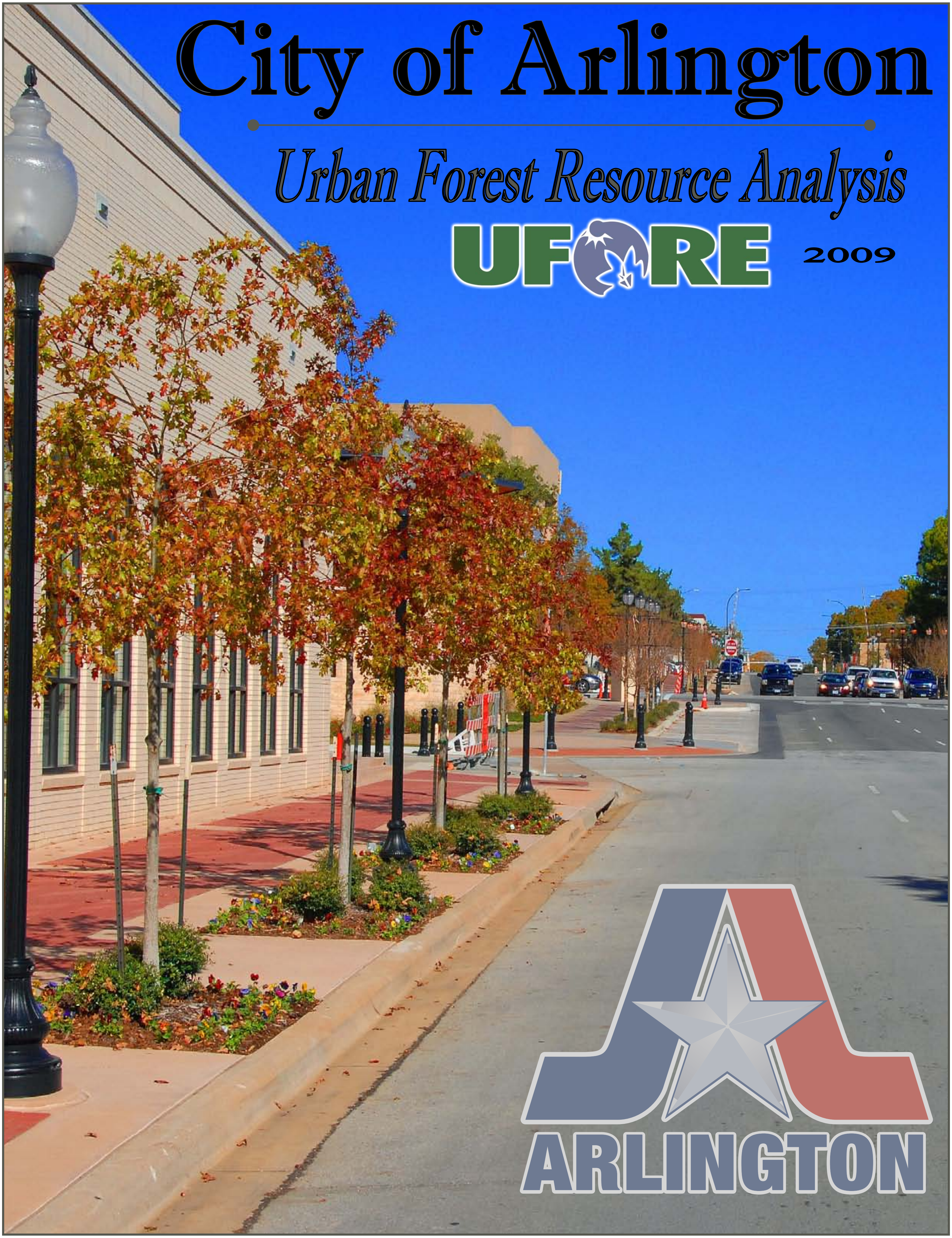
City of Arlington

Urban Forest Resource Analysis

UFORE 2009



ARLINGTON

City of Arlington Forestry and Beautification

1924 W. Randol Mill Rd.
Arlington, TX 76004

(817) 277-0434

www.arlingtontx.gov

For information regarding this project please contact:

Matt Churches
City of Arlington
matt.churches@arlingtontx.gov
(817) 277-0434

Micah Pace, M.S.
Texas Forest Service
mpace@tfs.tamu.edu
(214) 384-8673

Eric A. Kuehler
USDA Forest Service,
Southern Research Station
(706) 559-4268
ekuehler@fs.fed.us

Courtney Blevins, CF, CA
Texas Forest Service
cblevins@tfs.tamu.edu
(817) 926-8203

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Executive Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetative structure, function, and value of the Arlington urban forest was conducted during 2009 based on satellite imagery, field data, and computer modeling using i-Tree Eco, developed by the USDA Forest Service, Northern Research Station. Results from this model are used to advance the understanding of the urban forest resource, improve urban forest policies, planning and management, provide data for potential inclusion of trees within environmental regulations, and determine how trees affect the environmental quality and consequently enhance human health and the quality of life for residents of the City of Arlington.

Forest structure is the measure of tree species composition, density, health, leaf area, biomass, species diversity, and other various physical attributes of the vegetation. Arlington's urban forest is summarized in this report, providing an accurate representation of the forest resources as well as a detailed examination of where trees are located by species. Forest functions, which are determined by forest structure, include a wide range of environmental and ecosystem services such as air pollution removal and carbon storage. This study quantifies air pollution removal, carbon storage, and energy savings. Forest Values are the quantified economic values of the forest functions mentioned above – air pollution removal, carbon storage, energy savings – plus the replacement value of the forest. Other studies have measured values such as health benefits, property value increases, and floodwater retention.

Key Findings:

- Number Of Trees: 2,965,000
- Tree Cover: 22.4%
- Most Common Species: Cedar elm, Sugarberry, Post oak
- Percentage of Trees Less Than 6" diameter: 61.5%
- Pollution Removal: 568 tons/year ($2.94 million/year)
- Carbon Storage: 413,000 tons ($8.54 million)
- Carbon Sequestration: 22,100 tons/year ($457 thousand/year)
- Building Energy Savins: $2.8 million / year
- Avoided Carbon Emissions: $135 thousand / year
- Structural Values: $2.75 billion

Ton: short ton (U.S) (2,000 lbs)
Carbon storage: the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation.
Carbon sequestration: the removal of carbon dioxide from the air by plants through photosynthesis
Structural Value: value based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree)

UFORE Model and Field Measurements

UFORE is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects [1], including:

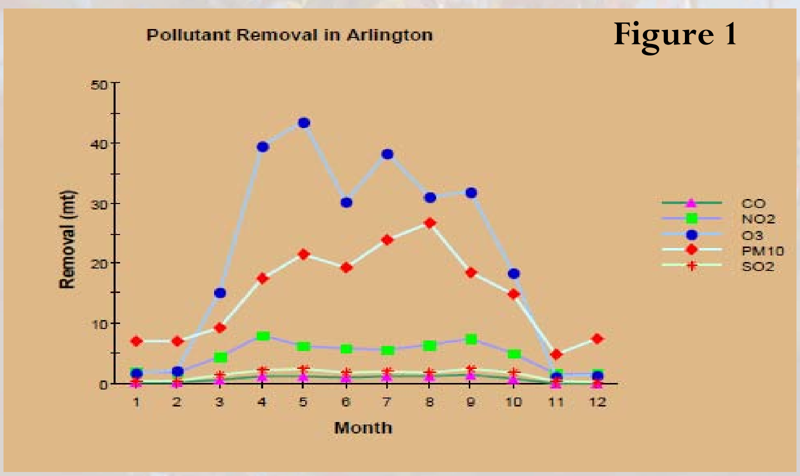
In the field, 1/10 acre plots were randomly distributed. Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Within each plot, typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings[2].

To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations[3]. To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models[4,5]. As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature[6,7] that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere[8]. In Figure 1 we see that while the removal of O3 and SO2 increased incrementally reaching their peaks during the summer months and then declined NO2, PM10,

Figure 1



and CO remained relatively flat over the 12 month cycle. This would indicate that pollution removal for O3 and SO2 is more closely affected by temperature, thus was highest during the fastest growth period for the trees.

Effects of trees on residential building energy use were calculated based on procedures described the literature[9] using distance and direction of trees from residential structures, tree height and tree condition data.

Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers[10], which uses tree species, diameter, condition and location information.

Arlington's Urban Forest Structure

The urban forest of Arlington has an estimated 2,965,000 trees with a tree cover of 22.4 percent. Trees that have diameters less than 6-inches constitute 61.5 percent of the population (Figure 2).

Figure 2. Percent of tree population by diameter class

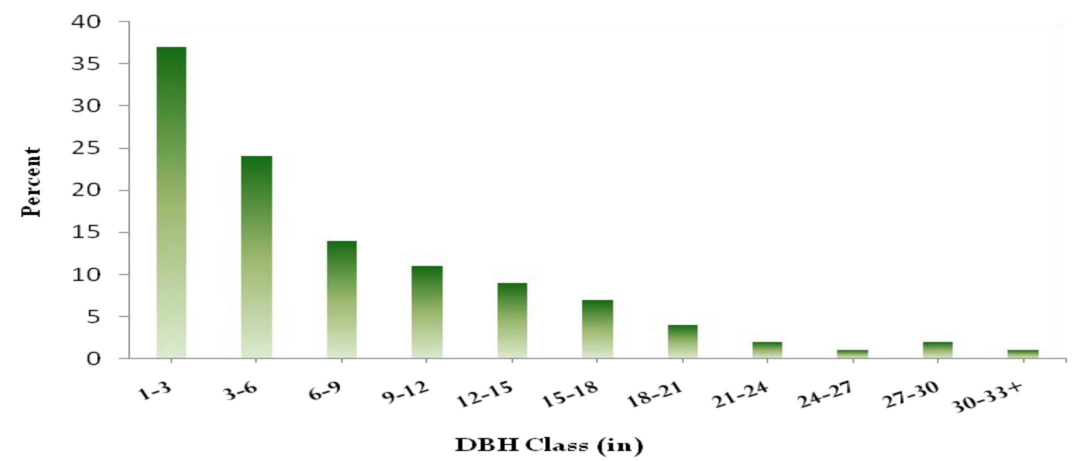


Figure 3 depicts the three most common species are Cedar elm (20.30 percent), Sugarberry (18.60 percent), and Post oak (14.80 percent).

Figure 3. Tree species composition in Arlington

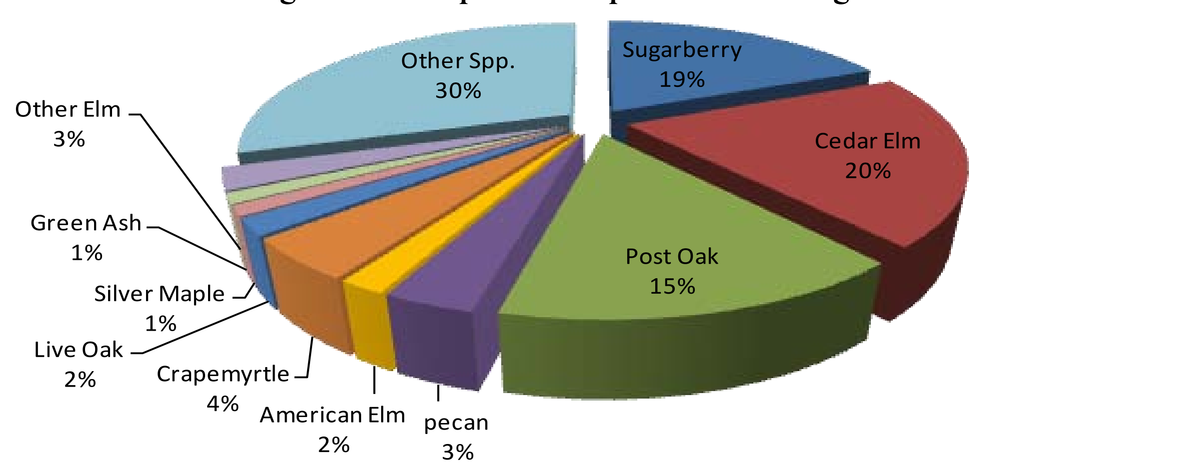
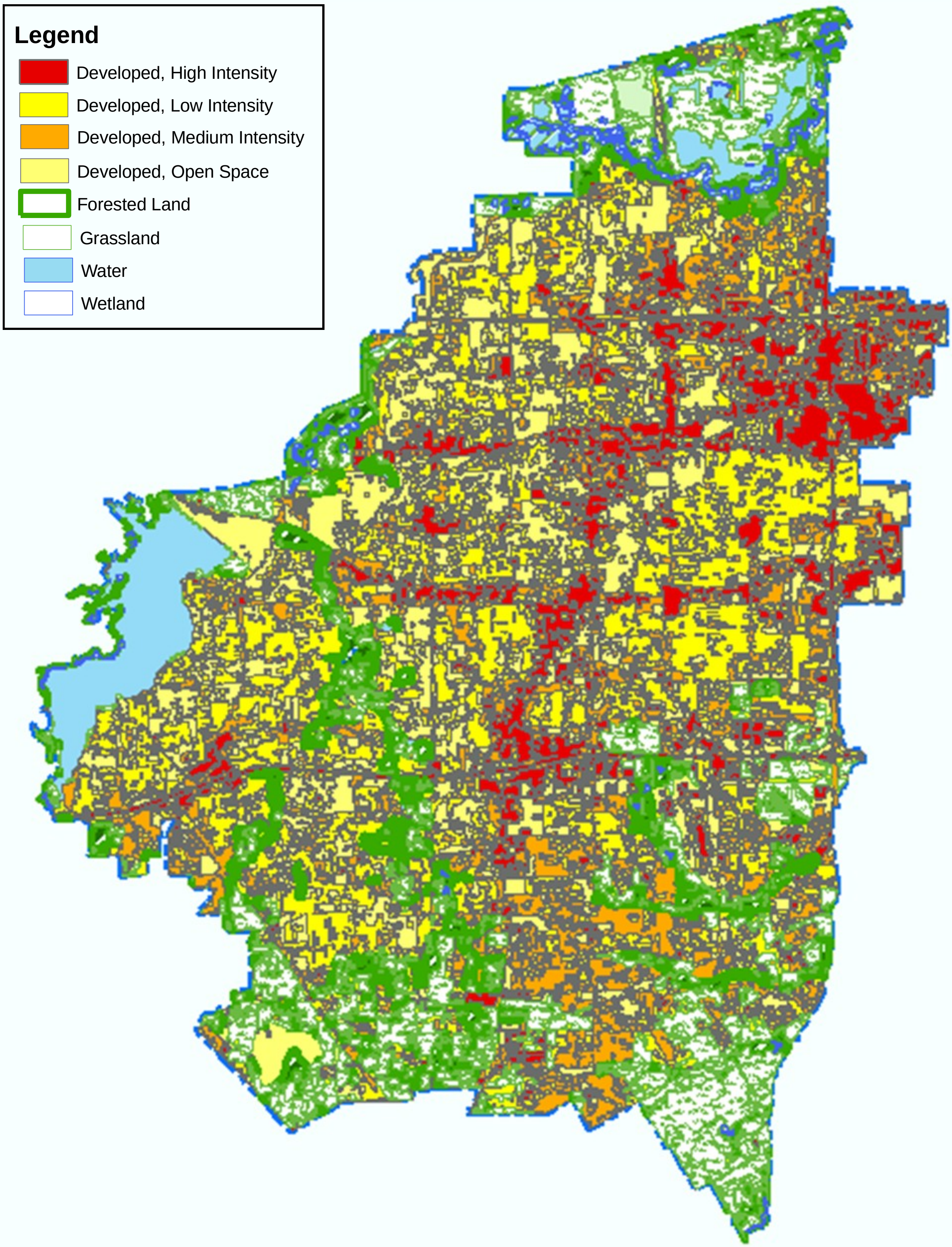


Figure 4 represents the map of the City of Arlington with the 8 defined land use categories and where they exist within the city limits.

Figure 4: Land Use by Category in Arlington



Among the land use categories, the highest tree densities occur in Forest followed by Developed, Open and Grassland/Herbaceous (Figure 3). The overall tree density in Arlington is 45.3 trees / acre (see Appendix II for comparable values from other cities).

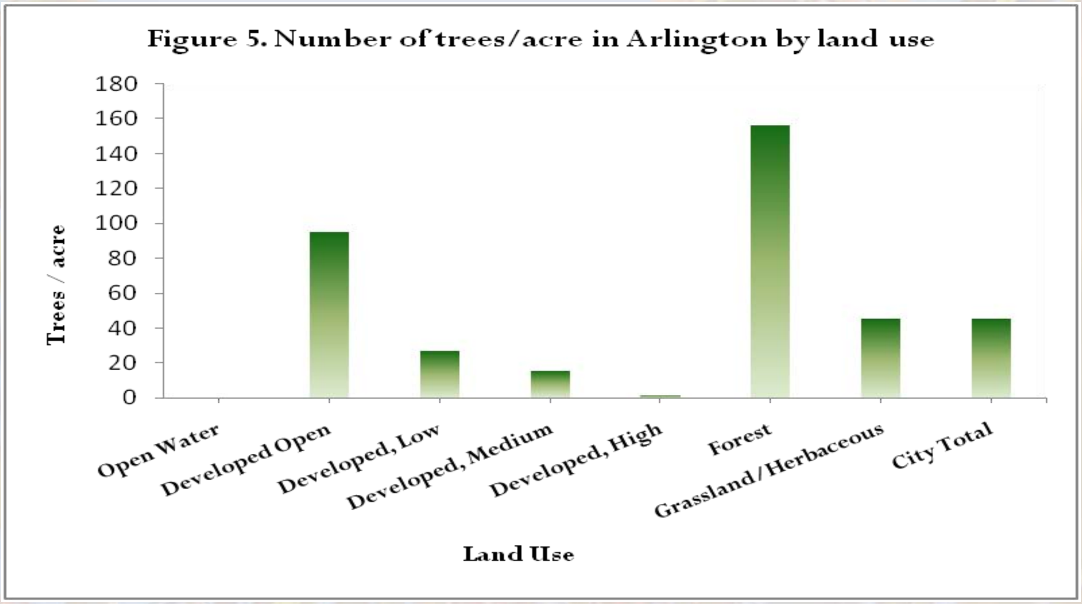


Figure 5. Number of trees/acre in Arlington by land use

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. An increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Arlington,

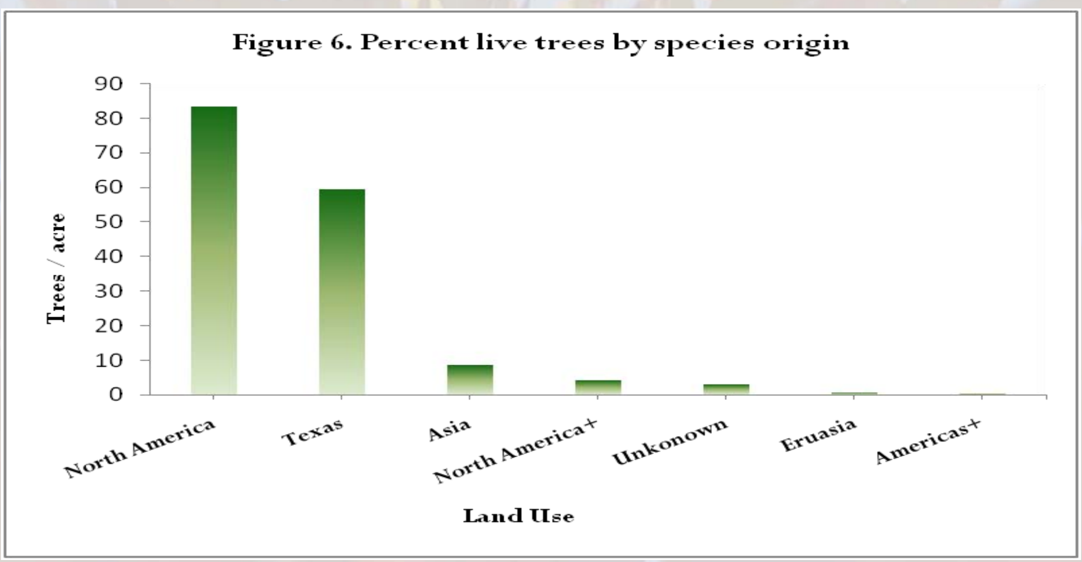


Figure 6. Percent live trees by species origin

about 84 percent of the trees are from species native to North America, while 59 percent are native to the state. Species exotic to Texas make up 17 percent of the population. Most exotic tree species have an origin from Asia (8.6 percent of the species)(Figure 6).

Urban Forest Cover and Leaf Area

Many tree benefits are directly influenced by the amount of healthy leaf surface area of the plant. In Arlington, the three most dominant species in terms of leaf area are Sugarberry, Post oak, and Cedar elm. Trees cover about 22.4 percent of Arlington.

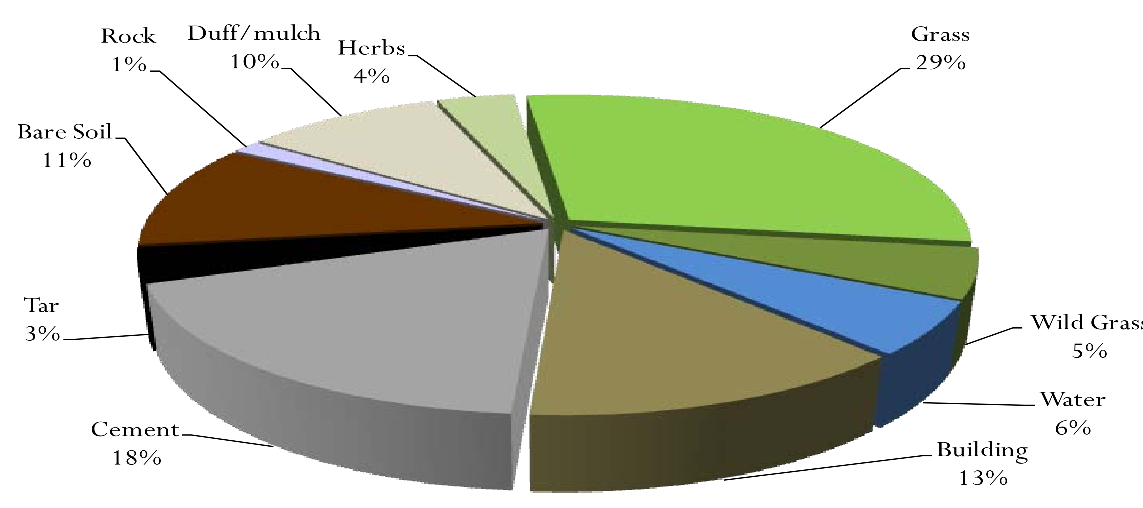
The 10 most important species are listed in table 1 below. Importance values (IV) are calculated as the sum of relative leaf area and relative composition.

Table 1. Most important species in Arlington

Common Name	Percent Population	Percent Leaf Area	IV
Sugarberry	18.6	19.8	38.4
Cedar Elm	20.3	14.0	34.3
Post Oak	14.8	15.8	30.6
Pecan	3.3	7.4	10.7
American Elm	1.7	5.8	7.4
Crapemyrtle	4.6	2.6	7.2
Live Oak	1.9	4.2	6.1
Silver Maple	1.2	3.7	4.8
Green ash	1.2	3.0	4.2
Elm	2.6	1.3	3.9

The two most dominant ground cover types are grass (29.2 percent) and Cement (18.3 percent).

Figure 7: Ground Cover Types in Arlington by percent



Air Pollution Removal by Arlington's Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power plants. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation[11].

Pollution removal by trees in Arlington was estimated using field data and recent pollution and weather data available. Pollution removal was greatest for O3(Figure 8). It is estimated that trees remove 568 tons of air pollution (CO, NO2, O3, PM10, SO2) per year with an associated value of $2.94 million (based on estimated national median externality costs associated with pollutants[12]).

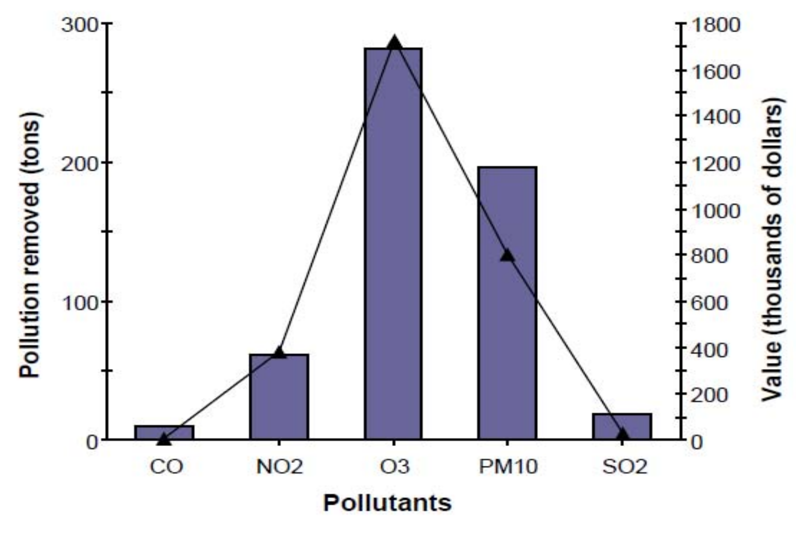
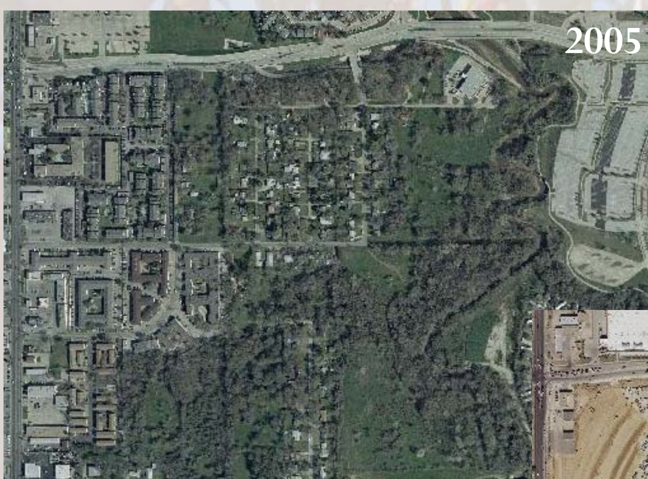


Figure 8. Pollution removal and associated value for trees in Arlington (line graph is value)

In the Dallas-Fort Worth Metroplex, the primary form of air pollution is ground level ozone. In 2006, the American Lung Association (ALA) once again ranked Dallas/Fort Worth as the eighth most ozone-polluted metropolitan area in the country, and Tarrant County as the 11th most ozone-polluted county. It was the sixth consecutive year that the ALA gave the region a grade of "F" for air quality.

In 1998, the U.S. Environmental Protection Agency (EPA) classified the counties of Collin, Dallas, Denton and Tarrant as an area of serious non-attainment under the federal one -hour ozone standard. As part of that designation, pollution levels in the area were not to exceed the federal one-hour ozone standard more than three days during any three-year monitoring period. EPA also required the four-county area to prepare and implement a State Implementation Plan (SIP), which included initiatives to help reduce ozone-forming emissions in the future. In the monitoring period from 1997 to 1999, the region exceeded the federal one-hour standard 26 times, which could have caused the EPA to downgrade the region to severe non-attainment.

However, on April 15, 2004, EPA made its final designation for an eight-hour ozone non-attainment area comprising Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker, and Rockwall counties. The nine-county designation became effective on June 15, 2004. EPA created the eight-hour ozone standard in July 1997, based on information demonstrating that the one-hour standard was inadequate for protecting public health. Ozone can affect human health at lower levels, and over longer exposure times than one hour. The eight-hour standard is much more difficult to attain. Under the one-hour standard, any hourly average of 125 ppb or higher of ozone at any regional air monitor is an exceedance. Under the eight-hour standard, any eight-hour average of 85 ppb or higher of ozone is an exceedance.



These pictures depict an example of the large amount of trees lost due to development in the city of Arlington.

In 2006, the nine-county region exceeded the eight-hour standard 31 times compared to 44 times in 2005. Tarrant County alone exceeded air quality standards 22 times in 2006 compared to 26 times in 2005. In figure 9, Tarrant County is shown in red:

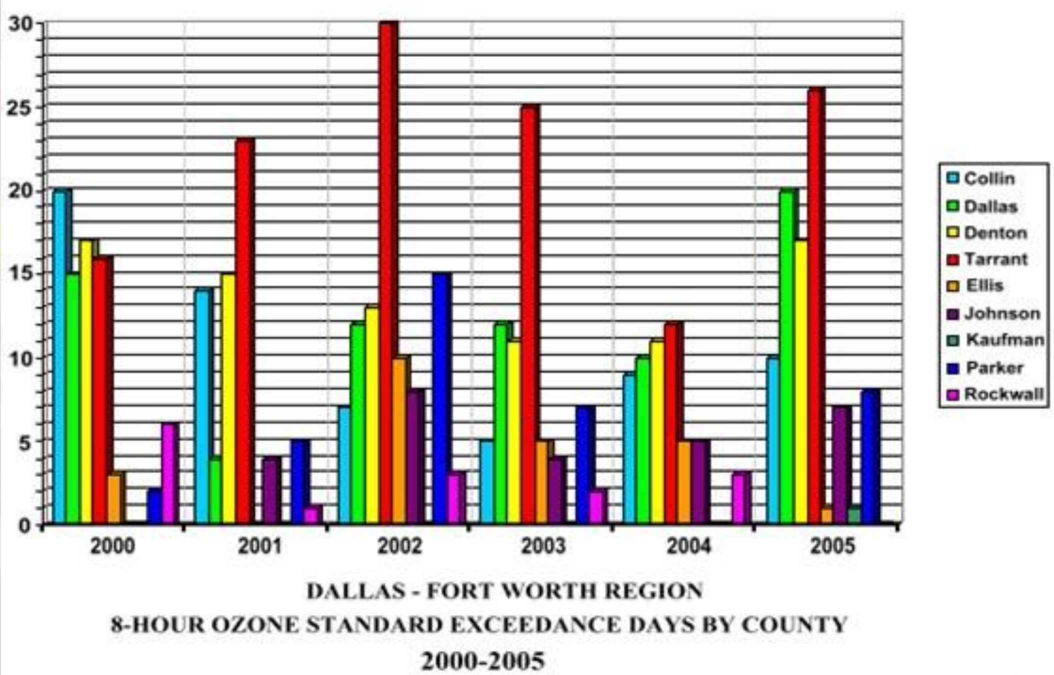


Figure 9.

The level at which unhealthy side effects occur for ozone is 85 parts per billion, however each individual can have their own tolerance level for ozone exposure. Even healthy adults can develop lung damage from elevated ozone concentrations. The respiratory symptoms associated with lower levels of ozone exposure are generally more notable in the elderly, the young, and the immune challenged.

- The estimated health cost of human exposure to outdoor air pollutants is $50 billion a year.
- An estimated 50,000 to 120,000 premature deaths are associated with exposure to air pollutants.
- People with asthma experience more than 100 million days of restrictive activity annually, costing $4 billion a year. Death rates for asthma are up over 40 percent in the past few years.

Carbon Storage and Sequestration

Climate change is an issue of global concern. Trees play an important role with regard to the carbon cycle and associated climate variability. Trees moderate the amount of carbon dioxide in the atmosphere through the process of photosynthesis. Carbon that remains locked up in trees from year to year is referred to as *carbon storage*. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power plants.

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year, they *sequester* additional carbon and add it to the carbon already stored in trunks, branches, and leaves. Unlike deciduous trees, evergreens retain their leaves for more than one season, thus adding to their stored carbon. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Arlington trees is about 22,100 tons of carbon per year with an associated value of $457 thousand. Net carbon sequestration is about 20,300 tons.

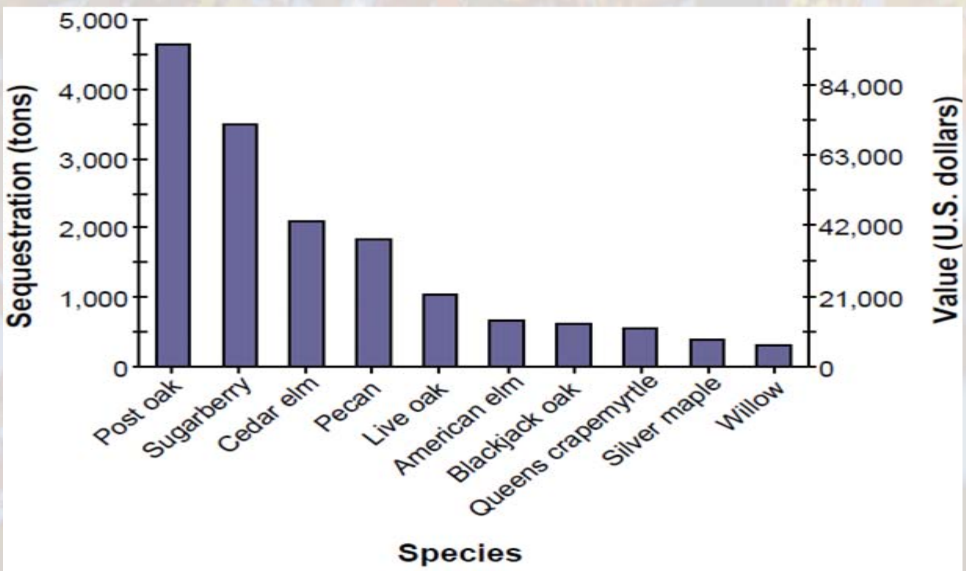


Figure 10. Carbon sequestration and value for species with greatest overall carbon sequestration in Arlington

As trees grow they store more carbon as wood. As trees die and decay, they release much of the stored carbon back to the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be lost if trees are allowed to die and decompose. Trees in Arlington are estimated to store 413,000 tons of carbon ($8.54 million). While Post oak is only the 3rd most populous species in Arlington, it stores and sequesters the most carbon, 24.7% and 22.8%, respectively (Figure 10).

Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings[13].

All energy savings value estimates were based on a 2002 state average energy rate. Table 2 shows the estimated energy savings values based directly from the shading effect of trees within 60 feet of a air conditioned structure of 2 stories or less. Due to winter month heating requirements there was a net negative value for the total MBTU reduced. However, trees in Arlington directly attribute to an annual reduction of 39,118 MWh.

Trees in Arlington are estimated to reduce energy-related costs from residential buildings by $2.80 million annually. Trees also provide an additional $135,108 in value[1] by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of 6,530 tons of carbon emissions) (Table 3.).

Table 2. Annual energy savings due to trees near residential buildings. Note: negative numbers indicate an increased energy use or carbon emission.

[1]One million British Thermal Units
[2]Megawatt-hour

	Heating	*Cooling*	*Total*
MBTU[1]	**-114,061**	**n/a**	**-114,061**
MWH[2]	**-4,643**	**43,761**	**39,118**
Carbon Avoided (t)	**-2,737**	**9,269**	**6,532**

Table 3. Annual savings[1] (US $) in residential energy expenditure during heating and cooling seasons. Note: negative numbers indicate a cost due to increased energy use or carbon emission.

[1]Based on state-wide energy costs for Texas.
[2]One million British Thermal Units
[3]Megawatt-hour

	Heating	*Cooling*	*Total*
MBTU[1]	**-743,475**	**n/a**	**-743,475**
MWH[2]	**-420,010**	**3,958,661**	**3,538,651**
Carbon Avoided (t)	**-56,612**	**191,720**	**135,108**

Structural and Functional Values

Urban forests have a structural value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The structural value of an urban forest tends to increase with a rise in the number and size of healthy trees [13]. Annual functional values also tend to increase with increased number and size of healthy trees, and are usually on the order of several million dollars per year. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Structural values:
- Structural value: $2.75 billion
- Carbon storage: $8.54 million

Annual functional values:
- Carbon sequestration: $457 thousand
- Pollution removal: $2.94 million
- Lower energy costs and carbon emission reductions: $2.93 million (Note: negative value indicates increased energy cost and carbon emission value)

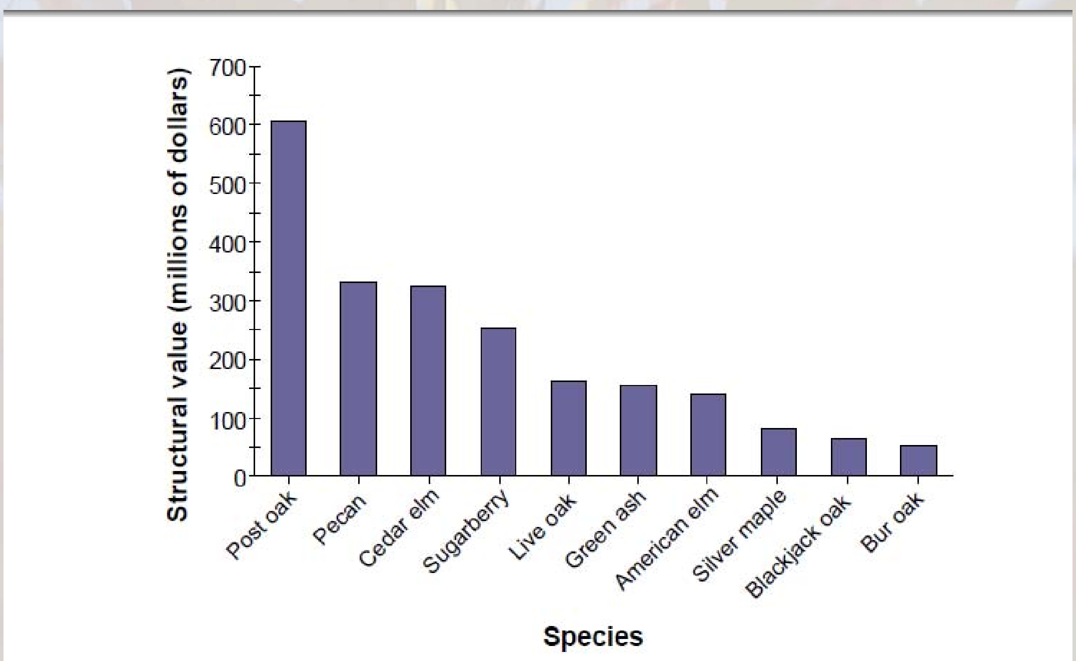


Figure 11. Structural value of the 10 most valuable tree species in Arlington

Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ. Four exotic, and three endemic pests were analyzed for their potential impact: **Oak wilt (OW), mistletoe (MST), Hypoxylon canker (HC), Asian longhorned beetle (ALB), gypsy moth (GM), emerald ash borer (EAB),** and **Dutch elm disease (DED).**

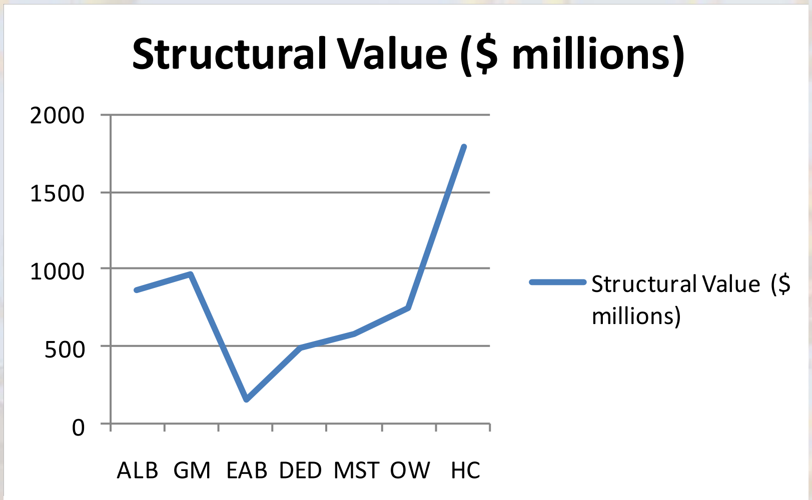


Figure 12. Number of susceptible Arlington trees and structural value by pest (line graph is structural value)

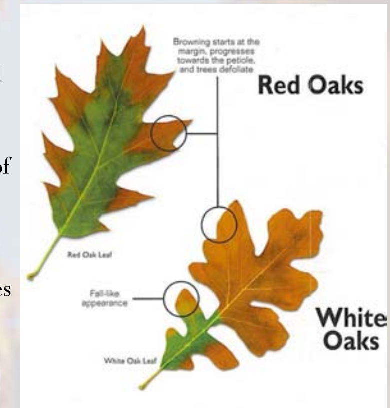
Oak wilt (OW) is the number one tree disease issue in Texas and is killing oak trees in central Texas (including the DFW area) at epidemic proportions. Oak wilt is an infectious disease caused by the fungus *Ceratocystis fagacearum*, which invades and disables the water-conducting system in susceptible trees. This disease causes millions of dollars in damage to landscape trees in the Metroplex from the loss of trees themselves and the subsequent property value loss associated with a less healthy landscape or property.

All oaks (*Quercus* spp.) are susceptible to oak wilt to some degree, but some species are affected more than others. Red oaks, particularly Texas red oak (Q. buckleyi), Shumard oak (Q. shumardii), and blackjack oak (Q. marilandica), are extremely susceptible and may play a unique role in the establishment of new oak wilt infections.

White oaks, including post oak (Q. stellata), bur oak (Q. macrocarpa), Mexican white oak (Q. polymorpha), and Chinquapin oak (Q. muehlenbergii), are more resistant to the fungus and die less often from oak wilt. Post oak is the most resistant species.

Live oaks (Q. virginiana and Q. fusiformis) are intermediate in susceptibility to oak wilt, but are most seriously affected due to their tendency to grow from root sprouts and form vast interconnected root systems that allow movement (or spread) of the fungus between adjacent trees. Oak wilt has the potential to affect 495,155 trees in Arlington with a structural value of $750,000,000. More information about this disease in Texas may be found at http://www.texasoakwilt.org/index.html.

Symptomatic live oak leaves - Veinal Necrosis. Area around leaf vein turns brown rest of leaf is still green, found on the tree or on the ground. This symptom does not always show up.



Mistletoe (MST) is a plant parasite that causes structural damage and stress to a large number of tree species. There is more than one species of mistletoe but locally the one of concern is the species that parasitizes deciduous trees.

Almost all mistletoes are hemi-parasites, bearing evergreen leaves that do some photosynthesis, and using the host mainly for water and mineral nutrients. They also commonly reduce a trees' growth and can kill them with heavy infestations. Of particular concern is the damage caused to a trees structure. Where the haustoria (roots) penetrate the tree they damage the wood and it becomes a weak point where breakage is far more likely to occur. If the visible portion of the mistletoe is removed, new plants often resprout from the haustoria so control is difficult.

Of particular concern in Arlington is the fact that the top two most common trees in the city are species that are highly susceptible to mistletoe infestation (cedar elm and sugarberry – *Ulmus crassifolia* and *Celtis laevigata*). These two species account for 39% of the total tree canopy in Arlington. Mistletoe has the potential to affect 1,153,385 trees in the city with a structural value of $580,000,000.

Hypoxylon canker (HC) is a fungus that causes cankers and death of oak and other hardwood trees. Relatively healthy trees are not invaded by the fungus, but the hypoxylon fungus will readily infect the sapwood of a tree that has been damaged, stressed, or weakened. Natural and man-caused factors that can weaken a tree include defoliation by insects or leaf fungi, saturated soil, fill dirt, soil compaction, excavation in the root zone of the tree, removal of top soil under the tree, disease, herbicide injury, drought, heat, nutrient deficiencies, competition or overcrowding, and other factors. The hypoxylon fungus is considered a weak pathogen in that it is not aggressive enough to invade healthy trees.

An early indication that hypoxylon canker may be invading a tree is a noticeable thinning of the crown. Also, the crown may exhibit branch dieback. As the fungus develops, small sections of bark will slough from the trunk and branches and collect at the base of the tree. Where the bark has sloughed off, tan, olive green, or reddish-brown, powdery spores can be seen.

Probably all oak trees are susceptible to hypoxylon canker. In addition, elm, pecan, hickory, sycamore, maple, and other trees may be infected. As mentioned earlier, when a tree is weakened or stressed, the fungus may then invade the sapwood and become one of several factors that ultimately cause the tree to die.

There is no known control for hypoxylon canker other than maintaining tree vigor. There is usually little that can be done to avoid naturally occurring stress factors, but many man-caused stress factors can be avoided. Damage to tree roots around construction areas commonly predisposes a tree to infection by hypoxylon canker.

Hypoxylon has the potential to affect 1,660,400 trees in Arlington with a structural value of $1,787,500,000. For more information go to http://texasforestservice.tamu.edu/main/popup.aspx?id=1262

Stages of Hypoxylon infection

The **Asian longhorned beetle (ALB)** [7] is an insect that bores into and kills a wide range of hardwood species. The ALB is considered an invasive species in North America, where it is a serious threat to many species of deciduous hardwood trees. During the larval stage, the ALB bores deep into a tree's heartwood, where it feeds on the tree's nutrients. The tunneling damages and eventually kills the tree. Tree species considered ALB host species include all species of maple (Norway, sugar, silver, and red maple) as well as Horse chestnut, Poplar, Willow, Birch, London plane, Mountain ash, Mimosa (silk tree), Elm and Hackberry. ALB poses a threat to 36.2 percent of the Arlington urban forest, which represents a loss of $864 million in damage to the structure. To date there have been no known reports of this pest in North Central Texas.

The gypsy moth (GM)[14] is a defoliator that feeds on many species causing widespread defoliation and tree death if outbreak conditions last several years. This pest threatens 22.3 percent of the population, which represents a loss of $969 million in structural value. Texas specific information - No gypsy moth (*Lymantria dispar*) infestations are known to exist in Texas. The US Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) in cooperation with the Texas Department of Agriculture (TDA) deploys traps in Texas each year and a few male moths are usually caught. Male moths that are trapped in Texas are brought here from infested areas by persons who unknowingly transport pupae or egg masses on their vehicles, camping gear, or other items. There are two strains of the GM – Asian and European and there is one major difference between the two. Female moths of the European GM are incapable of flight whereas Asian GM females are strong fliers and are attracted to lights at night. Males of both strains of GM can fly. In 2008 Asian GM was intercepted twice by APHIS at the ports of Houston and Brownsville. Intensive trapping in these two areas by APHIS in 2009 did not collect any GM adults. In addition, APHIS reports no interceptions of GM were made at any Texas ports in 2009. TDA placed 4,234 traps in 45 Texas counties in 2009. In Johnson County (south of Fort Worth) two European GMs were collected in the same trap; all other traps were negative (Joe Pase, entomologist, Texas Forest Service).

Emerald ash borer (EAB) in North America is an invasive species, highly destructive to ash trees in its introduced range. The damage of this insect rivals that of Chestnut blight and Dutch Elm Disease. To put its damage in perspective the number of chestnuts killed by the Chestnut Blight was around 3.5 billion chestnut trees while there are 3.5 billion ash trees in Ohio alone.

Dutch Elm Disease killed only a mere 200 million elm trees while EAB threatens 7.5 billion ash trees in the United States. EAB has the potential to affect 1.6 percent of the population ($157 million in structural damage). As of early 2010 this pest has not been reported in the North Texas area.

American elm, one of the most important street trees in the twentieth century, has been devastated by the **Dutch elm disease (DED)[**14]. Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Arlington could possibly lose 24 percent of its trees to this pest ($496 million in structural value). While at present time this disease is not a major issue in Arlington, isolated cases of DED have been reported in the communities of Flower Mound and Southlake as recent as 2009. This pest could potentially affect some 700,000 trees in Arlington.

Branch death, or flagging, at multiple locations in the crown of a diseased elm.

Appendix 1: Relative Tree Effects

The urban forest in Arlington provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions[15], average passenger automobile emissions[16], and average household emissions[17].

Carbon storage is equivalent to:
- Amount of carbon emitted in Arlington in 68 days
- Annual carbon (C) emissions from 248,000 automobiles
- Annual C emissions from 124,000 single-family houses

Carbon monoxide removal is equivalent to:
- Annual carbon monoxide emissions from 39 automobiles
- Annual carbon monoxide emissions from 160 single-family houses

Nitrogen dioxide removal is equivalent to:
- Annual nitrogen dioxide emissions from 3,910 automobiles
- Annual nitrogen dioxide emissions from 2,600 single-family houses

Sulfur dioxide removal is equivalent to:
- Annual sulfur dioxide emissions from 27,600 automobiles
- Annual sulfur dioxide emissions from 463 single-family houses

Particulate matter less than 10 micron (PM10) removal is equivalent to:
- Annual PM10 emissions from 521,000 automobiles
- Annual PM10 emissions from 50,300 single-family houses

Annual carbon sequestration is equivalent to:
- Amount of carbon emitted in Arlington in 3.6 days
- Annual C emissions from 13,300 automobiles
- Annual C emissions from 6,700 single-family houses

Note: estimates above are partially based on the user-supplied information on human population total for study area.

Appendix 2: Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the UFORE model.

City totals for trees

City	%Tree Cover	Number of Trees	Carbon Storage (tons)	Carbon Sequestration (tons/yr)	Pollution Removal (tons/yr)	Pollution Value ($US)
Calgary, Canada	7.2	11,889,000	445,000	21,422	326	1,611,000
Atlanta, GA	36.8	9,415,000	1,345,000	46,433	1,662	2,534,000
Toronto, Canada	20.5	7,542,000	992,000	40,345	1,212	6,105,000
New York, NY	21.0	5,212,000	1,351,000	42,283	1,677	8,071,000
Arlington, TX	22.4	2,965,000	413,000	22,100	568	2,940,000
Baltimore, MD	21.0	2,627,000	596,000	16,127	430	2,129,000
Philadelphia, PA	15.7	2,113,000	530,000	16,115	576	2,826,000
Washington, DC	28.6	1,928,000	523,000	16,148	418	1,956,000
Boston MA	22.3	1,183,000	319,000	10,509	284	1,426,000
Woodbridge, NJ	29.5	986,000	160,000	5561	210	1,037,000
Minneapolis, MN	26.5	979,000	250,000	8,895	305	1,527,000
Syracuse, NY	23.1	876,000	173,000	5,425	109	268,000
Morgantown, WV	35.9	661,000	94,000	2,940	66	311,000
Moorestown, NJ	28.0	583,000	117,000	3,758	118	576,000
Jersey City, NJ	11.5	136,000	21,000	890	41	196,000
Freehold, NJ	34.4	48,000	20,000	545	21	133,000

Per acre values of tree effects

City	No. of Trees	Carbon Storage (tons)	Carbon Sequestration (lbs/yr)	Pollution Removal (lbs/yr)	Pollution Value ($US)
Calgary, Canada	66.7	2.5	0.120	3.6	9.0
Atlanta, GA	111.6	15.9	0.550	39.4	30.0
Toronto, Canada	48.3	6.4	0.258	15.6	39.1
New York, NY	26.4	6.8	0.214	17.0	40.9
Arlington, TX	45.28	6.5	0.340	17.9	46.4
Baltimore, MD	50.8	11.5	0.312	16.6	41.2
Philadelphia, PA	25.0	6.3	0.190	13.6	33.5
Washington, DC	49.0	13.3	0.410	21.2	49.7
Boston MA	33.5	9.0	0.297	16.0	40.4
Woodbridge, NJ	66.5	10.8	0.375	28.4	70.0
Minneapolis, MN	26.2	6.7	0.238	16.4	40.9
Syracuse, NY	54.5	10.8	0.338	13.6	16.7
Morgantown, WV	119.7	17.0	0.532	23.8	56.3
Moorestown, NJ	62.0	12.5	0.400	25.2	61.3
Jersey City, NJ	14.3	2.2	0.094	8.6	20.7
Freehold, NJ	38.5	16.0	0.437	33.6	106.6

Appendix 3:
Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are[18]:

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities[19]. Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include[20]:

Strategy	**Result**
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

Bronze Leaf Award:

Cross Timbers Urban Forestry Council is comprised of members from various backgrounds. All are drawn to the organization because of a love of our local native trees and the role they play in our urban environment. Members seek to educate the public on the value of the unique Cross Timbers ecosystem. CTUFC has many programs in place to help promote urban forestry. The organization is dynamic and creative and is continually developing new programs for the public.

Each year at the North Central Texas Urban Forestry Workshop, Cross Timbers Urban Forestry Council awards the Bronze Leaf to those who have made outstanding contributions to Urban Forestry. Nominations can be made for any person, group, organization, by explaining the contribution to urban/community forestry in the Cross Timbers region.

On February 19, 2010, at the *16th annual North Central Texas Urban Forestry Conference,* the City of Arlington Forestry and Beautification was awarded the Bronze Leaf Award for Outstanding Municipal Project of the Year for 2009. The award was in recognition of the Urban Forest Effects Model (UFORE) that was completed.

Bronze Leaf Award

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