# URBAN FOREST RESOURCE ANALYSIS OF INVENTORIED PUBLIC TREES

## Mesquite, Nevada

**June 2013**

DAVEY RESOURCE GROUP
*A Division of The Davey Tree Expert Company*

# *Mesquite, Nevada*

# ***Resource Analysis***

## *Of Inventoried Public trees*

June 2013

Prepared for

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# Executive Summary

Trees play a vital role in Mesquite, Nevada. They provide numerous benefits both tangible and intangible, to residents, visitors, and neighboring communities. The City of Mesquite maintains 1,779 public trees. These 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 Mesquite, North Las Vegas, Las Vegas, Boulder City, unincorporated Clark County, the Clark County School District, and the University of Nevada, Las Vegas (UNLV). During the inventory, a certified arborist briefly inspected each tree and recorded information including species, size, condition, geographic location, and current maintenance needs. Arborists collected this information for nearly 100,000 individual tree sites across the AOI. For Mesquite, this included 1,779 individual 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 the tree resource using the inventory data in conjunction with i-Tree benefit-cost modeling software.

Mesquite's public trees in the inventoried areas are providing annual benefits of $68,580 ($4.49 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.

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

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

Mesquite's public tree resource is reducing annual electric energy consumption by 104 megawatts (MWh) and annual natural gas consumption by 742 therms, for a combined value of $7,429 annually. In addition, these trees are removing 1.66 tons of pollutants from the air, including ozone ($O_3$), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$) and particulates ($PM_{10}$) for an overall annual air quality benefit of $3,022. Canopy from this population covers approximately 9.9 acres. This canopy reduces annual stormwater runoff by 466,676 gallons and protects local water resources by preventing sediment and pollution loading.

Trees are a part of the community infrastructure. However, unlike many other public assets, with proper maintenance, trees have the potential to increase in value over time. Mesquite's inventoried tree resource is a relatively young population in overall good condition. With more than 46 different species, Mesquite is well positioned to realize a significant increase in environmental benefits as the tree population continues 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

Mesquite is a small community in southern Nevada's Clark County with an estimated population of 15,276. Mesquite's 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 1,779 trees in public areas. These trees constitute Mesquite's urban forest.

***A healthy urban forest plays an important role in the quality of life in Mesquite.***

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 lessen the impact of urbanization and industry (Center for Urban Forest Research, CUFR). Trees improve air quality by manufacturing oxygen and absorbing carbon dioxide (CO2), as well as filtering and absorbing 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 Mesquite a more enjoyable place to live, work, and play. The City's 1,779 inventoried public trees play a prominent role in the overall urban forest benefits afforded to the community. Mesquite residents rely on the City to protect and maintain this vital resource.

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

A team of International Society of Arboriculture (ISA) certified arborists from Davey Resource Group (DRG) mapped the location and collected data on publicly owned trees using global positioning system (GPS) 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 Mesquite, 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 urban forest resource analysis and report provides information on the structure, function, and value of a specific tree resource. With this information, managers and citizens can make informed decisions about tree management strategies. This report provides the following information:

- A description of the current structure of Mesquite's inventoried tree resource and an established benchmark for future management decisions.
- A quantified value of the benefits of 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

Mesquite's urban forest resource considered 1,779 public trees and 13 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:

- 46 unique tree species were identified in the inventory. The predominant tree species are *Fraxinus velutina* (velvet ash, 18%), *Washingtonia filifera* (California palm, 10%), and *Washingtonia robusta* (Mexican fan palm, 9%).
- The age structure of the inventoried tree population is young overall, with 46% of trees measuring between 0 to 6 inches DBH (diameter at breast height, measured at 4'6" above the ground) and 84% under 12 inches DBH.
- The majority of the inventoried trees (54%) are in good condition, with an additional 39% graded as fair.

***Replacement of Mesquite's 1,779 inventoried trees with trees of similar size, species, and condition would cost over $3.45 million.***

- To date, the inventoried tree population has sequestered 319 tons of carbon (CO2), valued at approximately $4,794.
- Replacement of Mesquite's 1,779 inventoried trees with trees of similar size, species, and condition would cost over $3.45 million.

## Summary of Urban Forest Benefits

Annually, Mesquite's inventoried public trees provide cumulative benefits to the community at an average value of $38.55 per tree, for a total gross value of $ 68,581 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 $7,429, an average of $4.18 per tree.
- Trees sequester 34 tons of atmospheric $CO_2$ per year. An additional 52 tons is avoided by reducing energy generation, resulting in a net value of $1,235 and an average of $0.69 per tree.
- Net air quality improvements provided by public trees through the removal and avoidance[1] of air pollutants is valued at $3,022, an average per tree benefit of $1.70.
- Mesquite's inventoried public trees intercept an estimated 466,676 gallons of stormwater annually for a total value of $2,240, an average of $1.26 per tree.
- The benefit contributed by Mesquite's inventoried public trees to property value increases, aesthetics, and socioeconomics equals $54,655, an average of $30.72 per tree.

[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.

## *Urban Forest Resource Management*

Mesquite's public tree population is a dynamic resource that requires continued investment to maintain and realize its full benefit potential. **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.***

Mesquite 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:

- Continue annual tree planting efforts to stock the available planting sites identified by the inventory.
- 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 large-stature trees where conditions are sustainable.
- Maximize the condition of the existing tree resource through comprehensive tree maintenance and a cyclical pruning schedule.
- 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 Mesquite's 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 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 Mesquite's urban forest. Existing mature trees should be maintained and protected whenever possible since the greatest benefits accrue from the continued growth and longevity of the existing canopy. Mesquite can take pride in knowing that trees improve the quality of life in the City.

# Chapter 2: Mesquite's Urban Forest Resource

A city's urban forest resource is more thoroughly understood through examination of its 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 hardwood species are the most common among Mesquite's inventoried public tree population, comprising 71% of the total inventory. Broadleaf trees typically have larger canopies than coniferous trees of the same size DBH. Since many of the measurable benefits derived from trees are directly related to leaf surface area, broadleaf trees generally provide the highest level of benefits to a community. Larger-statured broadleaf tree species provide greater benefits than smaller-statured trees, independent of diameter (DBH). Deciduous broadleaf species make up 55% of Mesquite's public tree population, including 3% large-stature, 39% medium-stature, and 13% small-stature trees. Evergreen broadleaf trees comprise 16% of the population, including 1% large-stature, and 10% medium, and 5% small stature. Conifers represent 7% of the overall population, and they are primarily large stature trees. Approximately 22% of the population is comprised of palms (Figure 1 and Table 1).

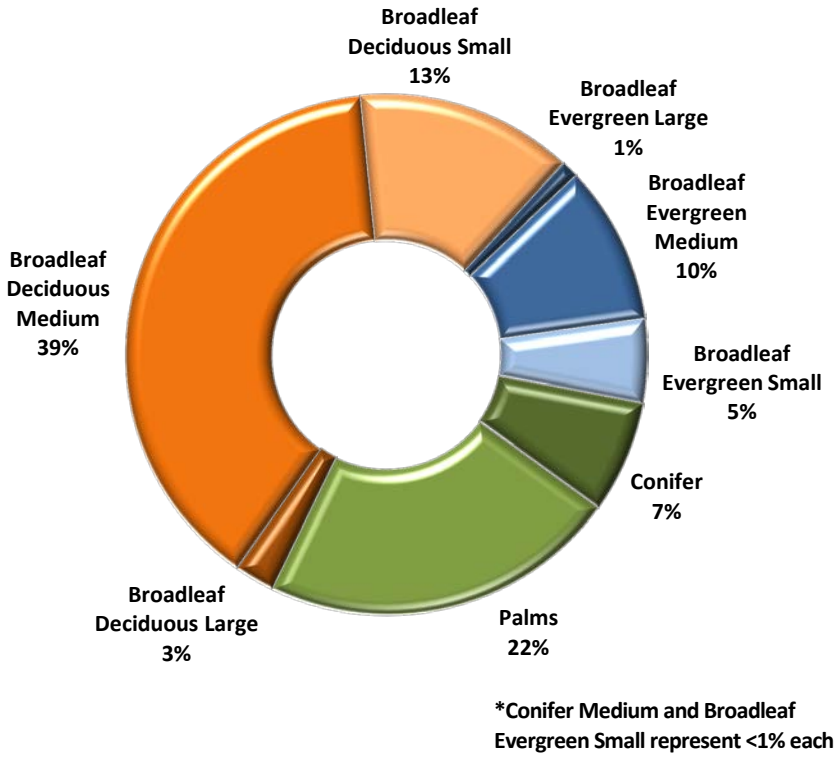


***Figure 1. Overall Composition of Mesquite's Inventoried Public Tree Population***

## *Species Richness and Composition*

Mesquite's inventoried public tree population (Table 1) includes a mix of 46 unique species. This is slightly less than the mean of 53 species reported by McPherson and Rowntree (1989) in their nationwide survey of street tree populations in 22 U.S. cities. In Mesquite, the top 10 species represent 73% of the total population (Figure 2). The predominant tree species are *Fraxinus velutina* (velvet ash, 17.6%), *Washingtonia filifera* (California palm, 9.9%), and *Washingtonia robusta* (Mexican fan palm, 9.4%).

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 *Fraxinus* (29%) is over-represented and *Fraxinus velutina* (18%) exceeds the 10% species rule. *Washingtonia filifera* (California fan palm, 9.9%) is borderline over-represented. Table 1 includes a complete summary of all populations.

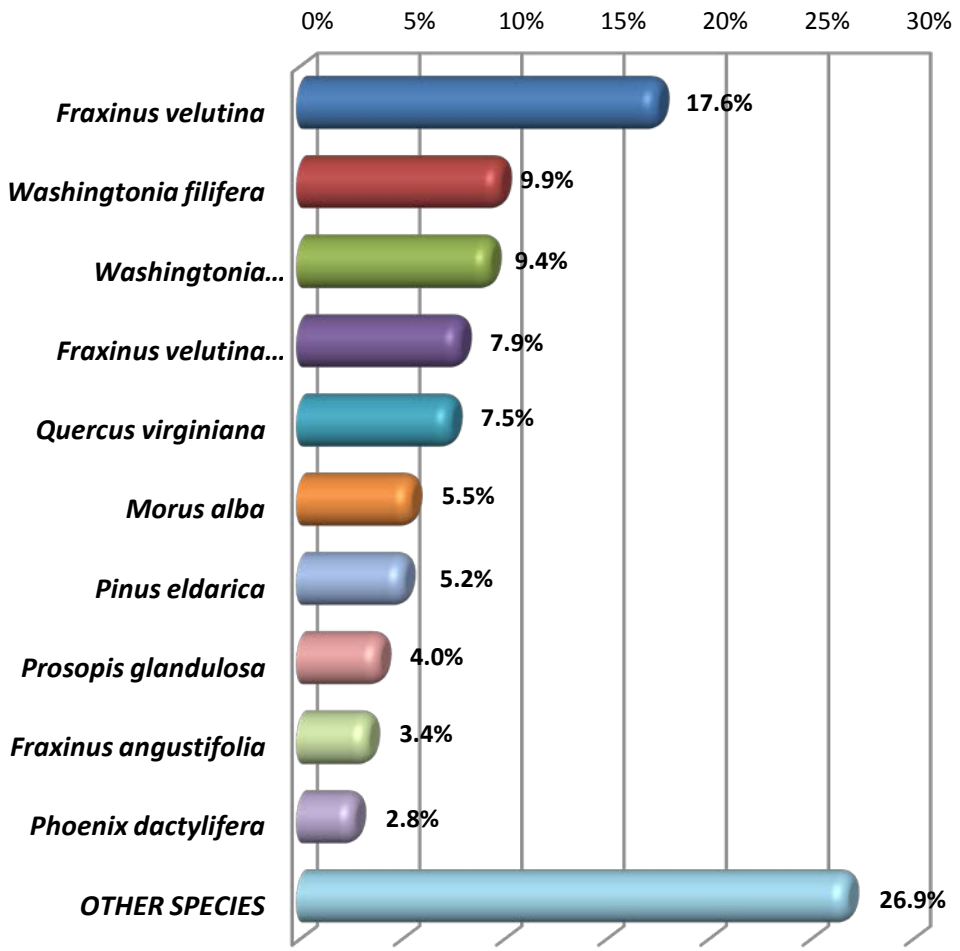


***Figure 2. Frequency of Top 10 Species in Mesquite's Inventoried Public Tree Population***

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 Mesquite's Inventoried Public Trees*

| Species | DBH Class (in) 0-3 | 3-6 | 6-12 | 12-18 | 18-24 | Total | % of Pop. |
|---|---|---|---|---|---|---|---|
| **Broadleaf Deciduous Large (BDL)** | | | | | | | |
| *Populus fremontii* | 1 | 3 | 17 | 8 | 1 | 30 | 2% |
| *Gleditsia triacanthos* | 2 | 8 | 1 | 0 | 0 | 11 | 1% |
| *Plantanus occidentalis* | 0 | 0 | 3 | 0 | 0 | 3 | 0% |
| *Zelkova serrata* | 0 | 0 | 1 | 0 | 0 | 1 | 0% |
| **Total** | **3** | **11** | **22** | **8** | **1** | **45** | **3%** |
| **Broadleaf Deciduous Medium (BDM)** | | | | | | | |
| *Fraxinus velutina* | 60 | 94 | 117 | 42 | 0 | 313 | 18% |
| *Fraxinus velutina 'Fan-Tex'* | 71 | 50 | 19 | 1 | 0 | 141 | 8% |
| *Morus alba* | 0 | 0 | 17 | 74 | 7 | 98 | 6% |
| *Fraxinus angustifolia* | 9 | 18 | 31 | 3 | 0 | 61 | 3% |
| *Parkinsonia florida* | 7 | 19 | 7 | 0 | 0 | 33 | 2% |
| *Parkinsonia aculeata* | 4 | 6 | 5 | 1 | 1 | 17 | 1% |
| *Prosopis chilensis* | 4 | 5 | 1 | 2 | 1 | 13 | 1% |
| *Ulmus parvifolia* | 0 | 1 | 4 | 0 | 0 | 5 | 0% |
| *Pistacia chinensis* | 2 | 2 | 0 | 0 | 0 | 4 | 0% |
| *Albizia julibrissin* | 1 | 0 | 0 | 0 | 0 | 1 | 0% |
| **Total** | **158** | **195** | **201** | **123** | **9** | **686** | **39%** |
| **Broadleaf Deciduous Small (BDS)** | | | | | | | |
| *Prosopis glandulosa* | 15 | 40 | 15 | 1 | 0 | 71 | 4% |
| *Parkinsonia x 'Desert Museum'* | 3 | 15 | 24 | 0 | 0 | 42 | 2% |
| *Chiltalpa tashkentensis* | 1 | 22 | 7 | 1 | 0 | 31 | 2% |
| *Chilopsis linearis* | 13 | 7 | 8 | 1 | 0 | 29 | 2% |
| *Acacia farnesiana* | 10 | 4 | 8 | 0 | 0 | 22 | 1% |
| *Prosopis torreyana* | 4 | 2 | 5 | 2 | 0 | 13 | 1% |
| *Parkinsonia x 'Sonoran Emerald'* | 1 | 7 | 3 | 0 | 0 | 11 | 1% |
| *Vitex agnus-castus* | 5 | 3 | 3 | 0 | 0 | 11 | 1% |
| *Tamarix chinensis* | 3 | 0 | 0 | 0 | 0 | 3 | 0% |
| *Parkinsonia microphylla* | 0 | 0 | 2 | 0 | 0 | 2 | 0% |
| *Pyrus calleryana* | 0 | 1 | 1 | 0 | 0 | 2 | 0% |
| *Lagerstroemia indica* | 1 | 0 | 0 | 0 | 0 | 1 | 0% |
| *Prosopis velutina* | 0 | 0 | 1 | 0 | 0 | 1 | 0% |
| **Total** | **56** | **101** | **77** | **5** | **0** | **239** | **13%** |
| **Broadleaf Evergreen Large (BEL)** | | | | | | | |
| *Eucalyptus microtheca* | 1 | 5 | 12 | 0 | 0 | 18 | 1% |
| *Quercus ilex* | 1 | 0 | 0 | 0 | 0 | 1 | 0% |
| **Total** | **2** | **5** | **12** | **0** | **0** | **19** | **1%** |

| Species | DBH Class (in) 0-3 | 3-6 | 6-12 | 12-18 | 18-24 | Total | % of Pop. |
|---|---|---|---|---|---|---|---|
| **Broadleaf Evergreen Medium (BEM)** | | | | | | | |
| *Quercus virginiana* | 46 | 75 | 11 | 1 | 0 | 133 | 7% |
| *Prosopis alba* | 12 | 20 | 9 | 1 | 0 | 42 | 2% |
| **Total** | **58** | **95** | **20** | **2** | **0** | **175** | **10%** |
| **Broadleaf Evergreen Small (BES)** | | | | | | | |
| *Chamaerops humilis* | 0 | 27 | 0 | 0 | 0 | 27 | 2% |
| *Ebenopsis ebano* | 19 | 4 | 0 | 0 | 0 | 23 | 1% |
| *Olea europaea 'Swan Hill'* | 14 | 4 | 1 | 0 | 0 | 19 | 1% |
| *Sophora secundiflora* | 12 | 0 | 0 | 0 | 0 | 12 | 1% |
| *Yucca brevifolia* | 0 | 5 | 0 | 0 | 0 | 5 | 0% |
| *Rhus lancea* | 4 | 0 | 0 | 0 | 0 | 4 | 0% |
| *Acacia constricta* | 2 | 0 | 0 | 0 | 0 | 2 | 0% |
| *Eucalyptus latens* | 1 | 0 | 0 | 0 | 0 | 1 | 0% |
| **Total** | **52** | **40** | **1** | **0** | **0** | **93** | **5%** |
| **Conifer Evergreen Large (CEL)** | | | | | | | |
| *Pinus eldarica* | 8 | 28 | 51 | 5 | 0 | 92 | 5% |
| *Pinus halepensis* | 0 | 4 | 21 | 7 | 0 | 32 | 2% |
| **Total** | **8** | **32** | **72** | **12** | **0** | **124** | **7%** |
| **Conifer Evergreen Medium (CEM)** | | | | | | | |
| *Pinus brutia* | 0 | 0 | 0 | 3 | 0 | 3 | 0% |
| **Total** | **0** | **0** | **0** | **3** | **0** | **3** | **0%** |
| **Palm Evergreen Large (PEL)** | | | | | | | |
| *Phoenix canariensis* | 0 | 0 | 0 | 2 | 1 | 3 | 0% |
| **Total** | **0** | **0** | **0** | **2** | **1** | **3** | **0%** |
| **Palm Evergreen Medium (PEM)** | | | | | | | |
| *Phoenix dactylifera* | 0 | 0 | 0 | 49 | 0 | 49 | 3% |
| **Total** | **0** | **0** | **0** | **49** | **0** | **49** | **3%** |
| **Palm Evergreen Small (PES)** | | | | | | | |
| *Washingtonia filifera* | 3 | 1 | 129 | 40 | 3 | 176 | 10% |
| *Washingtonia robusta* | 0 | 3 | 142 | 22 | 0 | 167 | 9% |
| **Total** | **3** | **4** | **271** | **62** | **3** | **343** | **19%** |
| **Citywide Total** | **340** | **483** | **676** | **266** | **14** | **1,779** | **100%** |

## *Species Importance*

To quantify the significance of any one particular species to Mesquite's urban forest, an *importance value* (IV) is derived for each of the most common species. Importance values are particularly meaningful to urban forest managers because they indicate a community's reliance on the functional capacity of a particular species. **i-Tree *Streets* calculates importance value based on the mean of three values: percentage of total population, percentage of total leaf area, and percentage of total canopy cover.** Importance value goes beyond tree numbers alone to suggest reliance on specific species based on the benefits they provide. The importance value can range from zero (which implies no reliance) to 100 (suggesting total reliance).

No single species should dominate the composition in the 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 short rotations and increased long-term management costs.

The 22 most abundant species each represent greater than 1% of the total population. Together, these 22 species represent 93% of the total population, 93% of the total leaf area, and 92% of the total canopy cover for a combined importance value of 92.5 (Table 2). Of these species, Mesquite relies most *on Fraxinus velutina* (velvet ash, IV=22.2), and *Morus alba* (white mulberry, IV=15.4).

Mesquite's *Morus alba* (white mulberry) accounts for 5.5% of the population yet has an importance value of 15.4, and are providing the greatest per-tree functional benefit capacity. *Populus fremontii* (Fremont cottonwood) is also providing relatively high per-tree functional capacity with an importance value of 3.4 while representing just 1.7% of the population. Both of these species are large-stature deciduous hardwoods that grow vigorously, and can have substantial maintenance costs. These costs may be justified, however, considering the benefits provided are relatively high.

*Table 2. Importance Value (IV) of Mesquite's Most Abundant Public Tree Species*

| Species | Number of Trees | % of Total Trees | Leaf Area (ft2) | % of Total Leaf Area | Canopy Cover (ft2) | % of Total Canopy Cover | Importance Value |
|---|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 313 | 17.6 | 303,810 | 25.7 | 100,485 | 23.2 | **22.2** |
| *Washingtonia filifera* | 176 | 9.9 | 52,277 | 4.4 | 5,029 | 1.2 | **5.2** |
| *Washingtonia robusta* | 167 | 9.4 | 37,248 | 3.1 | 10,046 | 2.3 | **5.0** |
| *Fraxinus velutina 'Fan-Tex'* | 141 | 7.9 | 53,566 | 4.5 | 24,896 | 5.7 | **6.1** |
| *Quercus virginiana* | 133 | 7.5 | 42,174 | 3.6 | 18,898 | 4.4 | **5.1** |
| *Morus alba* | 98 | 5.5 | 239,605 | 20.3 | 88,531 | 20.4 | **15.4** |
| *Pinus eldarica* | 92 | 5.2 | 53,889 | 4.6 | 18,613 | 4.3 | **4.7** |
| *Prosopis glandulosa* | 71 | 4.0 | 39,068 | 3.3 | 18,878 | 4.4 | **3.9** |
| *Fraxinus angustifolia* | 61 | 3.4 | 54,201 | 4.6 | 25,573 | 5.9 | **4.6** |
| *Phoenix dactylifera* | 49 | 2.8 | 12,781 | 1.1 | 9,871 | 2.3 | **2.0** |
| *Parkinsonia x 'Desert Museum'* | 42 | 2.4 | 20,601 | 1.7 | 11,075 | 2.6 | **2.2** |
| *Prosopis alba* | 42 | 2.4 | 14,118 | 1.2 | 3,332 | 0.8 | **1.4** |
| *Parkinsonia florida* | 33 | 1.9 | 14,904 | 1.3 | 9,647 | 2.2 | **1.8** |
| *Pinus halepensis* | 32 | 1.8 | 41,475 | 3.5 | 9,937 | 2.3 | **2.5** |
| *Chiltalpa tashkentensis* | 31 | 1.7 | 12,165 | 1.0 | 6,618 | 1.5 | **1.4** |
| *Populus fremontii* | 30 | 1.7 | 58,771 | 5.0 | 15,070 | 3.5 | **3.4** |
| *Chilopsis linearis* | 29 | 1.6 | 8,651 | 0.7 | 4,785 | 1.1 | **1.2** |
| *Chamaerops humilis* | 27 | 1.5 | 9,998 | 0.8 | 3,637 | 0.8 | **1.1** |
| *Ebenopsis ebano* | 23 | 1.3 | 3,622 | 0.3 | 1,226 | 0.3 | **0.6** |
| *Acacia farnesiana* | 22 | 1.2 | 7,241 | 0.6 | 4,023 | 0.9 | **0.9** |
| *Olea europaea 'Swan Hill'* | 19 | 1.1 | 3,896 | 0.3 | 1,401 | 0.3 | **0.6** |
| *Eucalyptus microtheca* | 18 | 1.0 | 18,120 | 1.5 | 5,382 | 1.2 | **1.3** |
| OTHER TREES | 130 | 7.3 | 80,508 | 6.8 | 36,195 | 8.4 | **7.5** |
| **Total** | **1,779** | **100%** | **1,182,688** | **100%** | **433,149** | **100%** | **100** |

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, *Washingtonia filifera* and *W. robusta* (Mexican fan palm and California fan palm) represent 9% and 8% of the population respectively, but because of their small leaf surface areas, their importance values are 5.2 and 5.0.

## 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 9.9 acres of tree canopy cover. *Fraxinus velutina* (velvet ash) and *Morus alba* (white mulberry) provide the largest proportion of canopy, accounting for 23% and 20% 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 ideal-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).

Mesquite's total tree population has a well-established age distribution (Figure 3). Overall, the age distribution is weighted towards young trees, with 46% of the population consisting of trees with a DBH (diameter at breast height) of six inches or smaller and 53% middle-aged established trees (6-18 inches DBH). Trees greater than 18 inches DBH make up less than 1% of the overall population (Figure 3). Mesquite has no 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.

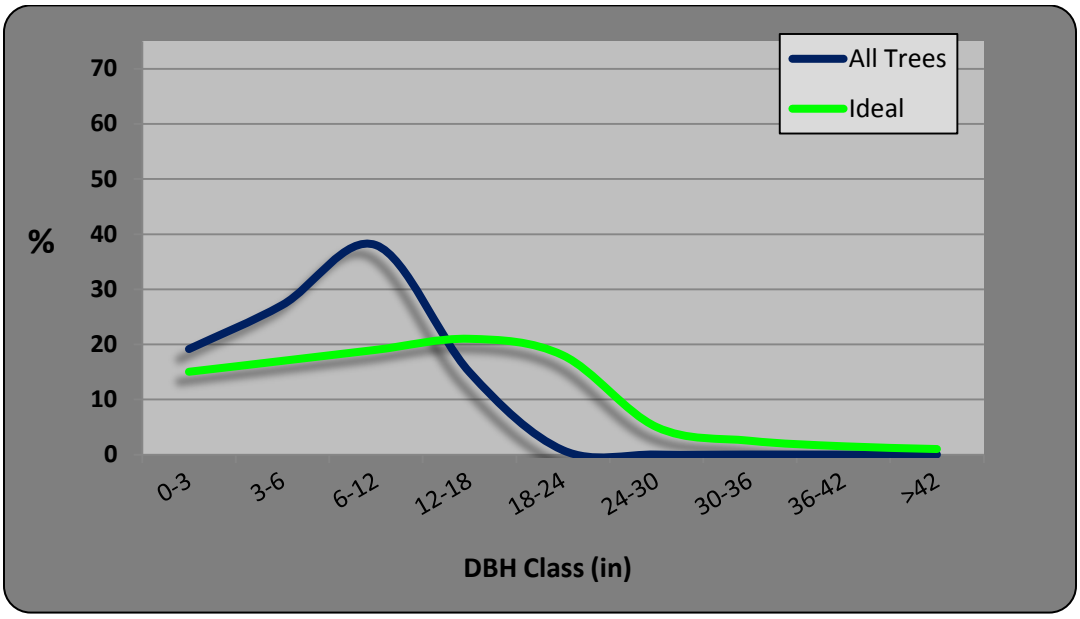


***Figure 3. Overall Relative Age Distribution of Mesquite's Tree Inventory***

Of Mesquite's seven most common species (Figure 4*),* one of the youngest populations is *Quercus virginiana* (live oak) with 91% of trees less than 6" DBH. *Fraxinus velutina* 'Fan-Tex' (Fan-Tex ash) is also a young population (86% under 6" DBH) that appears to have been favored over the general species, *Fraxinus velutina* (velvet ash, (49% under 6" DBH), in recent plantings. These young populations of large-stature trees have considerable potential to increase in value and benefit with appropriate maintenance.

In contrast*, Prosopis glandulosa* (honey mesquite) is a small-stature tree with significant representation in the small size class (77% < 6 inches DBH), but this may be more a representation of the species' natural small habit, rather than a true indication of young age. A high proportion of these trees were rated as poor (18%), and just 39% are in good condition. This population is likely to continue to provide benefits at a flat or declining rate over time.

Two species, *Pinus eldarica* and *Fraxinus angustifolia,* are established populations with 81%, 91%, and 85% of the population in the 3" to 18" DBH range. These medium-aged populations of large stature trees may continue to increase in stature and benefits over time. If desirable, these species should be included in future plantings. Currently, they have relatively low representation in the young age class (under 3" DBH).

The oldest population is likely *Morus alba* (white mulberry). This fast growing, large-stature tree population is mature, but not senescent, with 75.5% of trees in the 12"-18" DBH class and 7% in the 18 – 24" DBH class. Moreover, 79% of this population received a condition rating of good, indicating this population is performing well. *Morus alba* is likely to continue to produce benefits at a stable rate over time until the trees reach the end of their useful lives. This species typically lives 50 – 150 years, and maintenance and environmental factors impact the longevity significantly.

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, Mesquite can expect additional benefits as the trees mature. New installations should carefully consider species selection, increasing the use of underutilized and well-performing species, and focusing on medium and large-statured species. Due to their over-representation in the population, new plantings might avoid *Fraxinus velutina* (velvet ash, 17.6%). Due to their low leaf surface area, and because these species are already close to representing 10% of the population (9.9%, 9.4%), *Washingtonia sp.* (California and Mexican fan palms) should not be emphasized in new planting palettes.

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 reasonable pruning cycles, can ensure Mesquite's urban forest remains healthy and well-structured, thereby maximizing environmental services to the community, reducing risk, and promoting a consistent flow of benefits for many generations to come.

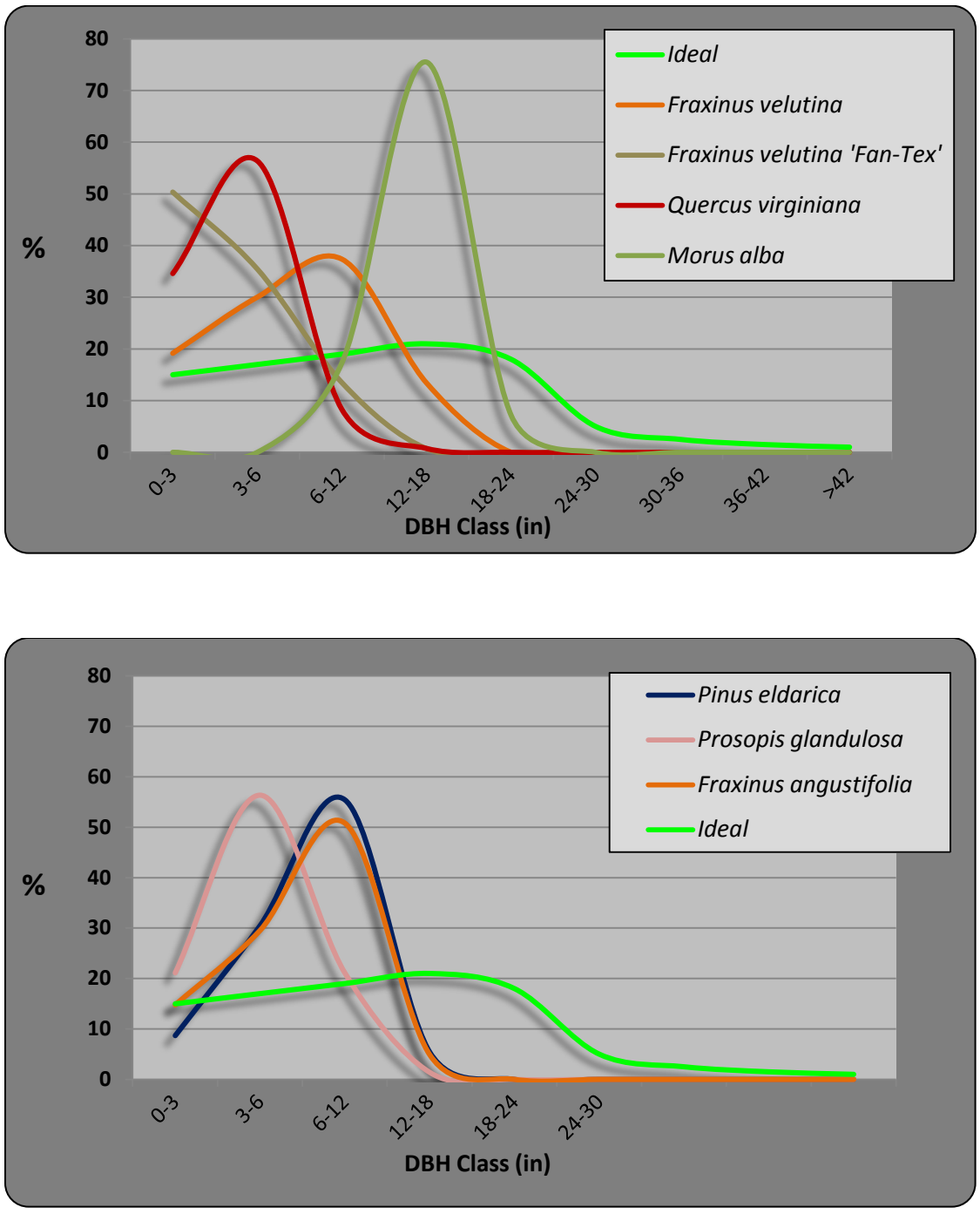


***Figure 4. Relative Age Distribution of Mesquite's Top 8 Inventoried Tree Species***

## *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 over half (54%) of Mesquite's trees in good condition, 38.5% in fair condition, and 7.6% in poor condition or dead. Removal or mitigation of dead and failing trees is recommended as soon as possible to reduce liability exposure.

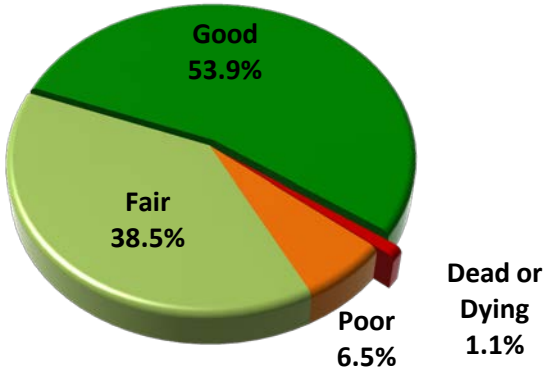


***Figure 5. Condition of Mesquite's Inventoried Public Trees***

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 29 most common species in the inventory, 15 have an RPI of 1.0 or greater (Table 3). Of these, *Chamaerops humilis* (Mediterranean fan palm, RPI=1.19)*, Washingtonia filifera* (California palm, RPI=1.17)*, and Prosopis torreyana* (Western honey mesquite, RPI=1.11) have the highest RPI, while *Chitalpa tashkentenssis* (Chitalpa, RPI=0.79), *Parkinsonia aculeata* (Jerusalem thorn, RPI=0.78), and *Ebenopsis ebano* (Texas ebony, RPI=0.75) 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 that also 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.

*Table 3. Relative Performance Index (RPI) for Mesquite's Inventoried Public Trees*

| Species | Dead or Dying | Poor | Fair | Good | RPI | # of Trees | % of All Trees |
|---|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 2.2 | 7.0 | 32.3 | 58.5 | **1.01** | 313 | 17.6 |
| *Washingtonia filifera* | 0.0 | 0.6 | 6.3 | 93.2 | **1.17** | 176 | 9.9 |
| *Washingtonia robusta* | 0.0 | 0.6 | 89.8 | 9.6 | **0.87** | 167 | 9.4 |
| *Fraxinus velutina 'Fan-Tex'* | 2.8 | 5.0 | 24.8 | 67.4 | **1.04** | 141 | 7.9 |
| *Quercus virginiana* | 0.0 | 9.0 | 30.1 | 60.9 | **1.02** | 133 | 7.5 |
| *Morus alba* | 1.0 | 8.2 | 12.2 | 78.6 | **1.08** | 98 | 5.5 |
| *Pinus eldarica* | 1.1 | 3.3 | 40.2 | 55.4 | **1.02** | 92 | 5.2 |
| *Prosopis glandulosa* | 0.0 | 18.3 | 42.3 | 39.4 | **0.92** | 71 | 4.0 |
| *Fraxinus angustifolia* | 0.0 | 21.3 | 21.3 | 57.4 | **0.97** | 61 | 3.4 |
| *Phoenix dactylifera* | 4.1 | 0.0 | 93.9 | 2.0 | **0.82** | 49 | 2.8 |
| *Prosopis alba* | 0.0 | 2.4 | 64.3 | 33.3 | **0.95** | 42 | 2.4 |
| *Parkinsonia x 'Desert Museum'* | 0.0 | 14.3 | 50.0 | 35.7 | **0.92** | 42 | 2.4 |
| *Parkinsonia florida* | 0.0 | 30.3 | 27.3 | 42.4 | **0.88** | 33 | 1.9 |
| *Pinus halepensis* | 0.0 | 3.1 | 18.8 | 78.1 | **1.10** | 32 | 1.8 |
| *Chiltalpa tashkentensis* | 0.0 | 16.1 | 83.9 | 0.0 | **0.79** | 31 | 1.7 |
| *Populus fremontii* | 3.3 | 0.0 | 23.3 | 73.3 | **1.08** | 30 | 1.7 |
| *Chilopsis linearis* | 0.0 | 10.3 | 17.2 | 72.4 | **1.06** | 29 | 1.6 |
| *Chamaerops humilis* | 0.0 | 0.0 | 0.0 | 100.0 | **1.19** | 27 | 1.5 |
| *Ebenopsis ebano* | 8.7 | 13.0 | 73.9 | 4.3 | **0.75** | 23 | 1.3 |
| *Acacia farnesiana* | 0.0 | 13.6 | 36.4 | 50.0 | **0.97** | 22 | 1.2 |
| *Olea europaea 'Swan Hill'* | 0.0 | 0.0 | 68.4 | 31.6 | **0.95** | 19 | 1.1 |
| *Eucalyptus microtheca* | 0.0 | 5.6 | 50.0 | 44.4 | **0.98** | 18 | 1.0 |
| *Parkinsonia aculeata* | 5.9 | 11.8 | 76.5 | 5.9 | **0.78** | 17 | 1.0 |
| *Prosopis chilensis* | 0.0 | 0.0 | 69.2 | 30.8 | **0.95** | 13 | 0.7 |
| *Prosopis torreyana* | 0.0 | 0.0 | 23.1 | 76.9 | **1.11** | 13 | 0.7 |
| *Sophora secundiflora* | 0.0 | 0.0 | 50.0 | 50.0 | **1.02** | 12 | 0.7 |
| *Parkinsonia x 'Sonoran Emerald'* | 9.1 | 0.0 | 0.0 | 90.9 | **1.10** | 11 | 0.6 |
| *Gleditsia triacanthos* | 0.0 | 0.0 | 72.7 | 27.3 | **0.94** | 11 | 0.6 |
| *Vitex agnus-castus* | 0.0 | 0.0 | 54.5 | 45.5 | **1.00** | 11 | 0.6 |
| Other Trees | 0.0 | 0.0 | 0.4 | 0.6 | **1.01** | 42 | 2.4 |
| **Citywide** | **1.1** | **6.5** | **38.5** | **53.9** | **1.00** | **1,779** | **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 All Trees |
|---|---|---|---|
| *Populus fremontii* | **1.08** | 30 | 1.7 |
| *Pinus halepensis* | **1.10** | 32 | 1.8 |
| *Pinus eldarica* | **1.02** | 92 | 5.2 |
| *Morus alba* | **1.08** | 98 | 5.5 |

## *Replacement Value*

The current value of Mesquite's inventoried tree resource is approximately $3.45 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 Mesquite's current inventoried tree population of 1,779 trees with trees of similar size, species, and condition would cost over $3.4 million (Table 5). The average replacement value per tree is $1,941.

*Fraxinus velutina* (velvet ash) account for 21% of the total replacement value and 17.6% of the population, while *Morus alba* (white mulberry) account for 14.7% of the replacement value but just 5.5% of the population, meaning the average *Morus alba* has a higher value. 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.

Mesquite's public trees represent a vital component of the City's infrastructure and are a public asset valued at approximately $3.45 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 Mesquite's inventoried public trees is very important. Annual benefits are examined in Chapter 3.

*Table 5. Replacement Value of Mesquite's Inventoried Public Trees*

| Species | DBH Class (in) | | | | | | Total | % of Total ($) |
|---|---|---|---|---|---|---|---|---|
| | 3 | 3-6 | 6-13 | 13-19 | 19-25 | 25+ | | |
| *Fraxinus velutina* | 9,526 | 74,032 | 333,079 | 315,121 | 0 | 0 | 731,758 | 21.19 |
| *Washingtonia filifera* | 639 | 252 | 62,267 | 24,612 | 2,275 | 0 | 90,044 | 2.61 |
| *Washingtonia robusta* | 0 | 474 | 27,523 | 5,102 | 0 | 0 | 33,100 | 0.96 |
| *Fraxinus velutina 'Fan-Tex'* | 15,977 | 69,332 | 97,996 | 14,349 | 0 | 0 | 197,654 | 5.72 |
| *Quercus virginiana* | 8,965 | 106,010 | 50,838 | 10,129 | 0 | 0 | 175,942 | 5.10 |
| *Morus alba* | 0 | 0 | 32,936 | 407,316 | 66,930 | 0 | 507,182 | 14.69 |
| *Pinus eldarica* | 1,170 | 24,606 | 195,294 | 48,964 | 0 | 0 | 270,035 | 7.82 |
| *Prosopis glandulosa* | 3,344 | 60,064 | 76,908 | 12,990 | 0 | 0 | 153,306 | 4.44 |
| *Fraxinus angustifolia* | 1,787 | 17,981 | 159,536 | 38,826 | 0 | 0 | 218,131 | 6.32 |
| *Phoenix dactylifera* | 0 | 0 | 0 | 34,312 | 0 | 0 | 34,312 | 0.99 |
| *Parkinsonia x 'Desert Museum'* | 545 | 19,681 | 97,996 | 0 | 0 | 0 | 118,223 | 3.42 |
| *Prosopis alba* | 2,361 | 17,996 | 27,306 | 7,268 | 0 | 0 | 54,930 | 1.59 |
| *Parkinsonia florida* | 1,405 | 28,404 | 33,754 | 0 | 0 | 0 | 63,563 | 1.84 |
| *Pinus halepensis* | 0 | 5,636 | 109,368 | 96,222 | 0 | 0 | 211,226 | 6.12 |
| *Chiltalpa tashkentensis* | 182 | 22,723 | 23,078 | 10,129 | 0 | 0 | 56,111 | 1.63 |
| *Populus fremontii* | 127 | 1,227 | 24,437 | 25,463 | 6,630 | 0 | 57,883 | 1.68 |
| *Chilopsis linearis* | 3,347 | 10,646 | 27,091 | 14,349 | 0 | 0 | 55,433 | 1.61 |
| *Chamaerops humilis* | 0 | 6,222 | 0 | 0 | 0 | 0 | 6,222 | 0.18 |
| *Ebenopsis ebano* | 3,589 | 2,952 | 0 | 0 | 0 | 0 | 6,541 | 0.19 |
| *Acacia farnesiana* | 2,508 | 6,512 | 41,018 | 0 | 0 | 0 | 50,037 | 1.45 |
| *Olea europaea 'Swan Hill'* | 2,771 | 5,636 | 4,013 | 0 | 0 | 0 | 12,421 | 0.36 |
| *Eucalyptus microtheca* | 182 | 5,368 | 59,868 | 0 | 0 | 0 | 65,417 | 1.89 |
| *Parkinsonia aculeata* | 541 | 3,043 | 7,676 | 4,132 | 7,723 | 0 | 23,114 | 0.67 |
| *Prosopis chilensis* | 787 | 4,666 | 2,900 | 14,535 | 13,652 | 0 | 36,539 | 1.06 |
| *Prosopis torreyana* | 1,030 | 2,594 | 26,757 | 24,478 | 0 | 0 | 54,858 | 1.59 |

| Species | DBH Class (in) | | | | | | Total | % of Total ($) |
|---|---|---|---|---|---|---|---|---|
| | 3 | 3-6 | 6-13 | 13-19 | 19-25 | 25+ | | |
| *Sophora secundiflora* | 2,361 | 0 | 0 | 0 | 0 | 0 | 2,361 | 0.07 |
| *Gleditsia triacanthos* | 393 | 6,732 | 4,108 | 0 | 0 | 0 | 11,233 | 0.33 |
| *Parkinsonia x 'Sonoran Emerald'* | 212 | 10,646 | 17,057 | 0 | 0 | 0 | 27,915 | 0.81 |
| *Vitex agnus0castus* | 1,212 | 3,221 | 13,713 | 0 | 0 | 0 | 18,145 | 0.53 |
| *Ulmus parvifolia* | 0 | 1,074 | 21,071 | 0 | 0 | 0 | 22,144 | 0.64 |
| *Yucca brevifolia* | 0 | 7,604 | 0 | 0 | 0 | 0 | 7,604 | 0.22 |
| *Pistacia chinensis* | 485 | 3,817 | 0 | 0 | 0 | 0 | 4,302 | 0.12 |
| *Rhus lancea* | 954 | 0 | 0 | 0 | 0 | 0 | 954 | 0.03 |
| *Phoenix canariensis* | 0 | 0 | 0 | 3,053 | 1,862 | 0 | 4,915 | 0.14 |
| *Pinus brutia* | 0 | 0 | 0 | 31,215 | 0 | 0 | 31,215 | 0.90 |
| *Plantanus occidentalis* | 0 | 0 | 12,040 | 0 | 0 | 0 | 12,040 | 0.35 |
| *Tamarix chinensis* | 853 | 0 | 0 | 0 | 0 | 0 | 853 | 0.02 |
| *Acacia constricta* | 439 | 0 | 0 | 0 | 0 | 0 | 439 | 0.01 |
| *Parkinsonia microphylla* | 0 | 0 | 8,118 | 0 | 0 | 0 | 8,118 | 0.24 |
| *Pyrus calleryana* | 0 | 1,074 | 4,013 | 0 | 0 | 0 | 5,087 | 0.15 |
| *Albizia julibrissin* | 163 | 0 | 0 | 0 | 0 | 0 | 163 | 0.00 |
| *Eucalyptus latens* | 257 | 0 | 0 | 0 | 0 | 0 | 257 | 0.01 |
| *Lagerstroemia indica* | 201 | 0 | 0 | 0 | 0 | 0 | 201 | 0.01 |
| *Prosopis velutina* | 0 | 0 | 7,264 | 0 | 0 | 0 | 7,264 | 0.21 |
| *Quercus ilex* | 182 | 0 | 0 | 0 | 0 | 0 | 182 | 0.01 |
| *Zelkova serrata* | 0 | 0 | 3,270 | 0 | 0 | 0 | 3,270 | 0.09 |
| **Citywide total** | **$68,492** | **$530,223** | **$1,612,294** | **$1,142,563** | **$99,071** | **$0** | **$3,452,642** | **100%** |

# Chapter 3: Urban Forest Resource Benefits

Trees are important to Mesquite. 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 Mesquite? 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 Mesquite's inventoried urban forest. While the annual benefits produced by the urban forest can be substantial, it is important to recognize that the greatest benefits from the urban forest are derived from the benefit stream that results over time, from a mature forest where trees are well managed, healthy, and long-lived.

This analysis used Mesquite's 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. These estimates provide first-order approximations of tree value. While i-Tree *Streets* only generally accounts for the benefits produced by Mesquite's public tree population, it is an accounting based on the best available and current scientific research with an accepted degree of uncertainty. The data returned from i-Tree *Streets* can provide a platform from which management decisions can be made (Maco and McPherson, 2003). A discussion of 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 Mesquite from both the shading and climate effects of inventoried trees is equal to 104 MWh (valued at $6,950) and 742 therms ($479), for a total retail savings of approximately $7,429 and an average of $4.18 per tree (Table 6). *Morus alba* (white mulberry), which represents 5.5% of the total tree population, is providing 15.5% of the energy savings, and the highest per-tree benefit with an average of $11.76 per tree. *Washingtonia filifera* (California palm, $8.37/tree) and *Populus fremontii* (Fremont cottonwood, $7.16/tree) provide the next greatest contributions towards energy savings per tree. The populations of *Washingtonia filifera* and *Fraxinus velutina* (velvet ash) are each providing almost 20% in energy benefits, for a total of 39.3%.

Small-stature trees are less able to provide electricity and natural gas reductions. On a per-tree basis, *Washingtonia robusta* (Mexican fan palm, $0.89/tree), *Ebenopsis microtheca* (Texas ebony, $0.69/tree), and *Olea europea* 'Swan Hill' (swan hill olive, $0.98/tree) provide less than $1/tree in energy savings, and represent the lowest energy benefits. *Washingtonia robusta* represents 9.4% of the total tree population, yet provides just 2% of the electricity savings.

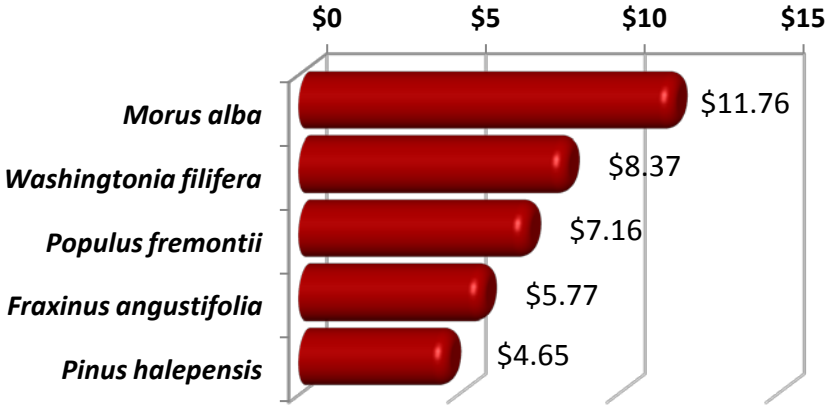


***Figure 6. Annual Electricity and Natural Gas Benefits - Top 5 Species***

*Table 6. Annual Electric and Natural Gas Benefits from Mesquite's Inventoried Public Trees*

| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | % of Total Tree Numbers | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 20 | 1,353 | 146 | 94 | **1,447** | 17.6 | 19.5 | 4.62 |
| *Washingtonia filifera* | 21 | 1,382 | 140 | 91 | **1,473** | 9.9 | 19.8 | 8.37 |
| *Washingtonia robusta* | 2 | 138 | 16 | 11 | **149** | 9.4 | 2.0 | 0.89 |
| *Fraxinus velutina 'Fan-Tex'* | 5 | 313 | 36 | 23 | **336** | 7.9 | 4.5 | 2.39 |
| *Quercus virginiana* | 4 | 249 | 28 | 18 | **267** | 7.5 | 3.6 | 2.01 |
| *Morus alba* | 16 | 1,079 | 113 | 73 | **1,152** | 5.5 | 15.5 | 11.76 |
| *Pinus eldarica* | 4 | 271 | 26 | 17 | **287** | 5.2 | 3.9 | 3.12 |
| *Prosopis glandulosa* | 4 | 239 | 27 | 18 | **257** | 4.0 | 3.5 | 3.61 |
| *Fraxinus angustifolia* | 5 | 330 | 35 | 23 | **352** | 3.4 | 4.7 | 5.77 |
| *Phoenix dactylifera* | 2 | 135 | 16 | 10 | **145** | 2.8 | 2.0 | 2.96 |
| *Parkinsonia x 'Desert Museum'* | 2 | 144 | 16 | 11 | **154** | 2.4 | 2.1 | 3.67 |
| *Prosopis alba* | 1 | 48 | 5 | 3 | **51** | 2.4 | 0.7 | 1.22 |
| *Parkinsonia florida* | 2 | 121 | 14 | 9 | **130** | 1.9 | 1.8 | 3.94 |
| *Pinus halepensis* | 2 | 140 | 14 | 9 | **149** | 1.8 | 2.0 | 4.65 |
| *Chiltalpa tashkentensis* | 1 | 85 | 10 | 6 | **91** | 1.7 | 1.2 | 2.95 |
| *Populus fremontii* | 3 | 201 | 21 | 13 | **215** | 1.7 | 2.9 | 7.16 |
| *Chilopsis linearis* | 1 | 61 | 7 | 5 | **66** | 1.6 | 0.9 | 2.27 |
| *Chamaerops humilis* | 1 | 45 | 6 | 4 | **49** | 1.5 | 0.7 | 1.81 |
| *Ebenopsis ebano* | 0 | 15 | 2 | 1 | **16** | 1.3 | 0.2 | 0.69 |
| *Acacia farnesiana* | 1 | 51 | 6 | 4 | **55** | 1.2 | 0.7 | 2.51 |
| *Olea europaea 'Swan Hill'* | 0 | 17 | 2 | 1 | **19** | 1.1 | 0.3 | 0.98 |
| *Eucalyptus microtheca* | 1 | 77 | 8 | 5 | **82** | 1.0 | 1.1 | 4.57 |
| OTHER TREES | 7 | 456 | 49 | 32 | **488** | 7.3 | 6.6 | 3.75 |
| **CITYWIDE TOTAL** | **104** | **$6,950** | **742** | **$479** | **$7,429** | **100%** | **100%** | **$4.18** |

## *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 (CUFR) 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 Mesquite's urban forest resource 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 $CO_2$ as wood and foliar biomass.
- Indirectly, by lowering the demand for heating and air conditioning, thereby reducing the emissions associated with electric power generation and natural gas consumption.

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, Mesquite's inventoried urban forest has sequestered a total of 319 tons of carbon dioxide ($CO_2$) valued at $4,794[2]. Annually, this tree resource directly sequesters 34 tons of $CO_2$, valued at $504, into woody and foliar biomass. Accounting for estimated $CO_2$ emissions from tree decomposition (-2.6 tons), tree related maintenance activity (-0.5 ton), and avoided $CO_2$ (52 tons) Mesquite's trees provide an annual net reduction in atmospheric $CO_2$ of 82 tons, valued at $1,235 with an average of $0.69 per tree (Table 7).

*Morus alba* (white mulberry, $1.87/tree) and *Eucalyptus microtheca* (coolibah, $1.42/tree) are currently providing the highest per tree benefit (Figure 7). *Fraxinus velutina* (velvet ash) are providing the greatest percentage of overall benefits at 21.3% due to their large stature and relative age distribution as well as their prevalence in the population (17.6%).

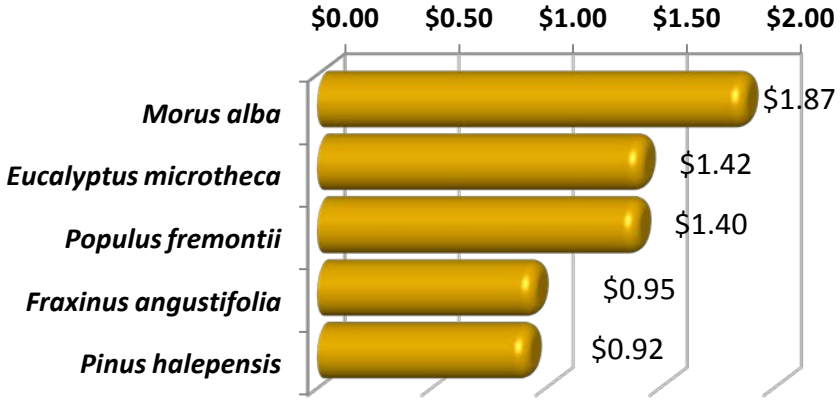


***Figure 7. Annual Reduction of $CO_2$ - Top 5 species***

[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 Mesquite's Inventoried Public Trees*

| Species | Sequestered (lb) | Sequestered ($) | Decomposition Release (lb) | Maintenance Release (lb) | Total Release ($) | Avoided (lb) | Avoided ($) | Net Total (lb) | Total ($) | % of Total Tree Numbers | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 15,959 | 120 | -912 | -172 | -8.13 | 20,149 | 151 | 35,023 | 263 | 17.6 | 21.3 | 0.84 |
| *Washingtonia filifera* | 58 | 0 | -467 | -122 | -4.42 | 20,590 | 154 | 20,058 | 150 | 9.9 | 12.2 | 0.85 |
| *Washingtonia robusta* | 4,404 | 33 | -766 | -127 | -6.70 | 2,059 | 15 | 5,570 | 42 | 9.4 | 3.4 | 0.25 |
| *Fraxinus velutina 'Fan-Tex'* | 3,287 | 25 | -94 | -41 | -1.01 | 4,662 | 35 | 7,815 | 59 | 7.9 | 4.8 | 0.42 |
| *Quercus virginiana* | 5,737 | 43 | -208 | -41 | -1.86 | 3,705 | 28 | 9,193 | 69 | 7.5 | 5.6 | 0.52 |
| *Morus alba* | 9,538 | 72 | -1,056 | -111 | -8.75 | 16,075 | 121 | 24,447 | 183 | 5.5 | 14.9 | 1.87 |
| *Pinus eldarica* | 2,334 | 18 | -160 | -53 | -1.59 | 4,031 | 30 | 6,153 | 46 | 5.2 | 3.7 | 0.50 |
| *Prosopis glandulosa* | 2,354 | 18 | -75 | -28 | -0.77 | 3,560 | 27 | 5,811 | 44 | 4.0 | 3.5 | 0.61 |
| *Fraxinus angustifolia* | 2,982 | 22 | -130 | -33 | -1.22 | 4,909 | 37 | 7,728 | 58 | 3.4 | 4.7 | 0.95 |
| *Phoenix dactylifera* | 832 | 6 | -187 | -35 | -1.66 | 2,007 | 15 | 2,618 | 20 | 2.8 | 1.6 | 0.40 |
| *Parkinsonia x 'Desert Museum'* | 2,642 | 20 | -158 | -23 | -1.36 | 2,138 | 16 | 4,599 | 34 | 2.4 | 2.8 | 0.82 |
| *Prosopis alba* | 924 | 7 | -62 | -16 | -0.58 | 714 | 5 | 1,560 | 12 | 2.4 | 1.0 | 0.28 |
| *Parkinsonia florida* | 903 | 7 | -33 | -12 | -0.34 | 1,803 | 14 | 2,661 | 20 | 1.9 | 1.6 | 0.60 |
| *Pinus halepensis* | 1,971 | 15 | -93 | -24 | -0.88 | 2,084 | 16 | 3,937 | 30 | 1.8 | 2.4 | 0.92 |
| *Chiltalpa tashkentensis* | 1,514 | 11 | -86 | -14 | -0.75 | 1,265 | 9 | 2,679 | 20 | 1.7 | 1.6 | 0.65 |
| *Populus fremontii* | 2,810 | 21 | -186 | -24 | -1.58 | 3,001 | 23 | 5,601 | 42 | 1.7 | 3.4 | 1.40 |
| *Chilopsis linearis* | 410 | 3 | -3 | -11 | -0.10 | 911 | 7 | 1,307 | 10 | 1.6 | 0.8 | 0.34 |
| *Chamaerops humilis* | 256 | 2 | -7 | -10 | -0.12 | 674 | 5 | 914 | 7 | 1.5 | 0.6 | 0.25 |
| *Ebenopsis ebano* | 68 | 1 | -1 | -4 | -0.04 | 219 | 2 | 283 | 2 | 1.3 | 0.2 | 0.09 |
| *Acacia farnesiana* | 922 | 7 | -52 | -8 | -0.45 | 765 | 6 | 1,626 | 12 | 1.2 | 1.0 | 0.55 |
| *Olea europaea 'Swan Hill'* | 86 | 1 | -3 | -4 | -0.05 | 257 | 2 | 336 | 3 | 1.1 | 0.2 | 0.13 |
| *Eucalyptus microtheca* | 2,335 | 18 | -70 | -10 | -0.60 | 1,153 | 9 | 3,408 | 26 | 1.0 | 2.1 | 1.42 |
| OTHER TREES | 4,858 | 36 | -306 | -57 | -2.73 | 6,793 | 51 | 11,287 | 85 | 7.3 | 6.9 | 0.65 |
| **CITYWIDE TOTAL** | **67,184** | **$504** | **-5,114** | **-978** | **-$45.69** | **103,524** | **$776** | **164,616** | **$1,235** | **100%** | **100%** | **$0.69** |

## *Air Quality Improvement*

Urban trees improve air quality in five fundamental ways:

- Absorption of gaseous pollutants such as ozone ($O_3$), sulfur dioxide ($SO_2$), and nitrogen dioxide ($NO_2$) through leaf surfaces.
- Interception of particulate matter ($PM_{10}$), such as dust, ash, dirt, pollen, and smoke.
- 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.

According to data reported by the Clark County Department of Air Quality (CCDAQ), air quality in Clark County exceeded the state 8-hour standard of 150 µg/$m^3$ for $PM_{10}$ 19 days in 2012 (Table 8).

Between 2003 and 2012, there have been 91 exceedances of the Federal 8-hour standard (0.075 ppm) for ground level ($0_3$), an average of 9.1 days per year (Table 8) (CCDAQ, 2013).

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 can also contribute to ozone formation. i-Tree *Streets* analysis accounts for these BVOC emissions in the air quality net benefit.

***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** |

## Deposition and Interception

Each year, approximately 228 pounds of nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), small particulate matter ($PM_{10}$), and ozone ($O_3$) are intercepted or absorbed by the inventoried trees in Mesquite, for a value of $1,181 (Table 9). As a population, *Morus alba* (white mulberry, 50 lbs) is the greatest contributor to pollutant deposition and interception, accounting for approximately 22% of benefits.

## Avoided Pollutants

The energy savings provided by trees have the additional indirect benefit of reducing air pollutant emissions ($NO_2$, $PM_{10}$, $SO_2$, and VOCs) that result from energy production. Altogether, 355 pounds of pollutants, valued at $3,297, are avoided annually through the shading effects of Mesquite's inventoried trees.

## BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered. Approximately 364 pounds of BVOCs are emitted annually from Mesquite's inventoried trees, offsetting the total air quality benefit by -$1,456. *Phoenix dactylifera* (date palm) are the heaviest per tree emitters of BVOCs (-0.69 lbs. / tree), accounting for 9.3% of BVOC emissions while comprising just 2.4% of the population. *Quercus virginiana* (live oak, -0.66lbs/tree) and *Washingtonia robusta* (Mexican fan palm, -0.23lbs/tree) are also contributing substantial BVOCs. For these three species, the benefits from interception, deposition, and avoidance of air pollutants ($NO_2$, $PM_{10}$, $SO_2$, and VOCs) are not enough to offset their BVOC emissions, and their per tree net benefits are negative.

## Net Air Quality Improvement

The net value of air pollutants removed, avoided, and released by Mesquite's inventoried public tree population is $3,022 annually. The average net benefit per tree is $1.70. 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, *Morus alba* (white mulberry $6.03/tree), *Populus fremontii* (Fremont cottonwood, $4.75), and *Fraxinus angustifolia* (Raywood ash $3.07) currently produce the greatest per tree net air quality improvements (Figure 8). However, due to its high prevalence in the population, *Fraxinus velutina* (velvet ash) account for the greatest air quality improvements (28.5%) in terms of total benefits by species, collectively removing a net of 111 pounds of pollutants at a net value of $861.

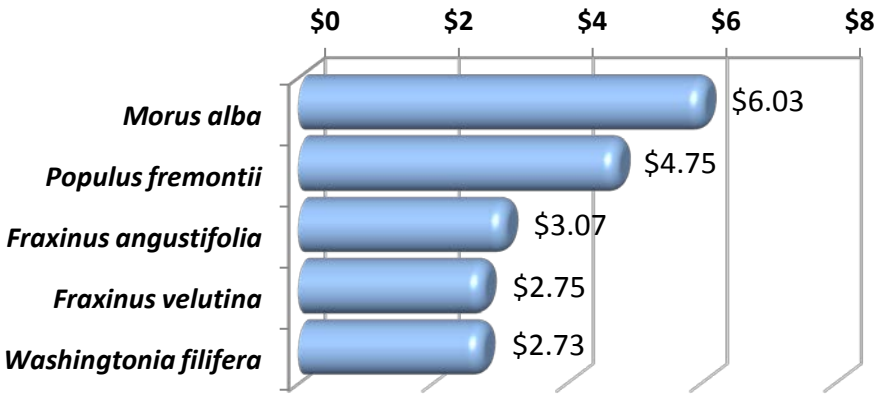


***Figure 8. Annual Improvement to Air Quality - Top 5 Species***

*Table 9. Annual Air Quality Improvements Provided by Mesquite's Inventoried Public Trees*

| Species | Deposition O3 (lb) | Deposition NO2 (lb) | Deposition PM10 (lb) | Deposition SO2 (lb) | Total Deposition ($) | Avoided NO2 (lb) | Avoided PM10 (lb) | Avoided VOC (lb) | Avoided SO2 (lb) | Total Avoided ($) | BVOC Emissions (lb) | BVOC Emissions ($) | Total (lb) | Total ($) | % of Pop. | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 17 | 7 | 17 | 1 | 216 | 36.4 | 1.9 | 0.3 | 31.0 | 645 | 0.0 | 0 | 111 | 861 | 17.6 | 2.75 |
| *Washingtonia filifera* | 3 | 2 | 3 | 0 | 41 | 36.9 | 1.9 | 0.3 | 31.6 | 656 | -54.2 | -217 | 24 | 481 | 9.9 | 2.73 |
| *Washingtonia robusta* | 4 | 2 | 4 | 0 | 56 | 3.8 | 0.2 | 0.0 | 3.2 | 67 | -38.5 | -154 | (21) | (31) | 9.4 | -0.19 |
| *Fraxinus velutina 'Fan-Tex'* | 3 | 1 | 4 | 0 | 44 | 8.3 | 0.4 | 0.1 | 7.1 | 148 | -7.6 | -30 | 17 | 162 | 7.9 | 1.15 |
| *Quercus virginiana* | 1 | 1 | 2 | 0 | 25 | 6.7 | 0.3 | 0.1 | 5.7 | 118 | -87.7 | -351 | (70) | (207) | 7.5 | -1.56 |
| *Morus alba* | 25 | 7 | 17 | 2 | 252 | 28.5 | 1.5 | 0.3 | 24.3 | 506 | -41.6 | -166 | 63 | 591 | 5.5 | 6.03 |
| *Pinus eldarica* | 3 | 2 | 4 | 0 | 52 | 7.3 | 0.4 | 0.1 | 6.3 | 130 | -6.0 | -24 | 18 | 158 | 5.2 | 1.72 |
| *Prosopis glandulosa* | 2 | 1 | 3 | 0 | 35 | 6.4 | 0.3 | 0.1 | 5.4 | 113 | -5.5 | -22 | 13 | 126 | 4.0 | 1.78 |
| *Fraxinus angustifolia* | 4 | 2 | 5 | 0 | 62 | 8.8 | 0.4 | 0.1 | 7.5 | 156 | -7.7 | -31 | 21 | 188 | 3.4 | 3.07 |
| *Phoenix dactylifera* | 5 | 3 | 5 | 1 | 69 | 3.6 | 0.2 | 0.0 | 3.1 | 64 | -33.9 | -136 | (14) | (2) | 2.8 | -0.04 |
| *Parkinsonia x 'Desert Museum'* | 3 | 2 | 3 | 0 | 45 | 3.8 | 0.2 | 0.0 | 3.3 | 68 | -8.5 | -34 | 7 | 79 | 2.4 | 1.88 |
| *Prosopis alba* | 0 | 0 | 0 | 0 | 6 | 1.3 | 0.1 | 0.0 | 1.1 | 23 | -4.0 | -16 | (0) | 13 | 2.4 | 0.31 |
| *Parkinsonia florida* | 1 | 1 | 2 | 0 | 20 | 3.2 | 0.2 | 0.0 | 2.8 | 57 | -4.3 | -17 | 6 | 60 | 1.9 | 1.81 |
| *Pinus halepensis* | 1 | 0 | 1 | 0 | 12 | 3.8 | 0.2 | 0.0 | 3.2 | 67 | -5.2 | -21 | 4 | 58 | 1.8 | 1.81 |
| *Chiltalpa tashkentensis* | 2 | 1 | 2 | 0 | 24 | 2.3 | 0.1 | 0.0 | 1.9 | 40 | -5.0 | -20 | 4 | 44 | 1.7 | 1.43 |
| *Populus fremontii* | 4 | 2 | 3 | 0 | 47 | 5.4 | 0.3 | 0.0 | 4.6 | 96 | 0.0 | 0 | 19 | 143 | 1.7 | 4.75 |
| *Chilopsis linearis* | 1 | 0 | 1 | 0 | 8 | 1.6 | 0.1 | 0.0 | 1.4 | 29 | -5.8 | -23 | (1) | 14 | 1.6 | 0.48 |
| *Chamaerops humilis* | 0 | 0 | 0 | 0 | 5 | 1.2 | 0.1 | 0.0 | 1.0 | 21 | 0.0 | 0 | 3 | 26 | 1.5 | 0.96 |
| *Ebenopsis ebano* | 0 | 0 | 0 | 0 | 1 | 0.4 | 0.0 | 0.0 | 0.3 | 7 | 0.0 | 0 | 1 | 8 | 1.3 | 0.35 |
| *Acacia farnesiana* | 1 | 1 | 1 | 0 | 15 | 1.4 | 0.1 | 0.0 | 1.2 | 24 | -3.0 | -12 | 3 | 28 | 1.2 | 1.26 |
| *Olea europaea 'Swan Hill'* | 0 | 0 | 0 | 0 | 2 | 0.5 | 0.0 | 0.0 | 0.4 | 8 | 0.0 | 0 | 1 | 10 | 1.1 | 0.53 |
| *Eucalyptus microtheca* | 1 | 0 | 1 | 0 | 10 | 2.1 | 0.1 | 0.0 | 1.8 | 37 | -11.4 | -46 | (6) | 2 | 1.0 | 0.09 |
| OTHER TREES | 10 | 5 | 10 | 1 | 133 | 12.1 | 0.6 | 0.1 | 10.3 | 215 | -33.9 | -136 | 15 | 213 | 7.3 | 1.64 |
| **CITYWIDE TOTAL** | **93** | **39** | **88** | **8** | **$1,181** | **185.7** | **9.5** | **1.7** | **158.6** | **$3,297** | **-363.9** | **-$1456** | **$219** | **$3,022** | **100%** | **$1.70** |

## *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 barren surfaces.

Mesquite's inventoried trees intercept 466,676 gallons of stormwater annually for an average of 262 gallons per tree (Table 10). The value of this benefit is $2,240, an average of $1.26 per tree. *Populus fremontii* (Fremont cottonwood) are currently providing the greatest per tree benefit of $3.35 (Figure 9) while *Fraxinus velutina* (velvet ash) are providing the largest portion of benefits at 20% although they represent just 17.6% of the population.

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 *Chilopsis linearis* (desert willow, $0.45/tree) and *Ebenopsis ebano* (Texas ebony, $0.39/tree) are small-stature trees. As such, their benefits will not increase much over time. However, other trees with currently low benefits, such as *Quercus virginiana* (live oak, $0.89/tree), a young population of medium-stature trees, will realize increasing benefits as their canopies mature.

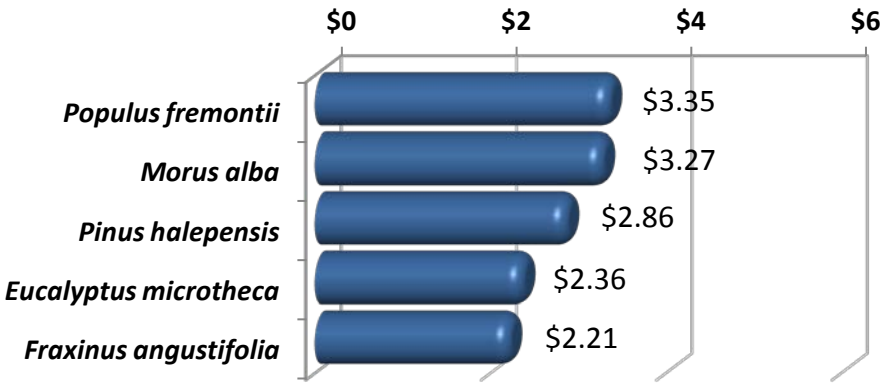


***Figure 9. Annual Reduction in Stormwater Runoff - Top 5 Species***

***Table 10. Annual Stormwater Runoff Reduction Benefits Provided by Mesquite's Inventoried Public Trees***

| Species | Total Rainfall Interception (Gal) | Total ($) | % of Pop. | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|
| *Fraxinus velutina* | 92,933 | 446 | 17.6 | 19.9 | 1.43 |
| *Washingtonia filifera* | 12,172 | 58 | 9.9 | 2.6 | 0.33 |
| *Washingtonia robusta* | 17,458 | 84 | 9.4 | 3.7 | 0.50 |
| *Fraxinus velutina 'Fan-Tex'* | 27,456 | 132 | 7.9 | 5.9 | 0.93 |
| *Quercus virginiana* | 24,691 | 119 | 7.5 | 5.3 | 0.89 |
| *Morus alba* | 66,734 | 320 | 5.5 | 14.3 | 3.27 |
| *Pinus eldarica* | 28,438 | 137 | 5.2 | 6.1 | 1.48 |
| *Prosopis glandulosa* | 20,472 | 98 | 4.0 | 4.4 | 1.38 |
| *Fraxinus angustifolia* | 28,056 | 135 | 3.4 | 6.0 | 2.21 |
| *Phoenix dactylifera* | 9,691 | 47 | 2.8 | 2.1 | 0.95 |
| *Parkinsonia x 'Desert Museum'* | 11,442 | 55 | 2.4 | 2.5 | 1.31 |
| *Prosopis alba* | 6,351 | 30 | 2.4 | 1.4 | 0.73 |
| *Parkinsonia florida* | 9,173 | 44 | 1.9 | 2.0 | 1.33 |
| *Pinus halepensis* | 19,082 | 92 | 1.8 | 4.1 | 2.86 |
| *Chiltalpa tashkentensis* | 6,798 | 33 | 1.7 | 1.5 | 1.05 |
| *Populus fremontii* | 20,939 | 101 | 1.7 | 4.5 | 3.35 |
| *Chilopsis linearis* | 2,707 | 13 | 1.6 | 0.6 | 0.45 |
| *Chamaerops humilis* | 5,332 | 26 | 1.5 | 1.1 | 0.95 |
| *Ebenopsis ebano* | 1,875 | 9 | 1.3 | 0.4 | 0.39 |
| *Acacia farnesiana* | 4,091 | 20 | 1.2 | 0.9 | 0.89 |
| *Olea europaea 'Swan Hill'* | 2,067 | 10 | 1.1 | 0.4 | 0.52 |
| *Eucalyptus microtheca* | 8,855 | 43 | 1.0 | 1.9 | 2.36 |
| OTHER TREES | 39,861 | 191 | 7.3 | 8.5 | 1.47 |
| **CITYWIDE TOTAL** | **466,676** | **$2,240** | **100%** | **100%** | **$1.26** |

## *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.

Tree location and land use impact the value a tree may add to a property. For example, street trees located in front of a multi-family home will not increase the property value at the same rate as trees in front of a single-family home. Furthermore, street trees located adjacent to commercial and nonresidential properties do not have the same impact on resale price as those in residential areas. These factors are taken into consideration and the value of those trees is adjusted accordingly.

**The calculation of annual aesthetic and other benefits corresponds with a tree's annual increase in leaf area.** When a tree is actively growing, leaf area may increase dramatically. Once a tree is mature, there may be little or no net increase in leaf area from one year to the next; thus, there is little or no incremental annual aesthetic benefit for that year, although the cumulative benefit over the course of the entire life of the tree may be large. Since this report represents a one-year sample snapshot of the 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 $54,655, an average of $30.72 per tree (Table 11). Tree species that produce the highest average per tree aesthetic benefits are *Populus fremontii* (Fremont cottonwood, $86.36 average, per tree), *and Eucalyptus microtheca* (Coolibah, $85.28) (Figure 10).

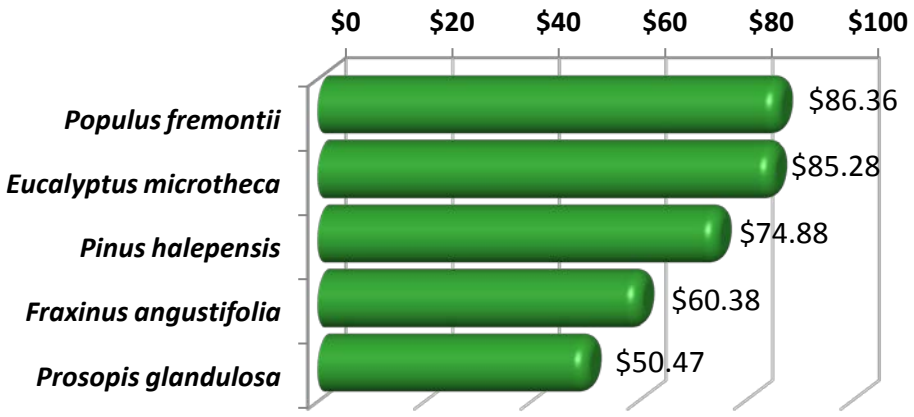


***Figure 10. Annual Increase in Property and Socioeconomic Values - Top 5 Species***

***Table 11. Annual Property Value, Aesthetic, and Socioeconomic Benefits of Mesquite's Inventoried Tree Resource***

| Species | Total ($) | % of Total Tree Numbers | % of Total $ | Avg. $/tree |
|---|---|---|---|---|
| *Fraxinus velutina* | 12,444 | 17.6 | 22.8 | 39.76 |
| *Washingtonia filifera* | 46 | 9.9 | 0.1 | 0.26 |
| *Washingtonia robusta* | 2,212 | 9.4 | 4.1 | 13.25 |
| *Fraxinus velutina 'Fan-Tex'* | 6,087 | 7.9 | 11.1 | 43.17 |
| *Quercus virginiana* | 3,259 | 7.5 | 6.0 | 24.50 |
| *Morus alba* | 4,177 | 5.5 | 7.6 | 42.62 |
| *Pinus eldarica* | 2,062 | 5.2 | 3.8 | 22.42 |
| *Prosopis glandulosa* | 3,583 | 4.0 | 6.6 | 50.47 |
| *Fraxinus angustifolia* | 3,683 | 3.4 | 6.7 | 60.38 |
| *Phoenix dactylifera* | 243 | 2.8 | 0.4 | 4.96 |
| *Parkinsonia x 'Desert Museum'* | 876 | 2.4 | 1.6 | 20.87 |
| *Prosopis alba* | 791 | 2.4 | 1.5 | 18.84 |
| *Parkinsonia florida* | 1,159 | 1.9 | 2.1 | 35.11 |
| *Pinus halepensis* | 2,396 | 1.8 | 4.4 | 74.88 |
| *Chiltalpa tashkentensis* | 587 | 1.7 | 1.1 | 18.95 |
| *Populus fremontii* | 2,591 | 1.7 | 4.7 | 86.36 |
| *Chilopsis linearis* | 441 | 1.6 | 0.8 | 15.20 |
| *Chamaerops humilis* | 664 | 1.5 | 1.2 | 24.61 |
| *Ebenopsis ebano* | 499 | 1.3 | 0.9 | 21.69 |
| *Acacia farnesiana* | 385 | 1.2 | 0.7 | 17.48 |
| *Olea europaea 'Swan Hill'* | 422 | 1.1 | 0.8 | 22.22 |
| *Eucalyptus microtheca* | 1,535 | 1.0 | 2.8 | 85.28 |
| OTHER TREES | 4,512 | 7.3 | 8.3 | 34.70 |
| **CITYWIDE TOTAL** | **$54,655** | **100%** | **100%** | **$30.72** |

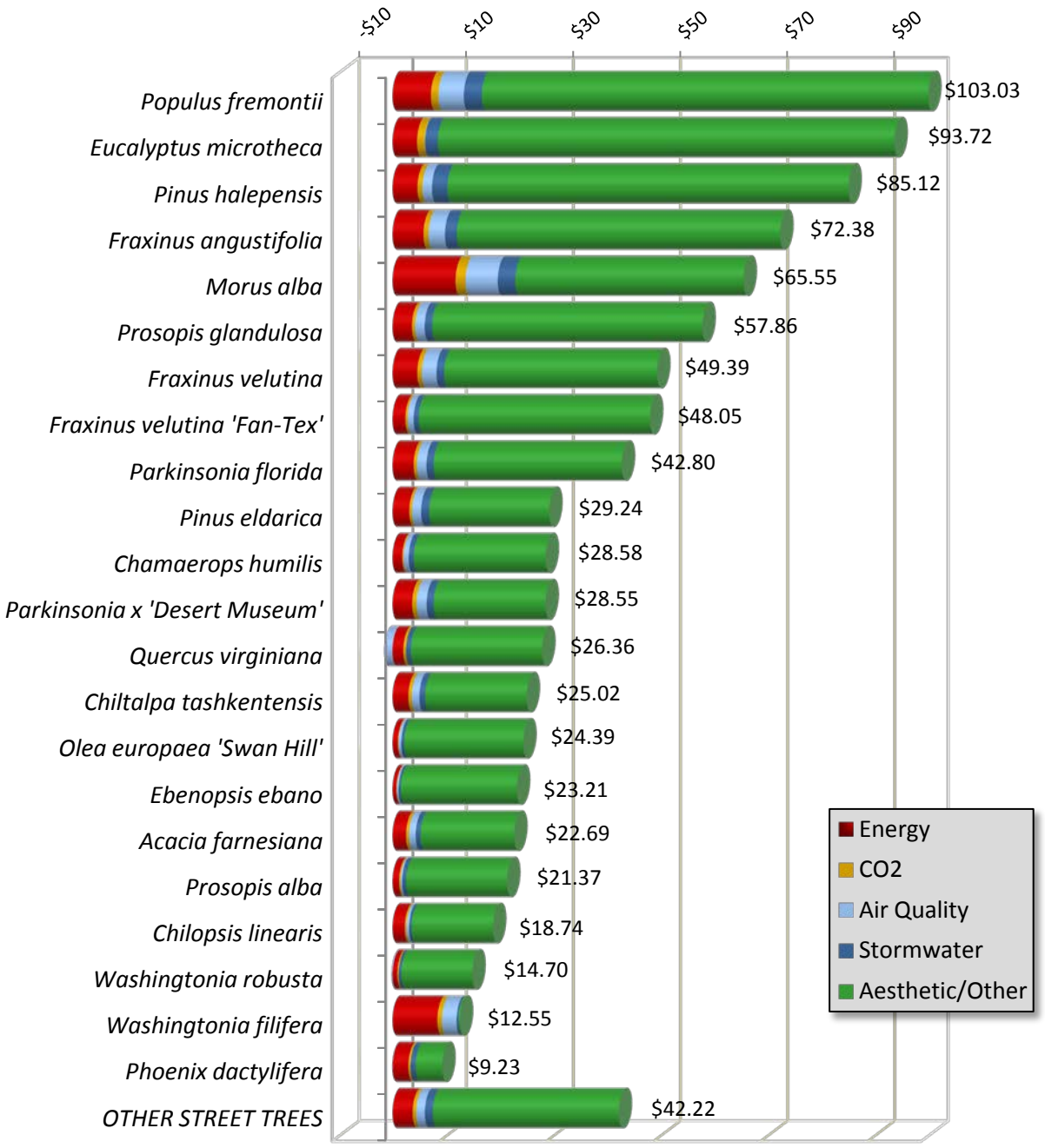


***Figure 11. Summary of Annual per Tree Benefits from Mesquite's Most Prevalent Inventoried Tree Species***

*Table 12. Summary of Current Annual Average per Tree Benefits ($/Tree) from Mesquite's Inventoried Tree Resource*

| Species | Energy | CO2 | Air Quality | Stormwater | Aesthetic/ Other | Total |
|---|---|---|---|---|---|---|
| *Fraxinus velutina* | 4.62 | 0.84 | 2.75 | 1.43 | 39.76 | **49.39** |
| *Washingtonia filifera* | 8.37 | 0.85 | 2.73 | 0.33 | 0.26 | **12.55** |
| *Washingtonia robusta* | 0.89 | 0.25 | -0.19 | 0.50 | 13.25 | **14.70** |
| *Fraxinus velutina 'Fan-Tex'* | 2.39 | 0.42 | 1.15 | 0.93 | 43.17 | **48.05** |
| *Quercus virginiana* | 2.01 | 0.52 | -1.56 | 0.89 | 24.50 | **26.36** |
| *Morus alba* | 11.76 | 1.87 | 6.03 | 3.27 | 42.62 | **65.55** |
| *Pinus eldarica* | 3.12 | 0.50 | 1.72 | 1.48 | 22.42 | **29.24** |
| *Prosopis glandulosa* | 3.61 | 0.61 | 1.78 | 1.38 | 50.47 | **57.86** |
| *Fraxinus angustifolia* | 5.77 | 0.95 | 3.07 | 2.21 | 60.38 | **72.38** |
| *Phoenix dactylifera* | 2.96 | 0.40 | -0.04 | 0.95 | 4.96 | **9.23** |
| *Parkinsonia x 'Desert Museum'* | 3.67 | 0.82 | 1.88 | 1.31 | 20.87 | **28.55** |
| *Prosopis alba* | 1.22 | 0.28 | 0.31 | 0.73 | 18.84 | **21.37** |
| *Parkinsonia florida* | 3.94 | 0.60 | 1.81 | 1.33 | 35.11 | **42.80** |
| *Pinus halepensis* | 4.65 | 0.92 | 1.81 | 2.86 | 74.88 | **85.12** |
| *Chiltalpa tashkentensis* | 2.95 | 0.65 | 1.43 | 1.05 | 18.95 | **25.02** |
| *Populus fremontii* | 7.16 | 1.40 | 4.75 | 3.35 | 86.36 | **103.03** |
| *Chilopsis linearis* | 2.27 | 0.34 | 0.48 | 0.45 | 15.20 | **18.74** |
| *Chamaerops humilis* | 1.81 | 0.25 | 0.96 | 0.95 | 24.61 | **28.58** |
| *Ebenopsis ebano* | 0.69 | 0.09 | 0.35 | 0.39 | 21.69 | **23.21** |
| *Acacia farnesiana* | 2.51 | 0.55 | 1.26 | 0.89 | 17.48 | **22.69** |
| *Olea europaea 'Swan Hill'* | 0.98 | 0.13 | 0.53 | 0.52 | 22.22 | **24.39** |
| *Eucalyptus microtheca* | 4.57 | 1.42 | 0.09 | 2.36 | 85.28 | **93.72** |
| **OTHER TREES** | **$3.75** | **$0.65** | **$1.64** | **$1.47** | **$34.70** | **$42.22** |

## *Benefit Summary*

Mesquite's trees have substantial environmental and aesthetic benefits. Annual increases in property value, socioeconomic, and other aesthetic values are substantial benefits, account for 80% of the total benefits.

Approximately 20% ($13,926) of the total annual benefits quantified in this study are environmental services (Table 13). Energy savings ($7,429) account for 53% of the annual environmental benefits and 11% of all annual benefits. Air quality benefits ($3,022) account for 22% of annual environmental benefits and 4% of all annual benefits. Stormwater benefits ($2,240) account for 16% of the annual environmental benefits and 3% of all benefits. Carbon reduction benefits, valued at $1,235, account for 9% of environmental benefits and 2% of all benefits.

The estimated sum of benefits provided by Mesquite's public tree resource is $68,581, a value of $38.55 per tree and $4.49 per capita. These benefits are realized on an annual basis. It is important to acknowledge that this is not a full accounting of the benefits provided by this tree resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence. Empirical evidence of these benefits does exist (Wolf, 2007; Kaplan, 1989; Ulrich, 1986), but there is limited knowledge about the physical processes at work and their interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and costs must consider variability among sites (e.g., tree species, growing conditions, maintenance practices) throughout the City, as well as variability in tree growth. In other words, **trees are worth far more than what one can ever quantify!**

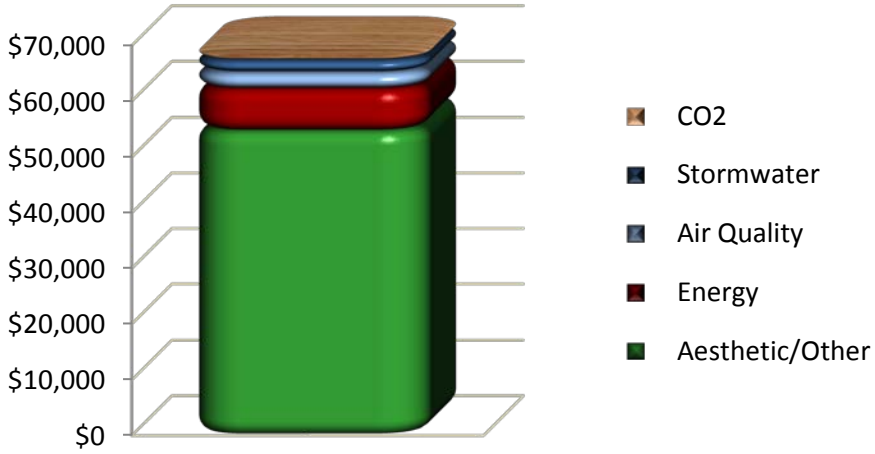


***Figure 12. Benefit Summary for Mesquite's Tree Resource***

**Total Annual Benefits from Mesquite's Tree Resource: $68,581**

**Average Annual per Tree Benefits: $38.55**

**Annual Value of Benefits Per Capita: $4.49**

***Table 13. Benefit Summary for Mesquite's Inventoried Tree Resource***

| Benefits | Total ($) | $/tree | $/capita |
|---|---|---|---|
| Energy | 7,429 | 4.18 | 0.49 |
| CO2 | 1,235 | 0.69 | 0.08 |
| Air Quality | 3,022 | 1.70 | 0.20 |
| Stormwater | 2,240 | 1.26 | 0.15 |
| Aesthetic/Other | 54,655 | 30.72 | 3.58 |
| **Total Benefits** | **$68,581** | **$38.55** | **$4.49** |

# Conclusion

This analysis describes the current structural characteristics of Mesquite's 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.

Mesquite's public trees are providing quantifiable benefits including energy savings, stormwater runoff reduction, reduction in atmospheric $CO_2$, and aesthetic benefits. The City's 1,779 trees are providing $68,581 in gross annual benefits. That is an average of $39 per tree and $4.49 per capita.

The trees inventoried in this project are relatively young and in good condition with more than 46 different species. It is critical to maintain an adequate level of resources to protect and nurture this resource. With adequate maintenance, Mesquite's 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:

- Continue annual tree planting efforts to stock the available planting sites identified by the inventory.
- 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 large-stature trees where conditions are sustainable.
- Maximize the condition of the existing tree resource through comprehensive tree maintenance and a cyclical pruning schedule.
- 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.

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

Mesquite's trees are of vital importance to the environmental, social, and economic well-being of the community. Mesquite 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 forwarding-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, Mesquite's urban forest can be expected to produce an even greater flow of benefits as this resource continues to mature. If Mesquite maintains 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 Mesquite's tree inventory using ArcPad software to assist the inventory arborist in locating the sample plots on the ground and inputting tree attributes (details about each tree's species, size, and condition). The data was formatted for use in i-Tree's public tree population assessment tool, **i-Tree *Streets, a STRATUM Analysis Tool*** (*Streets* v 5.0.1; i-Tree v 5.0.6). i-Tree *Streets* assesses tree population structure and the function of those trees, such as their role in building energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. In order to analyze the economic benefits of Mesquite's 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 (Mesquite 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 $NO_2$, $PM_{10}$, and VOCs reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values.

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

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

***Table 14. Mesquite 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 |
| $PM_{10}$ | $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 | $171,331 | $ | City-data.com |

i-Tree *Streets* default values (Table 13) 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, Natural Gas rates are residential rates from NV Energy. The median home value for Mesquite was estimated to be $171,331 in February 2013, based on the value reported at citydata.com. Using these rates, the magnitude of the benefits provided by the public tree resource was calculated using i-Tree *Streets*. **Program budget values used in benefit versus investment ratio calculations were not supplied by Mesquite.**

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