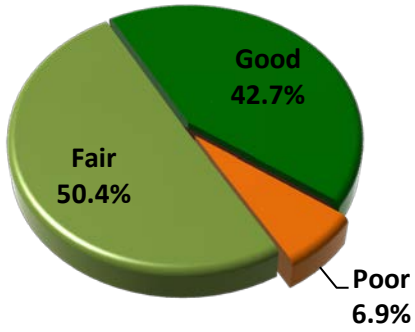


Figure 5. Condition of Las Vegas' Inventoried Public Trees

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 23 most common species collected by the inventory, 18 have an RPI of 1.0 or greater (Table 3). Of these, Mexican fan palm (*Washingtonia robusta*, RPI=1.15), date palm (*Phoenix dactylifera*, RPI=1.11), and Chilean mesquite (*Prosopis chilensis*, RPI=1.11) have the highest RPI, while Chitalpa (*Chitalpa tashkentenssis,* RPI=0.86) and Raywood ash (*Fraxinus angustifolia 'Raywood'*, RPI=0.89) 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 Las Vegas' Inventoried Public Trees

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Mondale pine	0	4.3	55.5	40.2	**1.00**	4,179	18.4
Fan-Tex ash	0	11.2	44.7	44.1	**0.99**	1,999	8.8
Chilean mesquite	0	4.2	24.5	71.4	**1.11**	1,614	7.1
Shoestring acacia	0	1.5	55.8	42.7	**1.02**	1,317	5.8
Chaste tree	0	4.5	63.9	31.6	**0.97**	1,202	5.3
Desert willow	0	5.3	36.0	58.7	**1.06**	1,111	4.9
Raywood ash	0	16.9	60.0	23.1	**0.89**	782	3.4
Velvet mesquite	0	4.9	75.5	19.6	**0.92**	719	3.2
Chiltalpa	0	12.6	77.0	10.3	**0.86**	697	3.1
Sweet acacia	0	2.6	35.6	61.7	**1.08**	606	2.7
Mexican fan palm	0	1.1	21.2	77.7	**1.15**	543	2.4
Chinese pistache	0	8.8	49.1	42.1	**0.99**	523	2.3
Desert Museum paloverde	0	6.0	62.2	31.9	**0.96**	518	2.3
Velvet ash	0	13.3	48.7	38.0	**0.96**	450	2.0
African sumac	0	4.3	73.5	22.2	**0.94**	445	2.0
Honey mesquite	0	8.7	65.5	25.7	**0.93**	435	1.9
Chinese elm	0	16.7	58.0	25.3	**0.90**	383	1.7
Aleppo pine	0	1.1	44.3	54.6	**1.06**	359	1.6
Live oak	0	16.6	57.8	25.7	**0.90**	296	1.3
Date palm	0	4.5	26.0	69.5	**1.11**	269	1.2
Western honey mesquite	0	0.8	42.7	56.5	**1.07**	246	1.1
Fremont cottonwood	0	6.7	45.6	47.7	**1.02**	239	1.1
Stone pine	0	2.1	41.3	56.6	**1.07**	235	1.0
Other Trees	0	9.6	48.1	42.3	**0.97**	3259	14.3
Citywide Total	**0**	**6.9**	**50.4**	**42.7**	**1.00**	**22,428**	**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.
Mediterranean fan palm	**1.19**	218	0.96
Coolibah tree	**1.15**	66	0.29
California palm	**1.13**	69	0.30
California sycamore	**1.13**	60	0.26
Siberian elm	**1.10**	170	0.75
Common crapemyrtle	**1.08**	54	0.24

Replacement Value

The current value of Las Vegas' inventoried tree resource is approximately $47.3 million. The community forest is a public asset that, 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).

To replace Las Vegas' current inventoried tree population of 22,731 trees with trees of similar size, species, and condition would cost nearly $47.3 million (Table 5). The average replacement value per tree is $2,080. Mondale pine *(Pinus eldarica)* and Fan-Tex ash *(Fraxinus velutina* 'Fan-Tex') are the most valuable populations, representing $18.9 million and 40% of the overall replacement value but just 27% of the inventoried population. A complete table, listing replacement value for all species, is included in Appendix C.

On a per-tree basis, Aleppo pine (*Pinus halepensis*, $8,296.67/tree) and Stone pine (*Pinus pinea*, $7,045.78) 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 $300 per tree, including Mexican fan palm (*Washingtonia robusta*, $274/tree) and chaste tree (*Vitex agnus-castus*, $328/tree).

Las Vegas' public trees represent a vital component of the City's infrastructure and a public asset valued at approximately $47.3 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 Las Vegas' inventoried public trees is very important. Annual benefits are examined in Chapter 3.

Table 5. Replacement Value of Las Vegas' Public Trees

	DBH Class (in)											
Species	**0-3**	**3-7**	**7-13**	**13-19**	**19-25**	**25-31**	**31-37**	**37-42**	**>42**	**Total $**	**% of Total**	**% of Pop.**
Mondale pine	17,748	1,300,882	6,131,315	6,492,665	1,118,476	35,329	0	0	0	**15,096,416**	31.9	18.4
Fan-Tex ash	161,162	1,020,470	1,591,017	912,422	100,097	0	0	0	0	**3,785,169**	8.0	9.0
Chilean mesquite	198,989	441,823	798,165	484,517	27,303	0	0	0	0	**1,950,797**	4.1	7.3
Shoestring acacia	101,313	878,140	643,497	118,168	0	0	0	0	0	**1,741,117**	3.7	5.8
Chaste tree	216,135	157,539	21,071	0	0	0	0	0	0	**394,745**	0.8	5.3
Desert willow	180,304	337,622	233,452	14,349	0	0	0	0	0	**765,727**	1.6	4.9
Raywood ash	14,160	590,883	811,395	105,507	0	0	0	0	0	**1,521,945**	3.2	3.6
Velvet mesquite	52,587	517,902	523,403	186,183	34,681	0	0	0	0	**1,314,756**	2.8	3.2
Chiltalpa	21,429	398,992	861,898	0	0	0	0	0	0	**1,282,319**	2.7	3.1
Sweet acacia	123,767	136,296	220,043	31,391	0	0	0	0	0	**511,497**	1.1	2.7
Mexican fan palm	1,361	2,504	51,521	80,494	7,283	5,275	465	0	0	**148,902**	0.3	2.4
Chinese pistache	14,213	448,968	946,825	178,606	0	0	0	0	0	**1,588,611**	3.4	2.3
Desert Museum paloverde	50,853	281,710	127,429	10,129	0	0	0	0	0	**470,120**	1.0	2.3
Velvet ash	15,737	122,062	367,364	308,427	21,531	0	0	0	0	**835,120**	1.8	2.1
African sumac	37,875	242,526	157,195	40,515	11,122	43,670	0	0	0	**532,903**	1.1	2.0
Honey mesquite	23,259	269,897	743,873	88,762	0	0	0	0	0	**1,125,790**	2.4	1.9
Chinese elm	11,676	288,509	251,512	34,606	0	0	0	0	0	**586,303**	1.2	1.7
Aleppo pine	2,241	15,745	844,172	1,959,049	157,296	0	0	0	0	**2,978,503**	6.3	1.6
Southern live oak	15,659	169,258	245,827	128,296	0	0	0	0	0	**559,040**	1.2	1.3
Date palm	530	0	1,994	119,201	131,367	0	0	0	0	**253,092**	0.5	1.2
Fremont cottonwood	3,522	20,053	38,801	150,882	289,367	279,298	108,463	44,551	23,878	**958,813**	2.0	1.1
Western honey mesquite	22,019	153,334	154,854	28,698	0	0	0	0	0	**358,906**	0.8	1.1
Stone pine	439	37,394	672,930	836,457	100,097	43,670	0	0	0	**1,690,988**	3.6	1.1
Other Trees	263,942	1,112,095	2,129,430	1,406,497	1,052,081	387,138	163,856	219,496	98,560	**6,833,095**	14.5	14.7
Citywide Total	**$1,550,919**	**$8,944,604**	**$18,568,981**	**$13,715,821**	**$3,050,702**	**$794,380**	**$272,783**	**$264,047**	**$122,438**	**$47,284,674**	**100%**	**100%**

Chapter 3: Urban Forest Resource Benefits

Trees are important to Las Vegas. Environmentally, they help conserve and reduce energy use, reduce global carbon dioxide (CO_2) levels, improve air quality, and mitigate stormwater runoff. Additionally, trees provide a wealth of well-documented psychological, social, and economic benefits related primarily to their aesthetic effects. Environmentally, trees make good sense, 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 Las Vegas? 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 Las Vegas' 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 Las Vegas' current 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).

Electricity and Natural Gas Reduction

Electricity and natural gas saved annually in Las Vegas from both the shading and climate effects of inventoried trees is equal to 1,067 MWh (valued at $71,621) and 7,536 therms ($4,865), for a total retail savings of approximately $76,486 and an average of $3.36 per tree (Table 6). Fremont cottonwood (*Populus fremontii*), which represents 1.1% of the population, is providing 3.8% of the energy benefits and the highest per-tree benefit ($11.59/tree). Similarly, Aleppo pine (*Pinus halepensis*), which represents just 1.6% of the population, is providing 3.3% of the total energy benefits and the next highest per-tree benefit of $6.99. Together, the populations of Mondale pine (*Pinus eldarica*) and Fan-Tex ash (*Fraxinus velutina* 'Fan-Tex') are providing 34% of the overall energy benefits while comprising just 27% of the population.

Small stature trees are less able to provide electricity and natural gas reductions. On a per-tree basis, Desert willow (*Chilopsis linearis*, $0.94/tree) and chaste tree (*Vitex agnus-castus*, $0.89/tree) provide the lowest benefits. Although these two species account for 10.2% of the urban forest, they are providing only 2.8% 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 Las Vegas' Public Trees

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Mondale pine	263.4	17,677	1,650	1,065.39	**18,743**	18.4	24.5	4.47
Fan-Tex ash	101.6	6,816	739	477.28	**7,294**	9.0	9.5	3.56
Chilean mesquite	70.4	4,725	510	329.34	**5,054**	7.3	6.6	3.05
Shoestring acacia	36.9	2,477	291	187.69	**2,665**	5.8	3.5	2.02
Chaste tree	14.7	990	137	88.17	**1,078**	5.3	1.4	0.89
Desert willow	14.5	971	124	80.03	**1,051**	4.9	1.4	0.94
Raywood ash	51.6	3,464	381	246.26	**3,711**	3.6	4.9	4.55
Velvet mesquite	32.3	2,167	243	156.84	**2,324**	3.2	3.0	3.23
Chiltalpa	30.0	2,015	233	150.18	**2,165**	3.1	2.8	3.05
Sweet acacia	10.5	702	91	58.44	**760**	2.7	1.0	1.24
Mexican fan palm	8.4	567	71	45.63	**613**	2.4	0.8	1.13
Chinese pistache	31.4	2,106	230	148.30	**2,254**	2.3	3.0	4.26
Desert Museum paloverde	13.1	879	108	69.81	**949**	2.3	1.2	1.83
Velvet ash	29.0	1,949	211	136.27	**2,085**	2.1	2.7	4.47
African sumac	11.4	768	90	58.15	**826**	2.0	1.1	1.85
Honey mesquite	28.3	1,901	203	131.18	**2,032**	1.9	2.7	4.65
Chinese elm	33.5	2,249	228	147.39	**2,396**	1.7	3.1	6.22
Aleppo pine	35.3	2,367	223	143.87	**2,511**	1.6	3.3	6.99
Live oak	13.8	928	97	62.87	**990**	1.3	1.3	3.25
Date palm	10.4	701	94	60.64	**762**	1.2	1.0	2.83
Fremont cottonwood	41.1	2,761	265	170.79	**2,931**	1.1	3.8	11.59
Western honey mesquite	7.5	502	60	38.83	**541**	1.1	0.7	2.18
Stone pine	20.6	1,382	131	84.84	**1,467**	1.1	1.9	6.11
Other Trees	157.3	10,558	1,125	726.35	**11,284**	14.7	14.8	3.38
Citywide Total	**1,067**	**$71,621**	**7,536**	**$4,865**	**$76,486**	**100%**	**100%**	**$3.36**

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 Las Vegas' urban forest resource may or may not qualify for carbon-offset credits or be traded in the open market, the City'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 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.

Sequestered Carbon Dioxide

To date, Las Vegas' inventoried urban forest has sequestered a total of 3,499 tons of carbon dioxide (CO_2), valued at $52,493[2]. Annually, this tree resource directly sequesters 392 tons of CO_2, valued at $5,876, into woody and foliar biomass. Accounting for estimated CO_2 emissions from tree decomposition (-28.0 tons), tree related maintenance activity (-5.3 tons), and avoided CO_2 (533.4 tons), Las Vegas' trees provide an annual net reduction in atmospheric CO_2 of 891.8 tons, valued at $13,377, with an average of $0.59 per tree, reflected by the negative numbers in decomposition release and maintenance release inTable 7.

Fremont cottonwood (*Populus fremontii*, $2.69/tree) and Stone pine (*Pinus pinea*, $1.19/tree) are currently providing the highest per tree benefit (Figure 7). Mondale pine (*Pinus eldarica*) are providing the greatest percentage of overall benefits at 21.8% due to their larger size and prevalence in the population (18.4%).

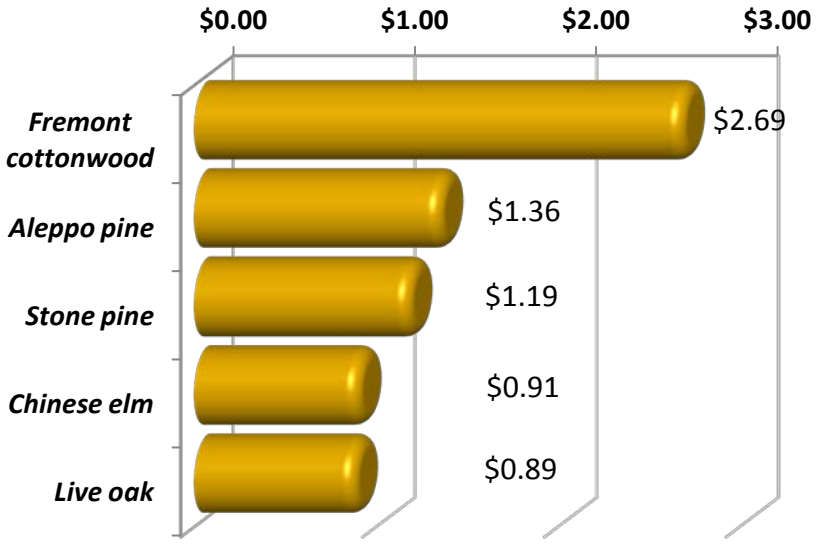


Figure 7. Annual Reduction of CO_2 - Top Five species

[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 Las Vegas' Inventoried Public 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
Mondale pine	143,407	1,075.55	- 15,171	- 2,998.9	- 136.28	263,314	1,974.85	388,550	**2,914.13**	18.4	21.8	0.70
Fan-Tex ash	66,525	498.93	- 2,949	- 767.2	- 27.87	101,533	761.49	164,341	**1,232.56**	9.0	9.2	0.60
Chilean mesquite	46,924	351.93	- 2,118	- 549.0	- 20.00	70,380	527.85	114,637	**859.78**	7.3	6.4	0.52
Shoestring acacia	13,767	103.25	- 631	- 458.5	- 8.17	36,896	276.72	49,573	**371.80**	5.8	2.8	0.28
Chaste tree	14,042	105.32	- 327	- 179.5	- 3.80	14,742	110.57	28,278	**212.09**	5.3	1.6	0.18
Desert willow	7,255	54.41	- 37	- 240.7	- 2.09	14,457	108.43	21,434	**160.76**	4.9	1.2	0.14
Raywood ash	32,942	247.06	- 1,279	- 374.5	- 12.40	51,604	387.03	82,892	**621.69**	3.6	4.7	0.76
Velvet mesquite	21,646	162.34	- 799	- 255.3	- 7.90	32,275	242.06	52,867	**396.51**	3.2	3.0	0.55
Chiltalpa	36,927	276.95	- 2,331	- 324.2	- 19.92	30,018	225.14	64,290	**482.17**	3.1	3.6	0.68
Sweet acacia	11,347	85.10	- 517	- 122.2	- 4.79	10,453	78.39	21,161	**158.71**	2.7	1.2	0.26
Mexican fan palm	13,196	98.97	- 3,019	- 534.5	- 26.65	8,446	63.34	18,088	**135.66**	2.4	1.0	0.25
Chinese pistache	13,955	104.66	- 913	- 260.8	- 8.80	31,372	235.29	44,153	**331.15**	2.3	2.5	0.63
Desert Museum paloverde	14,647	109.85	- 681	- 149.9	- 6.23	13,100	98.25	26,916	**201.87**	2.3	1.5	0.39
Velvet ash	24,279	182.09	- 1,480	- 252.9	- 13.00	29,031	217.73	51,577	**386.83**	2.1	2.9	0.83
African sumac	4,262	31.97	- 223	- 143.7	- 2.75	11,435	85.77	15,331	**114.98**	2.0	0.9	0.26
Honey mesquite	17,744	133.08	- 778	- 199.2	- 7.33	28,313	212.35	45,080	**338.10**	1.9	2.5	0.77
Chinese elm	14,195	106.46	- 690	- 155.9	- 6.34	33,494	251.21	46,844	**351.33**	1.7	2.6	0.91
Aleppo pine	32,192	241.44	- 2,169	- 351.3	- 18.90	35,261	264.46	64,934	**487.00**	1.6	3.6	1.36
Live oak	23,406	175.54	- 1,075	- 126.2	- 9.01	13,817	103.63	36,022	**270.16**	1.3	2.0	0.89
Date palm	4,381	32.86	- 1,248	- 189.2	- 10.78	10,444	78.33	13,388	**100.41**	1.2	0.8	0.37
Fremont cottonwood	56,018	420.13	- 6,111	- 310.8	- 48.16	41,121	308.41	90,717	**680.38**	1.1	5.1	2.69
Western honey mesquite	8,705	65.29	- 484	- 83.5	- 4.26	7,484	56.13	15,621	**117.16**	1.1	0.9	0.47
Stone pine	18,839	141.29	- 1,209	- 214.5	- 10.68	20,584	154.38	37,999	**284.99**	1.1	2.1	1.19
Other Trees	142,877	1,071.58	- 9,752	- 1,434.1	- 83.90	157,263	1,179.47	288,954	**2,167.15**	14.7	16.2	0.65
Citywide Total	**783,478**	**$5,876**	**-55,992**	**-10,677**	**-$500.02**	**1,066,838**	**$8,001**	**1,783,647**	**$13,377**	**100%**	**100%**	**$0.59**

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 3,377 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 Las Vegas, for a value of $17,651 (Table 9). As a population, Mondale pine (*Pinus eldarica*, 1,051 lbs) is the greatest contributor to pollutant deposition and interception, accounting for approximately 31% of the 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, 1.8 tons of pollutants, valued at $33,885, are avoided annually through the shading effects of Las Vegas' inventoried trees.

BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered. Approximately 1.5 tons of BVOCs are emitted annually from Las Vegas' inventoried trees, offsetting the total air quality benefit by -$12,012. Southern live oak (*Quercus virginiana*) are the heaviest per tree emitters of BVOCs (-1.10 lbs/tree), accounting for 0.04% of BVOC emissions while comprising just 1.3% of the population. Date palm (*Phoenix dactylifera*, -0.82 lbs/tree) also contributes substantial BVOCs. For these two 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 Las Vegas' inventoried public tree population is $39,524 annually. The average net benefit per tree is $1.74. 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, Fremont cottonwood (*Populus fremontii*, $10.09/tree) and Chinese elm (*Ulmus parvifolia*, $3.67/tree) currently produce the greatest per tree net air quality improvements (Figure 8). However, due to its established age distribution and high prevalence in the population (18.4%), Mondale pine (*Pinus eldarica*) account for the greatest air quality improvements (32%) in terms of total benefits by species, collectively removing 1,537 pounds of pollutants at a net value of $12,247.

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

Table 9. Annual Air Quality Improvements Provided by Las Vegas' Inventoried Public Trees

Species	Deposition O_3 (lb)	Deposition NO_2 (lb)	Deposition PM10 (lb)	Deposition SO_2 (lb)	Total Deposition ($)	Avoided NO_2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	% of Total Pop.	Avg. $/tree
Mondale pine	392.9	214.3	400.3	43.2	5,508.90	473.4	24.1	4.2	- 420.9	- 1,683.60	1537.0	**12,246.92**	18.4	2.92
Fan-Tex ash	99.3	47.7	106.0	9.9	1,379.55	181.2	9.2	1.6	- 173.6	- 694.28	436.2	**3,901.91**	9.0	1.91
Chilean mesquite	71.8	34.5	75.7	7.1	991.38	125.6	6.4	1.1	- 123.7	- 494.74	305.8	**2,725.96**	7.3	1.64
Shoestring acacia	28.0	15.3	34.8	3.1	429.77	66.0	3.4	0.6	0.0	0.00	207.4	**1,600.70**	5.8	1.21
Chaste tree	8.5	4.1	11.0	0.9	129.78	26.4	1.3	0.2	- 49.4	- 197.67	25.5	**399.47**	5.3	0.33
Desert willow	7.9	2.2	7.4	0.5	91.81	25.9	1.3	0.2	- 105.7	- 422.76	-38.3	**128.08**	4.9	0.11
Raywood ash	42.2	20.3	47.5	4.2	601.26	92.3	4.7	0.8	- 81.8	- 327.14	209.1	**1,912.54**	3.6	2.35
Velvet mesquite	26.1	12.5	29.5	2.6	372.58	57.7	2.9	0.5	- 53.3	- 213.04	127.9	**1,183.02**	3.2	1.64
Chiltalpa	48.7	23.4	45.9	4.8	639.68	53.9	2.8	0.5	- 122.2	- 488.66	103.8	**1,107.10**	3.1	1.56
Sweet acacia	11.3	5.5	11.8	1.1	155.91	19.0	1.0	0.2	- 39.0	- 155.99	27.0	**336.11**	2.7	0.55
Mexican fan palm	23.6	12.9	22.3	2.6	320.53	15.2	0.8	0.1	- 162.5	- 649.87	-72.0	**-60.25**	2.4	- 0.11
Chinese pistache	48.3	18.7	40.8	3.9	573.43	56.3	2.9	0.5	- 340.8	- 1,363.28	-121.4	**209.92**	2.3	0.40
Desert Museum paloverde	14.9	7.2	15.4	1.5	203.93	23.5	1.2	0.2	- 49.6	- 198.45	34.3	**422.09**	2.3	0.81
Velvet ash	27.6	10.7	26.0	2.2	343.65	52.1	2.7	0.5	0.0	0	166.2	**1,269.08**	2.1	2.72
African sumac	9.5	5.2	11.4	1.0	143.40	20.4	1.0	0.2	0.0	0	66.2	**505.95**	2.0	1.13
Honey mesquite	26.3	12.7	28.5	2.6	368.12	50.7	2.6	0.5	- 45.9	- 183.68	121.2	**1,083.72**	1.9	2.48
Chinese elm	27.5	10.6	27.2	2.2	349.91	60.0	3.1	0.5	0.0	0.00	182.3	**1,414.83**	1.7	3.67
Aleppo pine	18.9	10.3	26.1	2.1	305.73	62.9	3.2	0.6	- 94.1	- 376.23	83.8	**1,047.98**	1.6	2.92
Live oak	10.6	5.8	13.0	1.2	161.62	24.8	1.3	0.2	- 335.8	- 1,343.08	-257.8	**-741.36**	1.3	- 2.43
Date palm	34.4	18.7	32.2	3.8	465.16	18.2	0.9	0.2	- 220.5	- 881.82	-96.6	**-94.88**	1.2	- 0.35
Fremont cottonwood	104.4	45.6	87.5	9.0	1,266.42	72.3	3.7	0.6	0.0	0	385.1	**2,551.86**	1.1	10.09
Western honey mesquite	10.3	4.9	10.1	1.0	137.25	13.4	0.7	0.1	- 29.4	- 117.58	22.6	**257.82**	1.1	1.04
Stone pine	10.5	5.8	14.7	1.2	171.95	36.8	1.9	0.3	- 54.5	- 217.97	48.2	**608.12**	1.1	2.53
Other Trees	194.7	88.7	187.1	18.0	2,539.03	279.9	14.3	2.5	- 500.5	- 2,001.85	523.9	**5,507.22**	14.7	1.65
Citywide Total	**1,298**	**637.3**	**1,312**	**129.7**	**$17,651**	**1,908**	**97.4**	**17.2**	**- 3,003**	**-$12,012**	**4,027**	**$39,524**	**100%**	**$1.74**

Stormwater Runoff Reductions

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

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

Las Vegas' inventoried trees intercept 7,024,103 gallons of stormwater annually for an average of 309 gallons per tree (Table 10). The total value of this benefit to the City is $33,718, an average of $1.48 per tree. Fremont cottonwood (*Populus fremontii*) are currently providing the greatest per tree benefit of $6.56 (Figure 9) while Mondale pine (*Pinus eldarica),* due in part to their prevalence in the population (18.4%) as well as their large canopies, are providing the largest portion of overall benefits at 28%.

As trees grow, their stormwater benefits often improve, but some species will realize more substantial benefits than others will. Many of the tree species currently demonstrating very low benefits, including desert willow (*Chilopsis linearis*, $0.20/tree) and chaste tree (*Vitex agnus-castus,* $0.30/tree) are small-stature trees. As such, their benefits will not increase much over time. However, other trees with currently lower benefits, such as Chilean mesquite (*Prosopis chilensis*, $1.24/tree) and Chinese pistache (*Pistacia chinensis*, $1.24/tree), young populations of medium-stature species, will realize increasing benefits as their canopies mature.

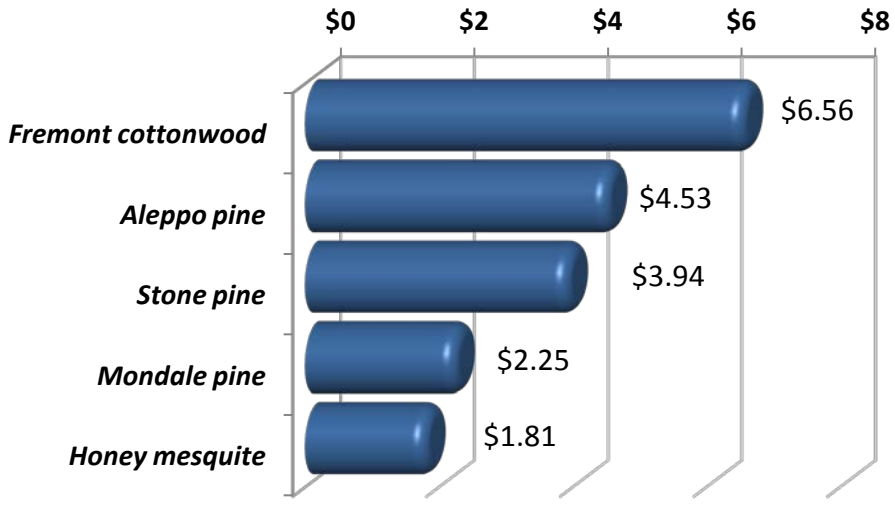


Figure 9. Annual Reduction in Stormwater Runoff - Top Five Species

Table 10. Annual Stormwater Runoff Reduction Benefits Provided by Las Vegas' Inventoried Public Trees

Species	Total Rainfall Interception (Gal)	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Mondale pine	1,965,257	**9,433.89**	18.4	28.0	2.25
Fan-Tex ash	610,952	**2,932.77**	9.0	8.7	1.43
Chilean mesquite	429,270	**2,060.64**	7.3	6.1	1.24
Shoestring acacia	277,668	**1,332.90**	5.8	4.0	1.01
Chaste tree	76,282	**366.18**	5.3	1.1	0.30
Desert willow	46,268	**222.10**	4.9	0.7	0.20
Raywood ash	298,595	**1,433.36**	3.6	4.3	1.76
Velvet mesquite	191,134	**917.51**	3.2	2.7	1.27
Chiltalpa	162,484	**779.98**	3.1	2.3	1.10
Sweet acacia	56,020	**268.92**	2.7	0.8	0.44
Mexican fan palm	74,151	**355.95**	2.4	1.1	0.66
Chinese pistache	137,105	**658.15**	2.3	2.0	1.24
Desert Museum paloverde	69,490	**333.57**	2.3	1.0	0.64
Velvet ash	137,630	**660.67**	2.1	2.0	1.42
African sumac	87,183	**418.51**	2.0	1.2	0.94
Honey mesquite	165,056	**792.32**	1.9	2.4	1.81
Chinese elm	142,722	**685.11**	1.7	2.0	1.78
Aleppo pine	338,998	**1,627.31**	1.6	4.8	4.53
Live oak	93,638	**449.50**	1.3	1.3	1.47
Date palm	60,691	**291.34**	1.2	0.9	1.08
Fremont cottonwood	345,539	**1,658.70**	1.1	4.9	6.56
Western honey mesquite	40,138	**192.67**	1.1	0.6	0.78
Stone pine	196,834	**944.87**	1.1	2.8	3.94
Other Trees	1,020,998	**4,901.13**	14.7	14.5	1.47
Citywide Total	**7,024,103**	**$33,718**	**100%**	**100%**	**$1.48**

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 $550,415, an average of $24.21 per tree (Table 11). Tree species that produce the highest average per tree aesthetic benefits are Fremont cottonwood (*Populus fremontii*, $91.85) and Aleppo pine (*Pinus halepensis,* $60.50).

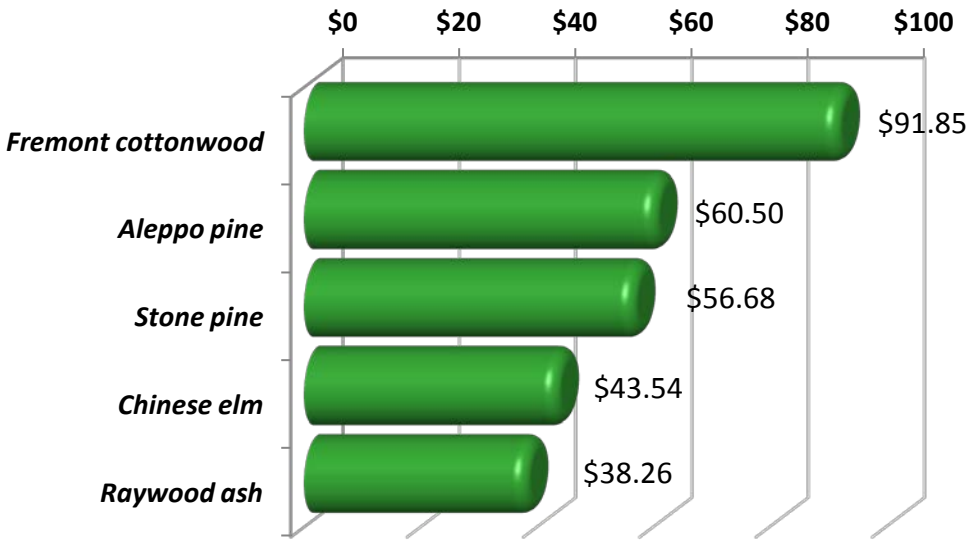


Figure 10. Annual Increase in Property and Socioeconomic Values - Top Five Species

Table 11. Annual Property Value, Aesthetic, and Socioeconomic Benefits Provided by Las Vegas' Inventoried Tree Resource

Species	Total ($)	% of Pop.	% of Total $	Avg. $/tree
Mondale pine	**77,688**	18.4	14.1	18.55
Fan-Tex ash	**69,365**	9.0	12.6	33.89
Chilean mesquite	**52,573**	7.3	9.6	31.69
Shoestring acacia	**22,230**	5.8	4.0	16.83
Chaste tree	**10,653**	5.3	1.9	8.84
Desert willow	**8,795**	4.9	1.6	7.87
Raywood ash	**31,184**	3.6	5.7	38.26
Velvet mesquite	**23,828**	3.2	4.3	33.09
Chiltalpa	**9,401**	3.1	1.7	13.26
Sweet acacia	**5,858**	2.7	1.1	9.56
Mexican fan palm	**4,050**	2.4	0.7	7.46
Chinese pistache	**13,307**	2.3	2.4	25.16
Desert Museum paloverde	**5,606**	2.3	1.0	10.80
Velvet ash	**12,858**	2.1	2.3	27.59
African sumac	**7,385**	2.0	1.3	16.56
Honey mesquite	**16,539**	1.9	3.0	37.85
Chinese elm	**16,765**	1.7	3.1	43.54
Aleppo pine	**21,719**	1.6	4.0	60.50
Southern live oak	**7,457**	1.3	1.4	24.45
Date palm	**902**	1.2	0.2	3.35
Fremont cottonwood	**23,238**	1.1	4.2	91.85
Western honey mesquite	**2,847**	1.1	0.5	11.48
Stone pine	**13,604**	1.1	2.5	56.68
Other Trees	**92,562**	14.7	16.8	27.75
Citywide Total	**$550,415**	**100%**	**100%**	**$24.21**

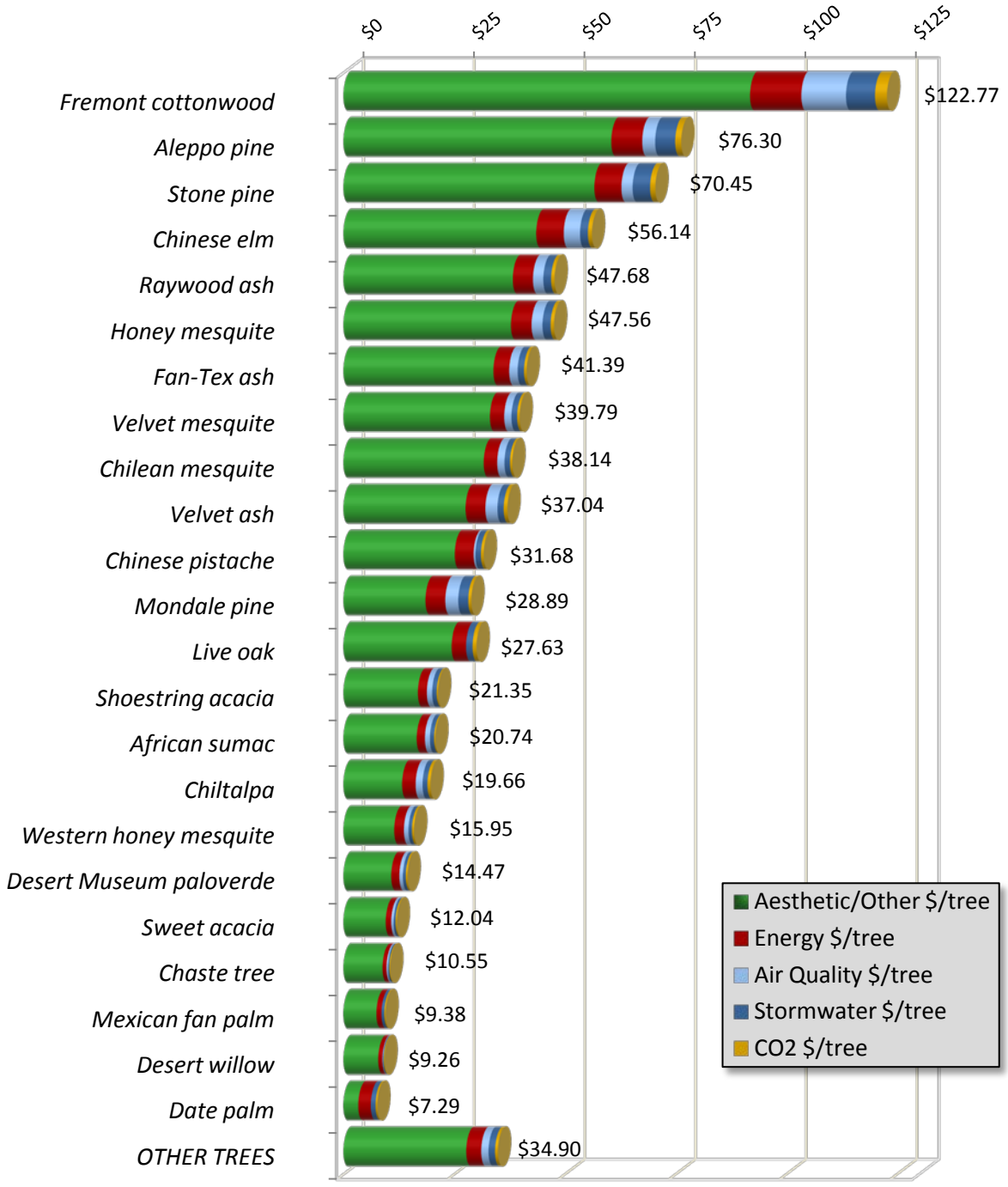


Figure 11. Summary of Annual per Tree Benefits

Table 12. Summary of Current Annual Average per Tree Benefits ($/Tree/yr.) from Las Vegas' Inventoried Tree Resource

Species	Energy $/tree	CO_2 $/tree	Air Quality $/tree	Stormwater $/tree	Aesthetic/Other $/tree	% of Pop.	Total $/tree
Fremont cottonwood	11.59	2.69	10.09	6.56	91.85	1.1	**122.77**
Aleppo pine	6.99	1.36	2.92	4.53	60.50	1.6	**76.30**
Stone pine	6.11	1.19	2.53	3.94	56.68	1.1	**70.45**
Chinese elm	6.22	0.91	3.67	1.78	43.54	1.7	**56.14**
Raywood ash	4.55	0.76	2.35	1.76	38.26	3.6	**47.68**
Honey mesquite	4.65	0.77	2.48	1.81	37.85	1.9	**47.56**
Fan-Tex ash	3.56	0.60	1.91	1.43	33.89	9.0	**41.39**
Velvet mesquite	3.23	0.55	1.64	1.27	33.09	3.2	**39.79**
Chilean mesquite	3.05	0.52	1.64	1.24	31.69	7.3	**38.14**
Velvet ash	4.47	0.83	2.72	1.42	27.59	2.1	**37.04**
Chinese pistache	4.26	0.63	0.40	1.24	25.16	2.3	**31.68**
Mondale pine	4.47	0.70	2.92	2.25	18.55	18.4	**28.89**
Southern live oak	3.25	0.89	- 2.43	1.47	24.45	1.3	**27.63**
Shoestring acacia	2.02	0.28	1.21	1.01	16.83	5.8	**21.35**
African sumac	1.85	0.26	1.13	0.94	16.56	2.0	**20.74**
Chiltalpa	3.05	0.68	1.56	1.10	13.26	3.1	**19.66**
Western honey mesquite	2.18	0.47	1.04	0.78	11.48	1.1	**15.95**
Desert museum paloverde	1.83	0.39	0.81	0.64	10.80	2.3	**14.47**
Sweet acacia	1.24	0.26	0.55	0.44	9.56	2.7	**12.04**
Chaste tree	0.89	0.18	0.33	0.30	8.84	5.3	**10.55**
Mexican fan palm	1.13	0.25	- 0.11	0.66	7.46	2.4	**9.38**
Desert willow	0.94	0.14	0.11	0.20	7.87	4.9	**9.26**
Date palm	2.83	0.37	- 0.35	1.08	3.35	1.2	**7.29**
Other Trees	3.38	0.65	1.65	1.47	27.75	14.7	**34.90**
Citywide Total	**$87.77**	**$16.32**	**$40.79**	**$39.33**	**$656.85**	**100%**	**$841.06**

Net Benefits and Benefit-Investment Ratio (BIR)

Las Vegas receives substantial benefits from their public trees; however, the City must also consider their investments in maintaining this resource. Applying a *benefit-investment ratio* (BIR) is a useful way to evaluate the public investment in the community tree population. A BIR is an indicator used to summarize the overall value compared to the investments of a given resource. Specifically, in this analysis, BIR is the ratio of the total value of benefits provided by the City's inventoried trees compared to the cost (investment) associated with their management.

Las Vegas' inventoried trees have beneficial effects on the environment. Approximately 23% ($163,105) of the total annual benefits ($713,520) quantified in this study are environmental services (Table 13). Energy savings ($76,486) account for 46.9% of the annual environmental benefits and 10.7% of all benefits. The inventoried trees provide $39,524 in air quality benefits, accounting for 24.2% of environmental benefits and 5.5% of all benefits. Stormwater benefits ($33,718) account for 20.7% of environmental benefits and 4.7% of all benefits. Carbon reduction, valued at $13,377, accounts for 8.2% of environmental benefits and 1.9% of all benefits. Annual increases to property value, socioeconomic, and other aesthetic benefits are substantial benefits, accounting for the remaining 77% ($550,415) of all benefits.

The total estimated benefits provided by Las Vegas' inventoried tree resource is $713,520, a value of $31.39 per tree and $1.20 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 resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence. Empirical evidence of these benefits does exist (Wolf, 2007; Kaplan, 1989; Ulrich, 1986), but there is limited knowledge about the physical processes at work and the complex nature of interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and investments must consider variability among sites (e.g., tree species, growing conditions, maintenance practices) throughout the City, as well as variability in tree growth. In other words, **trees are worth far more than what one can ever quantify!**

The total annual quantifiable benefit from Las Vegas' inventoried public trees is $713,520. When the City's annual tree related expenditure (or investment) of $804,961 in this resource is considered, the net annual benefit (benefits minus investment) to the City is a loss of $91,441. The average net loss for an individual public tree in Las Vegas is $4.02 and the per capita net loss is $0.15. Based on the inventory of 22,731 public trees, **Las Vegas is currently receiving $0.89 in benefits for every $1 invested in its urban forest resource** (Table 13).

Considering the relatively young age of Las Vegas' public urban forest and the vigorous dedication to tree planting (currently $200,753/year), a small loss is not unreasonable. As existing trees mature and vacant planting sites are filled, the benefits from this resource will increase and annual planting costs can be reduced. Over time, with proactive and timely management, Las Vegas's urban forest can contribute positive net benefits to the community. Furthermore, considering the vital importance of trees to the quality of life in the Las Vegas valley, the true value of Las Vegas' urban forest is incalculable.

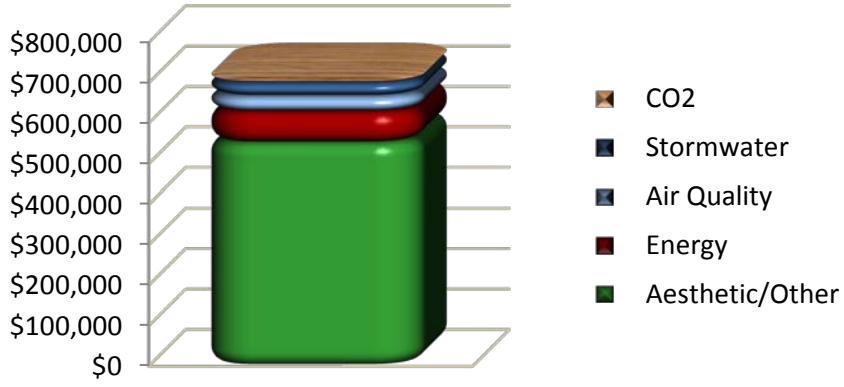


Figure 12. Total Annual Benefits from Las Vegas' Inventoried Trees

Total Annual Benefits: $713,520
Average Annual per Tree Benefits: $31.39
Annual Value of Benefits per Capita: $1.20

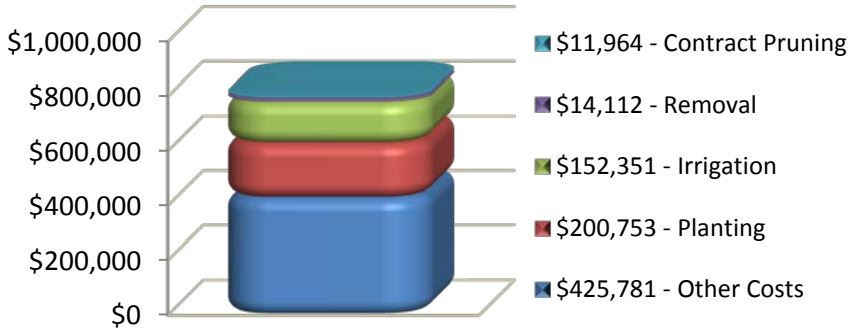


Figure 13. Total Annual Investment to Maintain Las Vegas' Inventoried Trees

Total Annual Investment: $804,961
Average Annual per Tree Investment: $35.41
Annual Investment per Capita: $1.35

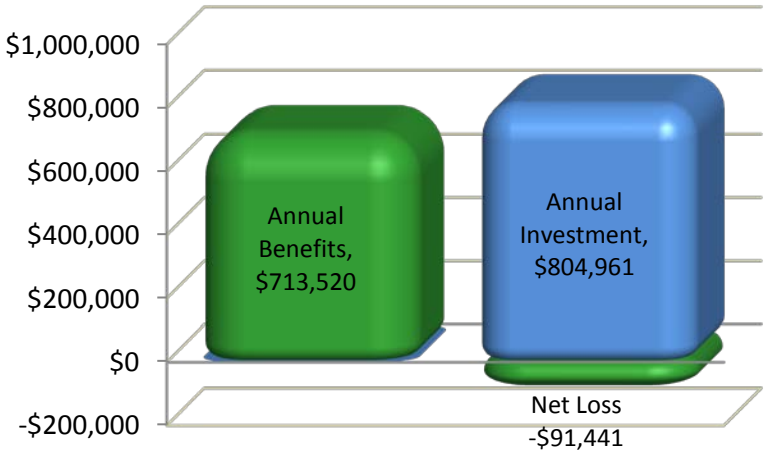


Figure 14. Benefit versus Investment Ratio

Annual Net Loss of Las Vegas' Inventoried Tree Resource: -$91,441

For EVERY $1 invested in trees, Las Vegas receives $0.89 in benefits.

Table 13. Annual Benefit versus Investment Summary for Las Vegas' Inventoried Tree Resource

Benefits	Total ($)	$/tree	$/capita
Energy	76,486	3.36	0.13
CO_2	13,377	0.59	0.02
Air Quality	39,524	1.74	0.07
Stormwater	33,718	1.48	0.06
Aesthetic/Other	550,415	24.21	0.93
Total Benefits	**$713,520**	**$31.39**	**$1.20**
Investment			
Planting	200,753	8.83	0.34
Contract Pruning	11,964	0.53	0.02
Irrigation	152,351	6.70	0.26
Removal	14,112	0.62	0.02
Other Investments	425,781	18.73	0.72
Total Investment	**$804,961**	**$35.41**	**$1.35**
Net Loss	**-$91,441**	**-$4.02**	**-$0.15**
Benefit-Investment Ratio	**$0.89**		

Conclusion

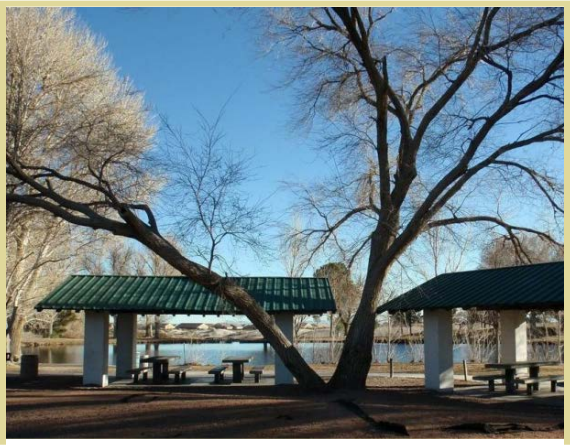
This analysis describes the current structural characteristics of Las Vegas' inventoried public tree resource using established tree sampling, numerical modeling, and statistical methods to provide a general accounting of the benefits. The analysis provides a "snapshot" of this resource at its current 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.

Las Vegas' inventoried trees are providing quantifiable benefits including energy savings, stormwater runoff reduction, reduction in atmospheric CO_2, and aesthetic benefits. The City's 22,731 inventoried trees are providing $713,520 in annual gross benefits. That is an average of $31.39 per tree and $1.20 per capita.

The trees inventoried in this project are relatively young and in fair to good condition with more than 100 different species. Although it is critical to maintain an adequate level of resources to protect and nurture this resource, Las Vegas' public trees can be expected to provide even greater benefits in the future and for many generations to come. The City 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 condition 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 City'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 and outside the organization.



Las Vegas' trees are of vital importance to the environmental, social, and economic well-being of the community.

Las Vegas' trees are of vital importance to the environmental, social, and economic well-being of the community. Las Vegas has demonstrated that public trees are a valued community resource, a vital component of the urban infrastructure, and an important part of the City's history and identity. The City 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, Las Vegas' 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 Las Vegas' 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 Las Vegas' trees, i-Tree *Streets* calculates the dollar value of annual resource functionality. This analysis combines the results of the City'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 City project information for 17 climate zones across the United States (Las Vegas 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 City provided the investment of planting, pruning, irrigation, removal, and other investments. These investments were adjusted to reflect the fact that the inventoried trees comprise just 45.3% of the estimated citywide inventory. For the purpose of this analysis, the investments were reduced to 45.3% of the total investments provided.

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. Las Vegas Benefit Prices Used In This Analysis

Benefits	Price	Unit	Source
Electricity	$0.0671	$/Kwh	Residential rates from NV Energy
Natural Gas	$0.6455	$/Therm	Residential rates from NV Energy
CO_2	$0.0075	$/lb	*Streets* default – Southwest Desert
PM10	$6	$/lb	*Streets* default – Southwest Desert
NO_2	$4	$/lb	*Streets* default – Southwest Desert
SO_2	$15.70	$/lb	*Streets* default – Southwest Desert
VOC	$4	$/lb	*Streets* default – Southwest Desert
Stormwater Interception	$0.0048	$/gallon	*Streets* default – Southwest Desert
Median Home Value	$118,653	$	City of Las Vegas

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 Nevada Energy (NV Energy). Median home value for Las Vegas was estimated to be $118,653 by the City of Las Vegas. Using these rates, the magnitude of the benefits provided by the inventoried tree resource was calculated using i-Tree *Streets***.** Program budget values used in benefit versus investment ratio calculations were supplied by the City of Las Vegas.

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Appendix C: Reports

Las Vegas' Population of Inventoried Trees

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Broadleaf Deciduous Large (BDL)											
Fremont cottonwood	20	42	30	58	57	33	9	3	1	253	1.1
Siberian elm	20	45	41	30	22	8	3	3	1	173	0.8
Honeylocust	27	32	15	1	0	0	0	0	0	75	0.3
California sycamore	1	7	15	30	7	0	0	0	0	60	0.3
Arizona sycamore	0	7	36	10	0	0	0	0	0	53	0.2
Cottonwood	4	20	19	7	0	1	0	0	0	51	0.2
Japanese Zelkova	0	4	5	2	0	0	0	0	0	11	0.0
Navajo globe willow	0	1	1	6	2	0	0	0	0	10	0.0
Shumard red oak	1	4	0	0	0	0	0	0	0	5	0.0
Evergreen ash	1	3	0	0	0	0	0	0	0	4	0.0
Pecan	1	2	0	0	0	0	0	0	0	3	0.0
Japanese pagoda tree	1	0	0	0	0	0	0	0	0	1	0.0
Camperdown wych elm	0	1	0	0	0	0	0	0	0	1	0.0
Total	**76**	**168**	**162**	**144**	**88**	**42**	**12**	**6**	**2**	**700**	**3.1**
Broadleaf Deciduous Medium (BDM)											
Fan-Tex ash	840	806	324	73	4	0	0	0	0	2,047	9.0
Chilean mesquite	909	449	239	60	2	0	0	0	0	1,659	7.3
Raywood ash	85	542	178	10	0	0	0	0	0	815	3.6
Chinese pistache	68	289	162	10	0	0	0	0	0	529	2.3
Velvet ash	101	174	144	45	2	0	0	0	0	466	2.1
Chinese elm	77	245	60	3	0	0	0	0	0	385	1.7
Jerusalem thorn	104	61	22	5	0	0	0	0	0	192	0.8
Blue paloverde	36	98	41	1	0	0	0	0	0	176	0.8
White mulberry	45	49	26	22	15	0	0	0	0	157	0.7
Black locust	9	86	30	0	0	0	0	0	0	125	0.5
Purple Rose locust	46	18	1	0	0	0	0	0	0	65	0.3
Modesto ash	0	13	30	4	0	0	0	0	0	47	0.2
Mimosa	10	8	7	6	0	0	0	0	0	31	0.1
Gooding willow	2	0	1	1	5	1	0	0	0	10	0.0
Chinaberry	1	3	2	2	1	0	0	0	0	9	0.0
Pistachio	0	3	5	0	0	0	0	0	0	8	0.0
Western hackberry	7	0	0	0	0	0	0	0	0	7	0.0
Common pear	5	0	1	0	0	0	0	0	0	6	0.0
Common hackberry	0	2	0	1	0	0	0	0	0	3	0.0
Total	**2,345**	**2,846**	**1,273**	**243**	**29**	**1**	**0**	**0**	**0**	**6,737**	**29.6**

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Broadleaf Deciduous Small (BDS)											
Chaste tree	1,073	128	4	0	0	0	0	0	0	1,205	5.3
Desert willow	793	275	49	1	0	0	0	0	0	1,118	4.9
Velvet mesquite	259	364	85	11	1	0	0	0	0	720	3.2
Chiltalpa	124	380	205	0	0	0	0	0	0	709	3.1
Sweet acacia	486	90	35	2	0	0	0	0	0	613	2.7
Desert Museum paloverde	238	252	28	1	0	0	0	0	0	519	2.3
Honey mesquite	113	181	137	6	0	0	0	0	0	437	1.9
Western honey mesquite	97	120	29	2	0	0	0	0	0	248	1.1
Five stamen tamarisk	59	25	7	0	0	0	0	0	0	91	0.4
Sonoran paloverde	36	46	7	1	0	0	0	0	0	90	0.4
Cherry plum	28	29	6	0	0	0	0	0	0	63	0.3
Common crapemyrtle	50	6	0	0	0	0	0	0	0	56	0.2
Bradford pear	6	10	10	0	1	0	0	0	0	27	0.1
Plum	16	3	0	0	0	0	0	0	0	19	0.1
Yellow paloverde	3	2	7	0	1	0	0	0	0	13	0.1
Smoke tree	10	1	1	0	0	0	0	0	0	12	0.1
Eastern redbud	2	3	0	0	0	0	0	0	0	5	0.0
Desert olive	5	0	0	0	0	0	0	0	0	5	0.0
Allegheny serviceberry	1	3	0	0	0	0	0	0	0	4	0.0
Sweet almond	1	2	0	0	0	0	0	0	0	3	0.0
Peach	0	3	0	0	0	0	0	0	0	3	0.0
Apple	2	0	0	0	0	0	0	0	0	2	0.0
Apricot	0	2	0	0	0	0	0	0	0	2	0.0
Common fig	0	1	0	0	0	0	0	0	0	1	0.0
Native mesquite	1	0	0	0	0	0	0	0	0	1	0.0
Screwbean mesquite	1	0	0	0	0	0	0	0	0	1	0.0
Mesquite species	1	0	0	0	0	0	0	0	0	1	0.0
Total	**3,405**	**1,926**	**610**	**24**	**3**	**0**	**0**	**0**	**0**	**5,968**	**26.3**
Broadleaf Evergreen Large (BEL)											
Red gum eucalyptus	0	66	5	0	0	0	0	0	0	71	0.3
Coolibah tree	4	20	31	12	2	0	0	0	0	69	0.3
Silver dollar gum	3	29	6	0	0	0	0	0	0	38	0.2
Holly oak	1	19	9	0	0	0	0	0	0	29	0.1
Yellow box eucalyptus	2	12	0	0	0	0	0	0	0	14	0.1
Desert gum eucalyptus	0	2	0	0	1	0	0	0	0	3	0.0
Red ironbark	0	0	2	0	0	0	0	0	0	2	0.0

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Total	**10**	**148**	**53**	**12**	**3**	**0**	**0**	**0**	**0**	**226**	**1.0**
Broadleaf Evergreen Medium (BEM)											
Southern live oak	89	150	55	11	0	0	0	0	0	305	1.3
California peppertree	2	9	21	0	0	0	0	0	0	32	0.1
Bottle tree	0	0	9	0	0	0	0	0	0	9	0.0
Loquat	2	0	0	0	0	0	0	0	0	2	0.0
Carob tree	1	0	0	0	0	0	0	0	0	1	0.0
Bay laurel	1	0	0	0	0	0	0	0	0	1	0.0
Total	**95**	**159**	**85**	**11**	**0**	**0**	**0**	**0**	**0**	**350**	**1.5**
Broadleaf Evergreen Small (BES)											
Shoestring acacia	436	743	132	10	0	0	0	0	0	1,321	5.8
African sumac	187	218	35	4	1	1	0	0	0	446	2.0
Mulga	174	44	0	0	0	0	0	0	0	218	1.0
Catclaw acacia	93	91	0	0	0	0	0	0	0	184	0.8
mescal bean	117	0	0	0	0	0	0	0	0	117	0.5
Olive	37	43	28	0	0	0	0	0	0	108	0.5
Oleander	85	14	0	0	0	0	0	0	0	99	0.4
Chinese privet	0	28	6	0	0	0	0	0	0	34	0.1
Weeping acacia	0	29	3	0	0	0	0	0	0	32	0.1
Other	27	2	0	0	1	0	0	0	0	30	0.1
Xylosma	25	3	0	0	0	0	0	0	0	28	0.1
Joshua tree	17	8	2	0	0	0	0	0	0	27	0.1
Myrtle	21	0	0	0	0	0	0	0	0	21	0.1
Whitethorn acacia	13	2	0	0	0	0	0	0	0	15	0.1
Texas ebony	10	0	0	0	0	0	0	0	0	10	0.0
Carolina cherry laurel	9	1	0	0	0	0	0	0	0	10	0.0
Narrow-leaved gimlet	0	6	0	0	0	0	0	0	0	6	0.0
Swan Hill olive	1	4	0	0	0	0	0	0	0	5	0.0
Feather bush	1	0	2	0	0	0	0	0	0	3	0.0
Milfoil wattle	1	1	0	0	0	0	0	0	0	2	0.0
Australian willow	1	1	0	0	0	0	0	0	0	2	0.0
Evergreen pear	0	1	1	0	0	0	0	0	0	2	0.0
Weeping bottlebrush	0	0	1	0	0	0	0	0	0	1	0.0
Total	**1,255**	**1,239**	**210**	**14**	**2**	**1**	**0**	**0**	**0**	**2,721**	**12.0**
Conifer Evergreen Large (CEL)											
Mondale pine	111	1,544	1,757	704	71	2	0	0	0	4,189	18.4
Aleppo pine	9	13	172	158	7	0	0	0	0	359	1.6
Stone pine	2	29	132	72	4	1	0	0	0	240	1.1
Chir pine	0	2	42	18	0	0	0	0	0	62	0.3

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total	% of Pop.
Italian cypress	13	0	2	0	0	0	0	0	0	15	0.1
Australian pine	1	4	6	0	0	0	0	0	0	11	0.0
Grey pine	1	1	2	2	1	0	0	0	0	7	0.0
Canary Island pine	0	1	0	0	0	0	0	0	0	1	0.0
Total	**137**	**1,594**	**2,113**	**954**	**83**	**3**	**0**	**0**	**0**	**4,884**	**21.5**
Conifer Evergreen Medium (CEM)											
Arizona cypress	0	2	5	1	0	0	0	0	0	8	0.0
Total	**0**	**2**	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**8**	**0.0**
Conifer Evergreen Small (CES)											
Oriental arborvitae	2	5	4	0	0	0	0	0	0	11	0.0
Bolander Beach pine	0	0	1	0	0	0	0	0	0	1	0.0
Total	**2**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0.1**
Palm Evergreen Large (PEL)											
Canary Island date palm	0	4	1	4	6	4	1	0	0	20	0.1
Total	**0**	**4**	**1**	**4**	**6**	**4**	**1**	**0**	**0**	**20**	**0.1**
Palm Evergreen Medium (PEM)											
Date palm	1	0	3	127	138	0	0	0	0	269	1.2
Total	**1**	**0**	**3**	**127**	**138**	**0**	**0**	**0**	**0**	**269**	**1.2**
Palm Evergreen Small (PES)											
Mexican fan palm	9	15	211	271	22	14	1	0	0	543	2.4
Mediterranean fan palm	159	19	42	0	0	0	0	0	0	220	1.0
California palm	1	0	10	26	18	9	5	0	0	69	0.3
Mexican blue palm	2	2	0	0	0	0	0	0	0	4	0.0
Total	**171**	**36**	**263**	**297**	**40**	**23**	**6**	**0**	**0**	**836**	**3.7**
Citywide Total	**7,497**	**8,127**	**4,783**	**1,831**	**392**	**74**	**19**	**6**	**2**	**22,731**	**100%**

Relative Performance Index (RPI) for Las Vegas' Inventoried Trees

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Mondale pine	0	4.28	55.47	40.25	**1.00**	4,179	18.38
Fan-Tex ash	0	11.21	44.67	44.12	**0.99**	1,999	8.79
Chilean mesquite	0	4.15	24.47	71.38	**1.11**	1,614	7.10
Shoestring acacia	0	1.52	55.81	42.67	**1.02**	1,317	5.79
Chaste tree	0	4.49	63.89	31.61	**0.97**	1,202	5.29
Desert willow	0	5.31	36.00	58.69	**1.06**	1,111	4.89
Raywood ash	0	16.88	59.97	23.15	**0.89**	782	3.44
Velvet mesquite	0	4.87	75.52	19.61	**0.92**	719	3.16
Chiltalpa	0	12.63	77.04	10.33	**0.86**	697	3.07
Sweet acacia	0	2.64	35.64	61.72	**1.08**	606	2.67
Mexican fan palm	0	1.10	21.18	77.72	**1.15**	543	2.39
Chinese pistache	0	8.80	49.14	42.07	**0.99**	523	2.30
Desert Museum paloverde	0	5.98	62.16	31.85	**0.96**	518	2.28
Velvet ash	0	13.33	48.67	38.00	**0.96**	450	1.98
African sumac	0	4.27	73.48	22.25	**0.94**	445	1.96
Honey mesquite	0	8.74	65.52	25.75	**0.93**	435	1.91
Chinese elm	0	16.71	57.96	25.33	**0.90**	383	1.68
Aleppo pine	0	1.11	44.29	54.60	**1.06**	359	1.58
Southern live oak	0	16.55	57.77	25.68	**0.90**	296	1.30
Date palm	0	4.46	26.02	69.52	**1.11**	269	1.18
Western honey mesquite	0	0.81	42.68	56.50	**1.07**	246	1.08
Fremont cottonwood	0	6.69	45.61	47.70	**1.02**	239	1.05
Stone pine	0	2.13	41.28	56.60	**1.07**	235	1.03
Mediterranean fan palm	0	1.38	9.63	88.99	**1.19**	218	0.96
Mulga	0	14.90	44.23	40.87	**0.96**	208	0.92
Jerusalem thorn	0	3.65	71.35	25.00	**0.95**	192	0.84
Catclaw acacia	0	1.63	64.67	33.70	**0.99**	184	0.81
Blue paloverde	0	3.98	63.64	32.39	**0.97**	176	0.77
Siberian elm	0	5.88	25.88	68.24	**1.10**	170	0.75
White mulberry	0	7.10	51.61	41.29	**0.99**	155	0.68
Black locust	0	35.83	50.00	14.17	**0.79**	120	0.53
mescalbean	0	3.42	47.86	48.72	**1.03**	117	0.51
Olive	0	2.80	59.81	37.38	**1.00**	107	0.47
Oleander	0	36.84	53.68	9.47	**0.77**	95	0.42
Five stamen tamarisk	0	1.10	37.36	61.54	**1.09**	91	0.40
Sonoran paloverde	0	12.36	73.03	14.61	**0.88**	89	0.39
Honeylocust	0	34.72	34.72	30.56	**0.85**	72	0.32
Red gum eucalyptus	0	7.04	78.87	14.08	**0.90**	71	0.31
California palm	0	0	27.54	72.46	**1.13**	69	0.30
Coolibah tree	0	4.55	13.64	81.82	**1.15**	66	0.29
Purple Rose locust	0	6.35	63.49	30.16	**0.96**	63	0.28
Chir pine	0	1.61	45.16	53.23	**1.06**	62	0.27
California sycamore	0	3.33	21.67	75.00	**1.13**	60	0.26
Cherry plum	0	26.32	64.91	8.77	**0.81**	57	0.25
Common crapemyrtle	0	3.70	33.33	62.96	**1.08**	54	0.24

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Arizona sycamore	0	21.15	78.85	0	**0.79**	52	0.23
Cottonwood	0	13.73	54.90	31.37	**0.93**	51	0.22
Modesto ash	0	15.38	38.46	46.15	**0.98**	39	0.17
Silver dollar gum	0	2.63	76.32	21.05	**0.94**	38	0.17
Chinese privet	0	2.94	82.35	14.71	**0.91**	34	0.15
Weeping acacia	0	0	93.75	6.25	**0.89**	32	0.14
Other	0	0	6.67	93.33	**1.21**	30	0.13
California peppertree	0	13.33	73.33	13.33	**0.87**	30	0.13
Mimosa	0	25.00	50.00	25.00	**0.87**	28	0.12
Xylosma	0	0	21.43	78.57	**1.15**	28	0.12
Holly oak	0	11.54	53.85	34.62	**0.95**	26	0.11
Joshua tree	0	0.00	32.00	68.00	**1.12**	25	0.11
Bradford pear	0	25.00	37.50	37.50	**0.92**	24	0.11
Canary Island date palm	0	0	15.00	85.00	**1.18**	20	0.09
Myrtle	0	42.11	57.89	0	**0.72**	19	0.08
Plum	0	17.65	23.53	58.82	**1.02**	17	0.07
Whitethorn acacia	0	13.33	80.00	6.67	**0.85**	15	0.07
Italian cypress	0	50.00	21.43	28.57	**0.79**	14	0.06
Yellow box eucalyptus	0	0	100.00	0	**0.87**	14	0.06
Yellow paloverde	0	0	92.31	7.69	**0.90**	13	0.06
Smoke tree	0	0	16.67	83.33	**1.17**	12	0.05
Japanese Zelkova	0	0	9.09	90.91	**1.20**	11	0.05
Australian pine	0	0	0	100.00	**1.23**	11	0.05
Oriental arborvitae	0	0	10.00	90.00	**1.20**	10	0.04
Gooding willow	0	30.00	40.00	30.00	**0.87**	10	0.04
Texas ebony	0	0	100.00	0	**0.87**	10	0.04
Carolina cherry laurel	0	10.00	90.00	0	**0.83**	10	0.04
Navajo globe willow	0	11.11	22.22	66.67	**1.07**	9	0.04
Chinaberry	0	11.11	33.33	55.56	**1.03**	9	0.04
Bottle tree	0	0	33.33	66.67	**1.11**	9	0.04
Pistachio	0	25.00	50.00	25.00	**0.87**	8	0.04
Arizona cypress	0	0	62.50	37.50	**1.01**	8	0.04
Grey pine	0	0	42.86	57.14	**1.08**	7	0.03
Western hackberry	0	0	0	100.00	**1.23**	7	0.03
Common pear	0	0	83.33	16.67	**0.93**	6	0.03
Narrow-leaved gimlet	0	0	100.00	0	**0.87**	6	0.03
Eastern redbud	0	0	0	100.00	**1.23**	5	0.02
Desert olive	0	0	20.00	80.00	**1.16**	5	0.02
Swan Hill olive	0	0	80.00	20.00	**0.94**	5	0.02
Allegheny serviceberry	0	50.00	25.00	25.00	**0.78**	4	0.02
Evergreen ash	0	25.00	50.00	25.00	**0.87**	4	0.02
Mexican blue palm	0	50.00	25.00	25.00	**0.78**	4	0.02
Shumard red oak	0	0	75.00	25.00	**0.96**	4	0.02
Sweet almond	0	0	0	100.00	**1.23**	3	0.01
Pecan	0	66.67	0	33.33	**0.75**	3	0.01
Peach	0	0	33.33	66.67	**1.11**	3	0.01

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Trees	% of Pop.
Common hackberry	0	33.33	0	66.67	**0.99**	3	0.01
Feather bush	0	0	100.00	0	**0.87**	3	0.01
Desert gum eucalyptus	0	0	0	33.33	**0.99**	3	0.01
Apple	0	50.00	0	50.00	**0.87**	2	0.01
Milfoil wattle	0	0	50.00	50.00	**1.05**	2	0.01
Australian willow	0	0	100.00	0	**0.87**	2	0.01
Apricot	0	0	50.00	50.00	**1.05**	2	0.01
Loquat	0	100.00	0	0	**0.51**	2	0.01
Evergreen pear	0	100.00	0	0	**0.51**	2	0.01
Red ironbark	0	0	50.00	50.00	**1.05**	2	0.01
Mesquite species	0	0	0	100.00	**1.23**	1	0.00
Native mesquite	0	0	0	100.00	**1.23**	1	0.00
Screwbean mesquite	0	0	100.00	0	**0.87**	1	0.00
Japanese pagoda tree	0	100.00	0	0	**0.51**	1	0.00
Common fig	0	0	0	100.00	**1.23**	1	0.00
Camperdown wych elm	0	0	0	100.00	**1.23**	1	0.00
Canary Island pine	0	0	0	100.00	**1.23**	1	0.00
Carob tree	0	0	0	100.00	**1.23**	1	0.00
Bolander Beach pine	0	0	100.00	0	**0.87**	1	0.00
Weeping bottlebrush	0	0	100.00	0	**0.87**	1	0.00
Bay laurel	0	0	0	0	**0**	0	0.00
Citywide Total	**0**	**6.87**	**50.39**	**42.75**	**1.00**	**22,428**	**100%**

Replacement Value of Las Vegas' Inventoried Trees

	DBH Class (in)											
Species	0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total $	% of Total	% of Pop.
Mondale pine	17,748	1,300,882	6,131,315	6,492,665	1,118,476	35,329	0	0	0	**15,096,416**	31.9	18.4
Fan-Tex ash	161,162	1,020,470	1,591,017	912,422	100,097	0	0	0	0	**3,785,169**	8.0	8.8
Chilean mesquite	198,989	441,823	798,165	484,517	27,303	0	0	0	0	**1,950,797**	4.1	7.1
Shoestring acacia	101,313	878,140	643,497	118,168	0	0	0	0	0	**1,741,117**	3.7	5.8
Chaste tree	216,135	157,539	21,071	0	0	0	0	0	0	**394,745**	0.8	5.3
Desert willow	180,304	337,622	233,452	14,349	0	0	0	0	0	**765,727**	1.6	4.9
Raywood ash	14,160	590,883	811,395	105,507	0	0	0	0	0	**1,521,945**	3.2	3.4
Velvet mesquite	52,587	517,902	523,403	186,183	34,681	0	0	0	0	**1,314,756**	2.8	3.2
Chiltalpa	21,429	398,992	861,898	0	0	0	0	0	0	**1,282,319**	2.7	3.1
Sweet acacia	123,767	136,296	220,043	31,391	0	0	0	0	0	**511,497**	1.1	2.7
Mexican fan palm	1,361	2,504	51,521	80,494	7,283	5,275	465	0	0	**148,902**	0.3	2.4
Chinese pistache	14,213	448,968	946,825	178,606	0	0	0	0	0	**1,588,611**	3.4	2.3
Desert Museum paloverde	50,853	281,710	127,429	10,129	0	0	0	0	0	**470,120**	1.0	2.3
Velvet ash	15,737	122,062	367,364	308,427	21,531	0	0	0	0	**835,120**	1.8	2.0
African sumac	37,875	242,526	157,195	40,515	11,122	43,670	0	0	0	**532,903**	1.1	2.0
Honey mesquite	23,259	269,897	743,873	88,762	0	0	0	0	0	**1,125,790**	2.4	1.9
Chinese elm	11,676	288,509	251,512	34,606	0	0	0	0	0	**586,303**	1.2	1.7
Aleppo pine	2,241	15,745	844,172	1,959,049	157,296	0	0	0	0	**2,978,503**	6.3	1.6
Southern live oak	15,659	169,258	245,827	128,296	0	0	0	0	0	**559,040**	1.2	1.3
Date palm	530	0	1,994	119,201	131,367	0	0	0	0	**253,092**	0.5	1.2
Fremont cottonwood	3,522	20,053	38,801	150,882	289,367	279,298	108,463	44,551	23,878	**958,813**	2.0	1.1
Western honey mesquite	22,019	153,334	154,854	28,698	0	0	0	0	0	**358,906**	0.8	1.1
Stone pine	439	37,394	672,930	836,457	100,097	43,670	0	0	0	**1,690,988**	3.6	1.0
Mediterranean fan palm	31,647	3,429	10,639	0	0	0	0	0	0	**45,715**	0.1	0.96
Mulga	34,195	57,970	0	0	0	0	0	0	0	**92,165**	0.2	0.92
Jerusalem thorn	15,073	32,159	42,426	29,266	0	0	0	0	0	**118,925**	0.3	0.84
Catclaw acacia	20,005	105,742	0	0	0	0	0	0	0	**125,747**	0.3	0.81
Blue paloverde	7,976	148,309	233,715	18,402	0	0	0	0	0	**408,402**	0.9	0.77
Siberian elm	4,846	63,427	216,394	358,723	467,121	297,985	155,145	219,496	98,560	**1,881,698**	4.0	0.75
White mulberry	5,678	25,621	57,499	127,050	157,671	0	0	0	0	**373,517**	0.8	0.68
Black locust	1,666	82,303	117,060	0	0	0	0	0	0	**201,029**	0.4	0.53
mescalbean	22,644	0	0	0	0	0	0	0	0	**22,644**	0.0	0.51
Olive	8,712	59,054	186,289	0	0	0	0	0	0	**254,054**	0.5	0.47
Oleander	9,351	3,533	0	0	0	0	0	0	0	**12,884**	0.0	0.42
Five stamen tamarisk	15,433	38,733	42,299	0	0	0	0	0	0	**96,466**	0.2	0.40
Sonoran paloverde	6,572	50,277	28,094	10,129	0	0	0	0	0	**95,072**	0.2	0.39
Honeylocust	3,704	25,727	51,954	10,296	0	0	0	0	0	**91,681**	0.2	0.32
Red gum eucalyptus	0	33,188	9,769	0	0	0	0	0	0	**42,957**	0.1	0.31
Coolibah tree	909	26,122	170,239	163,746	54,021	0	0	0	0	**415,037**	0.9	0.30
California palm	302	0	4,472	14,767	12,314	7,765	4,828	0	0	**44,448**	0.1	0.29
Purple Rose locust	9,147	21,739	4,013	0	0	0	0	0	0	**34,899**	0.1	0.28
Cherry plum	4,179	22,194	18,607	0	0	0	0	0	0	**44,980**	0.1	0.27
Chir pine	0	1,827	108,983	143,932	0	0	0	0	0	**254,742**	0.5	0.26

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total $	% of Total	% of Pop.
California sycamore	192	3,454	31,401	168,711	76,583	0	0	0	0	**280,341**	0.6	0.25
Common crapemyrtle	12,524	9,767	0	0	0	0	0	0	0	**22,291**	0.0	0.24
Arizona sycamore	0	3,546	76,039	57,382	0	0	0	0	0	**136,967**	0.3	0.23
Cottonwood	541	9,664	34,611	39,251	0	12,448	0	0	0	**96,515**	0.2	0.22
Modesto ash	0	16,371	136,793	40,515	0	0	0	0	0	**193,679**	0.4	0.17
Silver dollar gum	545	32,474	30,770	0	0	0	0	0	0	**63,789**	0.1	0.17
Chinese privet	0	30,953	27,426	0	0	0	0	0	0	**58,379**	0.1	0.15
Weeping acacia	0	31,132	15,385	0	0	0	0	0	0	**46,517**	0.1	0.14
California peppertree	439	10,020	82,611	0	0	0	0	0	0	**93,070**	0.2	0.13
Mimosa	1,899	6,332	17,882	41,790	0	0	0	0	0	**67,903**	0.1	0.13
Other	6,875	2,594	0	0	27,010	0	0	0	0	**36,480**	0.1	0.12
Holly oak	106	21,381	46,155	0	0	0	0	0	0	**67,642**	0.1	0.12
Xylosma	5,155	2,236	0	0	0	0	0	0	0	**7,391**	0.0	0.11
Bradford pear	1,015	12,256	44,817	0	11,122	0	0	0	0	**69,210**	0.1	0.11
Joshua tree	4,210	9,483	9,699	0	0	0	0	0	0	**23,392**	0.0	0.11
Myrtle	3,271	0	0	0	0	0	0	0	0	**3,271**	0.0	0.09
Canary Island date palm	0	6,038	1,786	7,378	15,049	12,839	3,883	0	0	**46,972**	0.1	0.08
Plum	3,996	3,144	0	0	0	0	0	0	0	**7,140**	0.0	0.07
Whitethorn acacia	2,287	2,147	0	0	0	0	0	0	0	**4,434**	0.0	0.07
Italian cypress	2,014	0	11,372	0	0	0	0	0	0	**13,386**	0.0	0.06
Yellow box eucalyptus	363	12,882	0	0	0	0	0	0	0	**13,246**	0.0	0.06
Yellow paloverde	686	2,694	35,890	0	24,481	0	0	0	0	**63,751**	0.1	0.06
Smoke tree	2,100	927	2,308	0	0	0	0	0	0	**5,336**	0.0	0.05
Australian pine	257	6,083	34,115	0	0	0	0	0	0	**40,455**	0.1	0.05
Oriental arborvitae	515	6,888	22,743	0	0	0	0	0	0	**30,146**	0.1	0.05
Japanese Zelkova	0	3,436	16,349	16,286	0	0	0	0	0	**36,070**	0.1	0.04
Texas ebony	1,817	0	0	0	0	0	0	0	0	**1,817**	0.0	0.04
Carolina cherry laurel	1,636	626	0	0	0	0	0	0	0	**2,262**	0.0	0.04
Gooding willow	569	0	5,127	12,990	91,802	56,101	0	0	0	**166,588**	0.4	0.04
Navajo globe willow	0	1,347	5,982	94,174	69,362	0	0	0	0	**170,865**	0.4	0.04
Bottle tree	0	0	46,155	0	0	0	0	0	0	**46,155**	0.1	0.04
Chinaberry	231	2,399	7,008	17,564	19,340	0	0	0	0	**46,541**	0.1	0.04
Arizona cypress	0	2,594	21,740	14,349	0	0	0	0	0	**38,683**	0.1	0.04
Pistachio	0	2,773	21,740	0	0	0	0	0	0	**24,513**	0.1	0.04
Western hackberry	1,802	0	0	0	0	0	0	0	0	**1,802**	0.0	0.03
Grey pine	216	927	4,616	13,891	15,265	0	0	0	0	**34,915**	0.1	0.03
Narrow-leaved gimlet	0	8,083	0	0	0	0	0	0	0	**8,083**	0.0	0.03
Common pear	814	0	4,108	0	0	0	0	0	0	**4,922**	0.0	0.03
Eastern redbud	515	4,562	0	0	0	0	0	0	0	**5,077**	0.0	0.02
Desert olive	939	0	0	0	0	0	0	0	0	**939**	0.0	0.02
Swan Hill olive	182	4,741	0	0	0	0	0	0	0	**4,923**	0.0	0.02
Shumard red oak	182	4,920	0	0	0	0	0	0	0	**5,102**	0.0	0.02
Allegheny serviceberry	106	3,221	0	0	0	0	0	0	0	**3,327**	0.0	0.02
Mexican blue palm	788	1,198	0	0	0	0	0	0	0	**1,986**	0.0	0.02
Evergreen ash	79	1,686	0	0	0	0	0	0	0	**1,765**	0.0	0.02

Species	DBH Class (in) 0-3	3-7	7-13	13-19	19-25	25-31	31-37	37-42	>42	Total $	% of Total	% of Pop.
Pecan	257	1,252	0	0	0	0	0	0	0	**1,510**	0.0	0.01
Common hackberry	0	3,042	0	5,908	0	0	0	0	0	**8,950**	0.0	0.01
Desert gum eucalyptus	0	987	0	0	10,940	0	0	0	0	**11,927**	0.0	0.01
Feather bush	201	0	10,254	0	0	0	0	0	0	**10,455**	0.0	0.01
Sweet almond	284	3,817	0	0	0	0	0	0	0	**4,101**	0.0	0.01
Peach	0	5,164	0	0	0	0	0	0	0	**5,164**	0.0	0.01
Milfoil wattle	204	526	0	0	0	0	0	0	0	**730**	0.0	0.01
Loquat	172	0	0	0	0	0	0	0	0	**172**	0.0	0.01
Red ironbark	0	0	9,699	0	0	0	0	0	0	**9,699**	0.0	0.01
Australian willow	291	2,298	0	0	0	0	0	0	0	**2,590**	0.0	0.01
Apple	401	0	0	0	0	0	0	0	0	**401**	0.0	0.01
Apricot	0	3,256	0	0	0	0	0	0	0	**3,256**	0.0	0.01
Evergreen pear	0	467	1,692	0	0	0	0	0	0	**2,158**	0.0	0.01
Weeping bottlebrush	0	0	1,786	0	0	0	0	0	0	**1,786**	0.0	0.00
Carob tree	257	0	0	0	0	0	0	0	0	**257**	0.0	0.00
Common fig	0	1,909	0	0	0	0	0	0	0	**1,909**	0.0	0.00
Bay laurel	212	0	0	0	0	0	0	0	0	**212**	0.0	0.00
Canary Island pine	0	1,521	0	0	0	0	0	0	0	**1,521**	0.0	0.00
Bolander Beach pine	0	0	8,913	0	0	0	0	0	0	**8,913**	0.0	0.00
Native mesquite	257	0	0	0	0	0	0	0	0	**257**	0.0	0.00
Screwbean mesquite	163	0	0	0	0	0	0	0	0	**163**	0.0	0.00
Mesquite species	231	0	0	0	0	0	0	0	0	**231**	0.0	0.00
Japanese pagoda tree	106	0	0	0	0	0	0	0	0	**106**	0.0	0.00
Camperdown wych elm	0	1,521	0	0	0	0	0	0	0	**1,521**	0.0	0.00
Citywide Total	**$1,550,919**	**$ 8,944,604**	**$18,568,981**	**$ 13,715,821**	**$3,050,702**	**$794,380**	**$272,783**	**$264,047**	**$122,438**	**$47,284,674**	**100%**	**100%**