# STATE OF THE GRAND PRAIRIE URBAN FOREST

FINAL REPORT

DECEMBER 2025

# ACKNOWLEDGEMENTS

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## EXECUTIVE SUMMARY

The City of Grand Prairie recently funded a Parks, Arts, and Recreation Master Plan that will serve as a roadmap to guide short- and long-term priorities for the parks, arts, and recreation system in Grand Prairie over the next ten years. The Parks, Arts, and Recreation Master Plan intends to assess current and future system needs, gain broad community feedback through a variety of engagement strategies, determine a community vision for parks, arts, recreation, and open space, as well as develop a prioritized implementation plan to guide future investments. A component of the Parks, Arts, and Recreation Master Plan is this State of the Grand Prairie Urban Forest study. As a city within the greater DFW area that has maintained the Tree City USA designation for 41 years, this two-part study intends to provide data-backed recommendations which will assist the City in formalizing urban forestry municipal strategies and objectives, while also building upon their existing urban forestry program. Understanding an urban forest's structure, function, and value can promote municipal management decisions that will improve human health and environmental quality.

This assessment of the vegetative structure, function and value of the City of Grand Prairie urban forest was conducted in 2025 and consisted of two different methods to create a snapshot of the current state of the Grand Prairie urban forest. The first method included a canopy assessment utilizing GIS-based deep learning imagery technology to quantify the area of the urban canopy which could then be related spatially to different geographic boundaries including city limits, individual parcels, land use, census tracts, ZIP codes and city council districts. The second method entailed a plot-based assessment which involved the analysis of ground tree data from across the city utilizing the i-Tree Eco model, a state-of-the-art, peer-reviewed software suite from the USDA Forest Service. This model is common in the industry and allows a means to capture details about the canopy, including species composition and distribution. The model also provides quantified economic values of several different forest functions. Key findings from these two methods are summarized as follows.

i-Tree Eco Analysis

- Estimated number of trees: 3,281,000
- i-Tree estimated tree cover: 22.6% (Entire study area; 2025)
- Most common species of trees: Sugarberry, Cedar elm, American elm
- Percentage of trees less than 6" (15.2 cm) diameter: 63.9%
- Pollution Removal: 308.4 tons/year ($1.46 million/year)
- Carbon Storage: 494.6 thousand tons ($214 million)
- Carbon Sequestration: 21.88 thousand tons ($9.47 million/year)
- Oxygen Production: 46.14 thousand tons/year
- Avoided Runoff: 100.6 million gallon/year ($899 thousand/year)
- Building energy savings: $2,240,000/year
- Carbon Avoided: 3.306 thousand tons/year ($1,430,000/year)
- Replacement values: $2.2 billion

UTC Geospatial Analysis

- 2010 UTC Coverage: 15641.3 acres (24.7%)
- 2022 UTC Coverage: 15969.03 (25.2%)

The following six recommendations will help protect and promote the Grand Prairie urban forest:

1. *Refine municipal urban forest management strategies and objectives.*
2. *Improve and modify existing tree protection regulations.*
3. *Develop and maintain Integrated Pest Management program.*
4. *Enhance urban forest health by organizational or community involvement.*
5. *Conduct urban forest monitoring and follow-up studies.*
6. *Protect and maintain riparian forest buffers.*

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# 1.0 Introduction

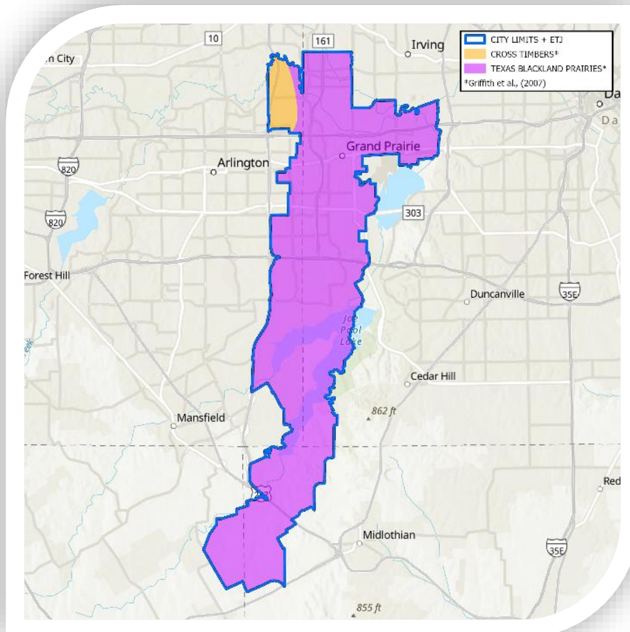
## *1.1 Definition and Characteristics of an Urban Forest*

Urban lands can be defined as all land located within either urbanized areas or urban clusters. An “urban forest” is defined as all trees within urban lands. Urban forests have defining characteristics which distinguish them from other forest types. These characteristics include close proximity to large or dense human populations, patchwork forest structures, multiple public and private ownership types, and sustainment-minded management focusing on tree health and ecosystem services (Mason & Robertson, 2016). These forests are unique in both structure and function, normally having higher species diversity than surrounding native forests with diverse tree configurations ranging from individual trees in residential yards to large patches of intact native forest in parks or other greenspaces. If managed properly, urban forests can reduce the environmental impacts of urban development by moderating climate, reducing building energy-use and atmospheric carbon dioxide (CO2), improving air quality, lowering rainfall runoff and flooding, and reducing noise levels (Dwyer & Nowak, 2007). The current state of an urban forest is primarily influenced by two major factors: the natural components of forests that existed prior to urbanization and the anthropogenic elements in the landscapes in which they occur (Mason & Robertson, 2016). Summarily, as major city in the highly urbanized Dallas-Fort Worth area (DFW), all lands within the Grand Prairie city limits and extraterritorial jurisdiction (ETJ) should be considered urban lands and all trees within the city limits and ETJ should be considered part of an “urban forest”.

## *1.2 Ecological History of Lands within the City of Grand Prairie*

The City of Grand Prairie, Texas is within the Texas Blackland Prairies and Cross Timbers ecoregions as defined by Griffith et al. (2007). Much of the city exists within the Texas Blackland Prairies; however, vegetation assemblages characteristic of the Cross Timbers can be found throughout the city (most notably in the far northwestern extents of the city limits). The presence of the West Fork Trinity River (West Fork) and its tributaries (i.e., Mountain Creek, Bear Creek, Walnut Creek, etc.) within the Grand Prairie city limits have had a significant influence on local plant communities as well as the cultural and economic maturation of the City of Grand Prairie.

Pre-settlement conditions of the Texas Blackland Prairie are best described as vast expanses of tall grass prairie which historically was maintained by fire. The frequency and intensity of prairie fires maintained tall grass-dominated vegetation communities due to the suppression of woody plant growth, even along streambanks, as dry conditions allowed these locations to burn during dry years. In summary, trees were relatively rare in the pre-settlement Blackland Prairie, save for along watercourses and scattered stands at locations with favorable soil conditions (Diggs et al., 1999).




Within the area that would become the City of Grand Prairie, the existing native tallgrass prairies were originally used by early settlers as grazing areas for cattle and horses. In the late 1800s, new technologies such as improved plows led to the large-scale conversion of rangelands into farmlands due to the rich soil conditions found in the region. While this event led to significant cultural and economic growth, this major land use change was estimated to have brought about the near-complete destruction of the native prairie vegetation communities.

While prairie was still predominant at the time of settlement, wooded areas were present in bottomlands and in ravines along larger riverine waterbodies and streams, as well as in scattered mottes where soils or topographic conditions allowed (Diggs et al., 1999). Components of these scattered Blackland Prairie forests consisted of species including (but not limited to) cedar elm (*Ulmus crassifolia*), sugar hackberry (*Celtis laevigata*), pecan (*Carya illinoinensis*), Texas ash (*Fraxinus albicans*), Texas redbud (*Cercis canadensis*), eastern red cedar (*Juniperus virginiana*), Ashe juniper (*Juniperus ashei*), deciduous holly (*Ilex decidua*), honey mesquite (*Prosopis glandulosa*), honey locust (*Gleditsia triacanthos*), and Osage orange (*Maclura pomifera*) (Diggs et al., 1999).

The East and West Cross Timbers with their woody overstory consisting of primarily post oak (*Quercus stellata*) and blackjack oak *(Quercus marilandica*) and sandier, slightly acidic soils provided stark contrast to open prairies overlaid on calcareous black clays. However, the historic context was likely variable, including both continuous canopies with dense underbrush as well as open savannah, where individual or clusters of trees consisted of grassland understories of little bluestem (*Schizachyrium scoparia*) and other lesser dominants (Diggs et al., 1999).

## *1.3 History of the City of Grand Prairie*

Before the arrival of settlers from the northeast, the lands of which modern day Grand Prairie stands were home to Native Americans whom resided in the area due to factors such as a mild climate, good soil, and frequent rains. Buffalo were found throughout the area and evidence of their previous presence can still be found in the City of Grand Prairie today in the form of wallows now contained within a protected preserve at the southwest corner of Freetown and Corn Valley Roads.

The first settlers to arrive in the area that would become the City of Grand Prairie were incentivized by a series of Republic of Texas land grants offered by investors in 1841 referred to as “Peters Colony”. This small group of settlers, including David Jordan, established early infrastructure such as a stagecoach stop, merchandise store, and the first school in the area. Jordan settled near the present-day MacArthur Boulevard and Northeast 31st Street, just south of the Trinity River. In 1859, another group of settlers (brothers Marion and James Loyd) from Dallas came to the area in search of cattle and horse grazing lands, eventually settling on Walnut Creek (now Joe Poole Lake) and establishing another school. Alexander MacRae Dechman was residing in Birdville (modern day Haltom City) when he purchased 239.5 acres in what is now downtown Grand Prairie. Dechman filed title with the county on January 2nd, 1863, which would ultimately become Grand Prairie.

Dechman granted right-of-way through the property to the railroad; however, the depression in 1873 stalled railroad construction. Despite the railroad construction stall, more settlers moved to Dechman in subsequent years, resulting in a post office being opened in the area in 1874. Dechman filed a town plat in 1876 which gave every other lot to the Texas and Pacific Railroad in exchange for operation of a depot there. Railroad tracks were finally constructed through Dechman to Fort Worth, and service began on July 19th, 1876. The railroad eventually renamed Dechman to "Grand Prairie" due to its location on the eastern edge of the expansive prairie that extend into west Texas.

Between 1900 and 1920, a trolley service between Dallas and Fort Worth began and the Grand Prairie Independent School District was founded. The increased growth of Grand Prairie caused early residents to experience several significant problems including fire hazards from homes being built too close together and a need for a public water system. These problems and needs pushed residents to pursue the community being incorporated as a city. After a failed vote for incorporation in 1908, the community became the town of Grand Prairie in 1909. Following incorporation as a town, Grand Prairie acquired its first ordinances and grew to include establishments such as a cotton gin, grocery stores, blacksmiths, a barbershop, drugstore, millinery shop, hotel, lumberyard, hardware store, carriage maker, and food stands. Grand Prairie established its first fire department in 1917 and installed its first water system in 1918. Just west of Grand Prairie, Dalworth Park was emerging as town with water, gas, sidewalks, telephones, and granitoide streets. Dalworth Park existed as a separate city until its incorporation into Grand Prairie in 1942.

Between 1920 and 1940, Grand Prairie put into service technological innovations and improvements such as an automobile fire engine, 16,000 feet of paved concrete along Main and Center streets, and mercury vapor lights on ornamental poles along Main Street (one of two cities in the United States with that type of lighting at that time). The Curtiss-Wright Flying Service opened near Dalworth in 1929, marking the start of Grand Prairie's extensive history of aviation. In 1930, the construction of Mountain Creek Lake began and work was completed in 1938.

Between 1940 and 1960, Grand Prairie experienced unforeseen population growth from around 1,600 in 1940 to 30,400 in 1960. With the start of World War II, the War Department allowed the Navy use of Hensley Field (now the Naval Reserve Aviation Base) and North American Aviation (an aircraft production company) opened next to the airfield. The North American Aviation facility brought in hundreds of workers resulting in the construction of many new homes. In the 1940s, Grand Prairie annexed Dalworth Park and constructed improvements to its wastewater and water systems, as well as paving streets. Grand Prairie opened its first fire station at 321 W. Main Street, where it still operates in the present day. The Great Southwest Corporation began building the Great Southwest Industrial Park, a large 5,000 acre industrial park, in the mid-1950s. Around this time, Grand Prairie's incorporated area was approximately 13 square miles; however, due to state legislature impositions that limited annexations, the City Council rapidly annexed land increasing Grand Prairie's limits to 57 square miles.

From 1960 to 1980, Grand Prairie further experienced large increases in population growth. In 1962, Grand Prairie issued nearly $12 million in building permits marking the City's greatest single year record in construction growth. By 1970, Grand Prairie's population increased past 50,000, matching the size of its next door neighbor Arlington, Texas.

Between 1980 and 2010, Grand Prairie underwent significant economic growth. 23 companies opened in Grand Prairie in 1997, including several big-name stores. The United States Army Corps of Engineers (USACE) completed Joe Pool Lake in 1987. During this time, Grand Prairie also experienced municipal growth including the opening of a recreation center, senior center, additional fire station, library, theatres, golf course, and the creation of a parks system that would go on to earn "best in the nation" title in 2008 by the National Recreation and Parks Association. Municipal growth was fueled by citizen involvement, as many improvements were funded by way of voter-approved taxes. Lone Star Park, a class one horse racetrack which to this day still draws large crowds to Grand Prairie, was also financed by way of voter-approved taxes in 1992. In the early 2000s, Grand Prairie acquired lake parks around Joe Pool Lake and many new parks were opened utilizing the voter-approved sales tax. During this time, many large retail establishments also made their way into the city. By 2007, Lone Star Park was paid off 18 years early and voters again approved the sales tax to fund a new public safety headquarters, active adult center, and minor league baseball stadium.

Between 2010 and the present day, the City of Grand Prairie has continued to serve its citizens by enacting and maintaining programs aimed at improving both public health and the environment. One such initiative was the pursuit and funding of a

Parks, Arts, and Recreation Master Plan that will serve as a roadmap to guide short- and long-term priorities for the parks, arts, and recreation system in Grand Prairie over the next ten years. The Parks, Arts, and Recreation Master Plan intends to assess current and future system needs, gain broad community feedback through a variety of engagement strategies, determine a community vision for parks, arts, recreation, and open space, as well as develop a prioritized implementation plan to guide future investments. A component of the Parks, Arts, and Recreation Master Plan is this State of the Grand Prairie Urban Forest study. This two-part study intends to provide data-backed recommendations which will assist the City of Grand Prairie (a 25-year recipient of the Tree City USA designation) in improving urban forestry municipal strategies and objectives that will ultimately improve human health and environmental quality, while also building upon their existing urban forestry program.

# 2.0 Methodology

## *2.1 Study Area Limits*

The study area for this two-part urban forest assessment (plot-based i-Tree Eco assessment (Eco) and urban tree canopy (UTC) geospatial analysis) includes the city limits of Grand Prairie, Texas, located at 32°44'44.2"N 97°00'24.9"W (32.74562, -97.00691; WGS84). The study area also includes the ETJ, the portions of Joe Pool Lake within the Grand Prairie city limits, and the entirety of parcels which partially lie within the Grand Prairie city limits. Overall, the study area has an area of approximately 99 $mi^2$ (or 63,452 acres). The UTC Analysis consisted of the creation and analysis of a land cover dataset (including urban tree canopy) utilizing the latest geographic information systems (GIS)-based deep learning technology. The i-Tree Eco assessment consisted of a pre-stratified, plot-based assessment which involved the analysis of true to ground tree data from across the city utilizing a state-of-the-art, peer-reviewed software suite from the USDA Forest Service.).

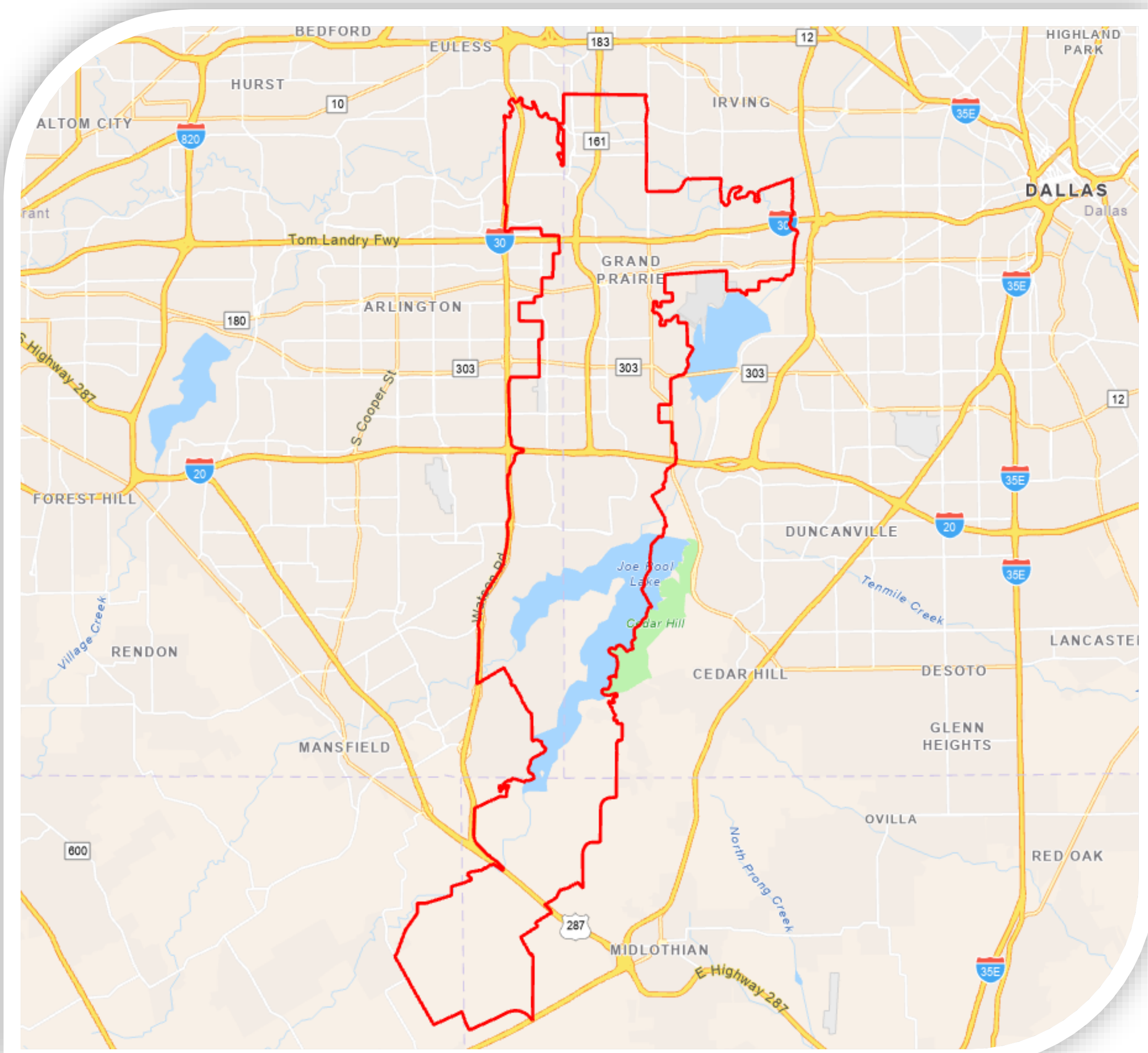
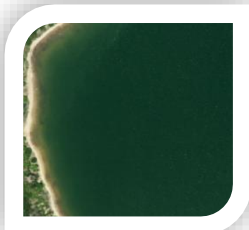



*Figure 1. Study Area utilized for the State of the Grand Prairie Urban Forest study.*

## 2.2 Land Cover Mapping

The initial step in determining the present-day coverage of urban tree canopy within the study area was creating a high-quality initial land cover dataset. Using high resolution aerial imagery from the United States Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) flown in 2022 when trees were fully-leafed, a raster imagery classification-based deep learning model for ArcGIS Pro was developed for the UTC analysis. The deep learning model was trained by machine learning scientists to output a land cover spatial dataset which consisted of five classes. This process was repeated utilizing aerial imagery from 2010 to produce a second land cover dataset for comparison with the 2022 land cover dataset. Output land cover classes consisted of waterbodies, urban tree canopy, low vegetation, bare soil, and impervious surfaces as described below.



*Waterbodies* – Representative of ponds, lakes, and streams within the study area. This land cover class also includes parts of the Elm Fork which was not covered by tree canopy.

*Urban Tree Canopy* – Representative of all areas of urban tree canopy within the study area. This class also includes individual or small clusters of trees that have attained a size to produce a discernible tree canopy on aerial imagery. This class does not include smaller trees with insufficient leaf mass to be detected in the model.

*Low Vegetation* – Representative of non-canopy yet still vegetated with grasses and forbs, and/or small shrubs. This class includes smaller trees with insufficient leaf mass to be detected in the model.

*Barren/Bare Soil* – Representative of non-canopy areas where herbaceous vegetation is either absent or sparse. This classification includes areas such as landfills, areas of lake shoreline, earthen or gravel parking lots/storage yards, or active construction sites that were present at the time of the sampled aerial imagery.

*Impervious Surface* – Representative of areas without vegetation that are paved or otherwise impermeable to precipitation. This classification also includes manmade features such as buildings, roadways, sidewalks, and parking lots.

Following the generation of a preliminary five-class land cover dataset, the initial output was manually checked for accuracy utilizing a series of 250 randomly generated, 2000-foot diameter plots. Following the plot-based check of the preliminary land cover dataset, the deep learning model was finely tuned resulting in the generation of the final land cover dataset to be used in the UTC analysis. A city-wide and sample representation of the generated five class land cover dataset is provided below.

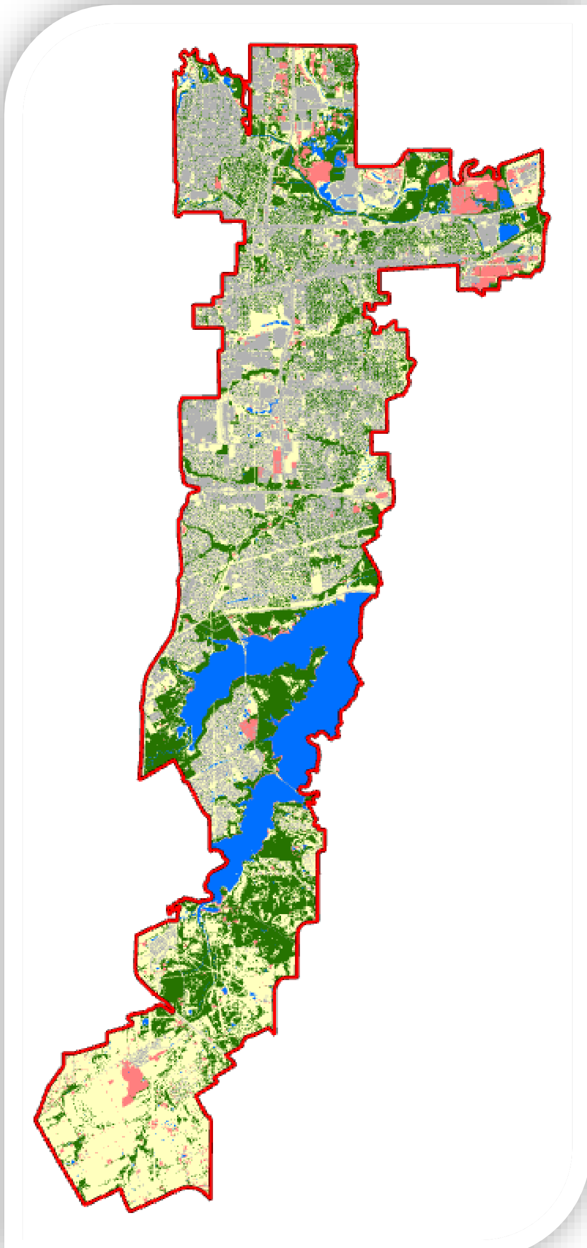


*Figure 2. Citywide View of 2022 Land Cover Dataset.*


*Figure 3. Sample Land Cover Classifications Paired with 2022 NAIP Imagery. Location shown is Lone Star Park.*

## 2.3 *i-Tree Eco Analysis*

Study design and field data collection protocol for the i-Tree Eco assessment portion of this project were developed by the U.S. Forest Service, Northeast Research Station. Using a random point generation tool within ArcGIS Pro in combination with the nine land use classes utilized in the UTC analysis portion of this study, 252 pre-stratified 1/10th-acre circular plots were established within the study area which encompassed both public and private properties. Study plots were located in the field using an EOS Positioning Systems Arrow 100 GPS Receiver capable of submeter accuracy, utilizing coordinates of plot centers and aerial imagery for each plot listed. Where plots or portions of plots fell within private property, permission to access private properties for plot measurement was obtained prior to data collection. Of the 252 plots, data were collected in the field within 237 of the plots as they were either completely accessible or visible such that tree data could be accurately collected. Data were not collected within the remaining 15 tree plots, as they were inaccessible or not visible from any accessible viewpoint.

For purposes of the i-Tree Eco assessment, a "tree" was defined as any woody plant equal to or greater than 1-inch diameter at breast height (DBH) which can achieve a height at maturity of at least 15 feet. These parameters were selected for defining a "tree" based upon similar studies and the fact that most woody plants which obtain a height of around 15-feet at maturity are generally considered "trees" within the region. Additionally, woody plants at or greater than 15-feet in height were identified as "tree canopy" by the deep learning model utilized in the UTC analysis portion of this study; therefore, justifying the need for a height requirement. A DBH of 1-inch was selected as the lowest threshold for defining a "tree", as urban forest characteristics such as sapling recruitment are reflected in dataset and may assist the city in long term planning. Plot and individual tree data were recorded utilizing i-Tree software and ArcGIS Field Maps on a smartphone. Latitude and longitude values in the World Geodetic System (WGS) 1984 datum were collected to provide a means of locating each plot for future studies. DBH for each recorded tree was taken to the nearest 0.1-inch via tree caliper. Distance and height were measured with a Nikon Forestry Pro II Rangefinder/Hypsometer, where applicable.

For each of the plots that were visited in the field, the following data were collected (units of measure included, if applicable):

- Percent measured and percent tree cover (percent)
- Land use (derived from Land Use GIS dataset)
- Percent plantable space (percent)
- Coordinates (decimal degrees; latitude and longitude)

For each individual tree 1" or greater within each plot, the following data were collected:

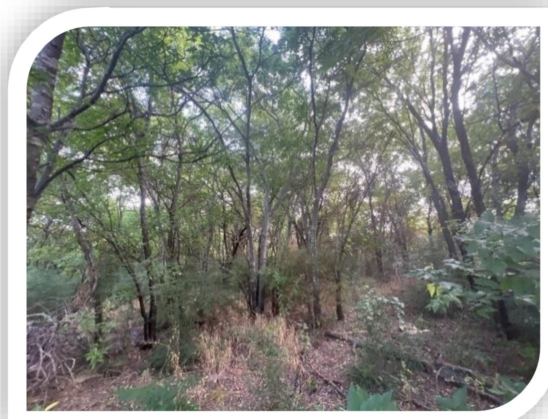
- Tree species (to the species level, unless variety or cultivar could be identified utilizing field characteristics only)
- Diameter at breast height (DBH), in inches, of trees greater than 1" to the nearest 0.1-inch
- Total tree height (feet)
- Crown size (feet; Height to top, Height to crown base, Crown width, Percent crown missing)
- Crown health (percent; dieback)
- Crown light exposure (number of sides of tree exposed to sunlight)
- Energy (feet; distance and direction to building)

### *2.4 Invasive Privet Assessment*

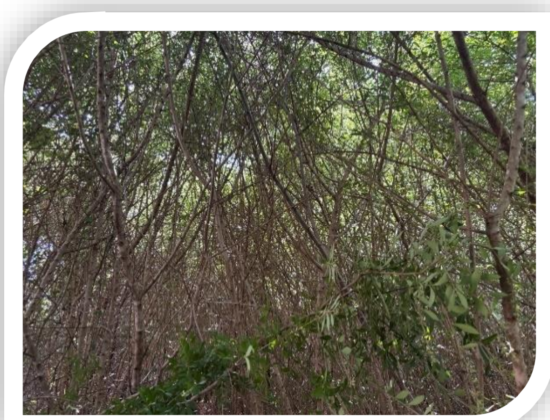
In southeastern forests, invasive privets (select *Ligustrum* spp.) are ecologically destructive in that they aggressively overtake forest understories creating monotypic, dense, evergreen stands that block out sunlight, which decreases sapling recruitment and preventing forest regeneration over time. Major invasive privet species, in this order, found throughout Dallas-Fort Worth (including the study area) are *Ligustrum quihoui*, *L. sinense*, and *L. lucidum*. Riparian forests worldwide are particularly vulnerable to invasion by alien plants due to frequent disturbances from repeat flood events that favor high species richness (Hanula et al., 2009). This becomes even more problematic in highly urbanized areas where large areas of continuous tree canopy are generally preserved in riparian forests near stream features with functioning, or at least partially functioning, floodplains. This is observable within the City of Grand Prairie, specifically in riparian forests around major tributaries to the West Fork Trinity River such as Mountain Creek, Fish Creek, and Cottonwood Creek where *Ligustrum* has invaded large areas of riparian forest understories. To make matters worse, effective removal of invasive *Ligustrum* is both time intensive and expensive, as it generally requires mechanical mulching or hand-felling, followed up by spot herbicide treatment to minimize chances of resprouting (Hanula et al., 2009). From a recreational use standpoint, older stands of *Ligustrum* can also prevent natural areas from being accessed by users reducing the public use value.

Managing the sustainability of urban forests usually includes remediating problems that may decrease overall tree canopy area over time. In areas where it has invaded and went unmanaged, invasive *Ligustrum* spp. infestations have been documented to have less diverse herbaceous and shrub layers, while also having lower tree sapling densities which negatively impacts forest regeneration (Hanula et al., 2009). Summarily, suppression of this ecologically destruction group of invasive plants is necessarily for long-term sustainable management of an urban forest. The first step in managing exotic biota is determining the extent and severity of infestation of the organisms. Utilizing the 252, 1/10-acre plots generated for the i-Tree Eco assessment, privet infestation level was rated within each plot on a scale of 0 to 4, following Hanula et al., 2009. All invasive privet observed within each plot was also identified to the species level. The rating scale, and visual representations of each taken during data collection, are shown below. A rating of 0 indicates no privet was observed within the plot:

1 - Some small privet, all less than 2.5 cm diameter and less than 2 meters in height.



2 - Privet is abundant, with some stems greater than 2 meters in height, but less than 2.5 cm diameter.



3 - Privet is numerous, plus some larger-diameter stems up to 3 meters in height.

4 - Privet is numerous, with large-diameter stems up to 3 meters in height.

*Figure 4. Visual representation of privet infestation rating scale. Note: a rating of zero indicates no privet was observed within a given plot.*

After rating the stands of privet within each plot, privet species and rating were utilized to provide generalized recommendations for managing invasive *Ligustrum* within the City of Grand Prairie with the ultimate goal of improving the overall health and self-sustainability of the City's urban forest. It should be note that other tree species considered to be invasive in Texas such as Chinese pistache (*Pistacia chinensis*) and white mulberry (*Morus alba*) were historically, or currently, utilized in landscaping within the City of Grand Prairie as ornamental plants and management recommendations may be more nuanced; therefore, not addressed by the privet assessment.

### *2.5 Existing Tree Regulations and Recommended Planting List Review*

At request of the City, a literature review of existing City tree regulations, including recommended tree planting lists and tree preservation requirements, was conducted to provide the City recommendations to promote longevity of the urban forest. Factors that may influence the sustainability of the urban forest were addressed such as identifying and removing plant species on the current City recommended planting lists that are regionally considered environmentally and/or economically destructive (e.g. invasive).

## 3.0 Canopy Assessment Results

### *3.1 Tree Canopy Dataset*

The tree canopy land cover classification dataset derived from high resolution aerial imagery from 2022 was extracted as a standalone dataset utilizing GIS software. An example from a low-density residential area of the extracted tree canopy land cover class derived from 2022 aerial imagery and reference aerial imagery is provided below. To provide a comprehensive suite of information on the City of Grand Prairie's UTC to different stakeholders (Tree Board (Park Board members), city staff, citizens, etc.), the standalone land cover dataset was utilized to perform area-specific UTC assessments for several geographical boundaries including the overall city limits, individual parcels, land use, census tracts, ZIP codes, and city council districts.

*Figure 5. Sample urban canopy cover dataset paired with NAIP imagery from 2022.*

### 3.2 City Limits and ETJ

Approximately 15,969.03 acres of the present-day Grand Prairie city limits and ETJ were covered by urban tree canopy in 2022, comprising approximately 25.2% of the 63,452.3 total acreage. In contrast, approximately 15,641.3 acres of the present-day Grand Prairie city limits and ETJ were covered by urban tree canopy in 2010, compromising approximately 24.7%. However, controlling for the area of Joe Poole Lake within this total acreage, which is open water excluding any canopy, the percent canopy is adjusted to approximately 27.7%. Approximately 47,483.2 acres of land were identified as non-canopy vegetation or other areas without trees. A summary of these cover types as shown in 6 and 7 is shown below:

- Urban Tree Canopy – 15,969.03 (25.2%)
- Low Vegetation – 22,162.6 acres (34.9%)
- Barren/Bare Soil – 2,395.9 acres (3.8%)
- Impervious Surface – 16,555.3 acres (26.1%)
- Waterbodies – 6,369.4 acres (10.0%)

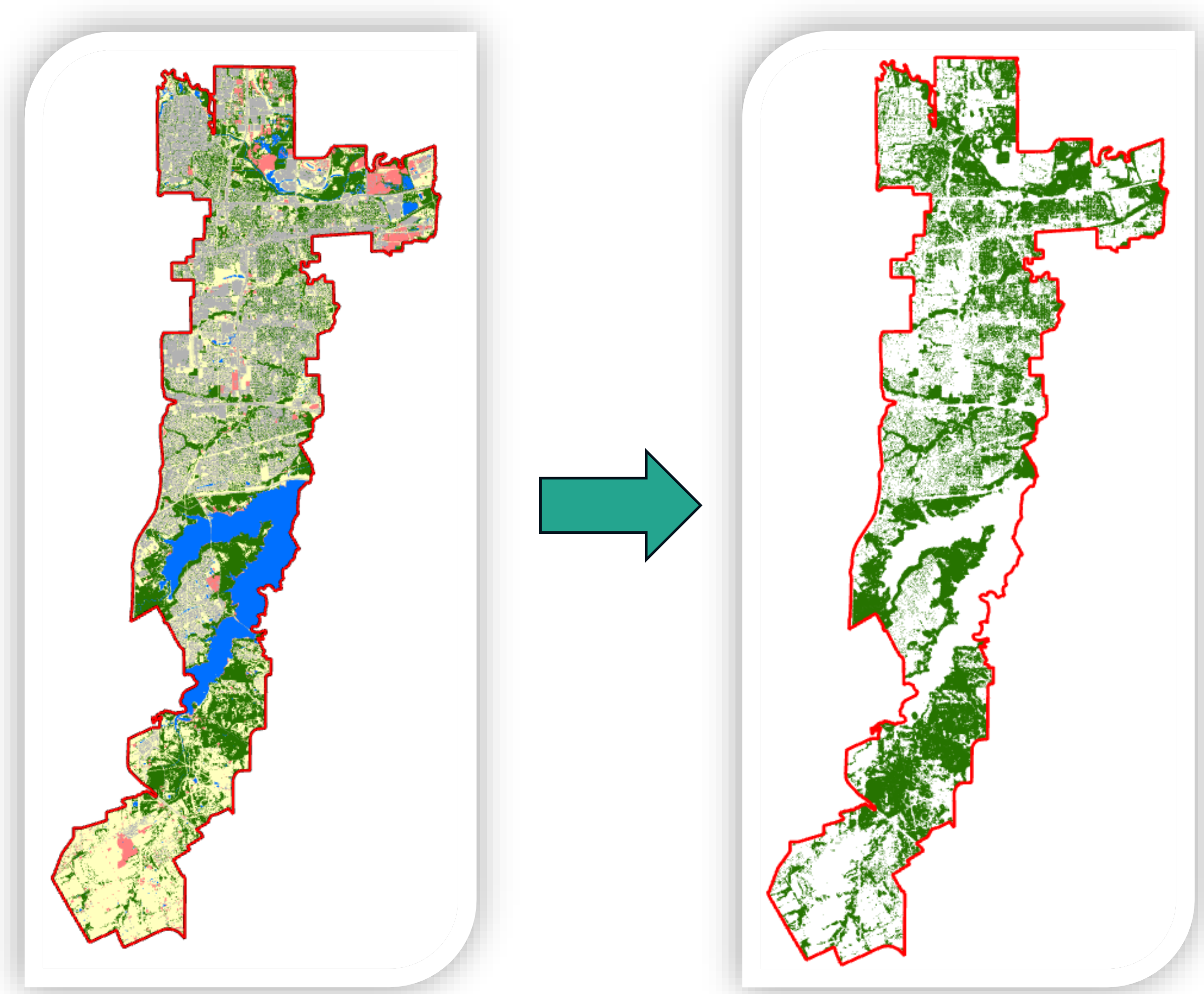


*Figure 7. Citywide View of 2022 Land Cover Dataset and Citywide View of 2022 Tree Canopy Cover Only*

### 3.3 *Parcels*

Parcels provided the most detailed demonstration of geography analyzed. This study analyzed urban tree canopy coverage percentage (UTC) for each of the over 55,000 parcels within the City of Grand Prairie. The results of the UTC assessment are expressed in urban tree canopy coverage as a percentage of land area for the variety of previously identified geographic boundaries. At the parcel level, UTC coverage was classified into five classes (0%-20%; 20%-40%; 40%-60%, 60%-80%; and 80%-100%). 10 on the next page shows and describes the five classes of 2022 canopy coverage on a representative parcel as a percentage of land area on high resolution aerial imagery from 2022.

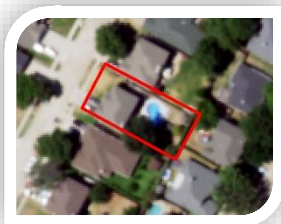
| | |
|---|---|
| 0-20% Canopy Coverage  | This class characterized by small stands of trees, composed of scattered small or large trees. Example from parcel with low density residential land use class. |
| 20-40% Canopy Coverage  | This class characterized by larger contiguous mottes or stands of trees, and more frequent larger trees. Example from parcel with open space/drainage land use class. |
| 40-60% Canopy Coverage  | This class characterized by stands of trees or collective of trees with near equal non-canopy land cover. Example from parcel with open space/drainage land use class. |
| 60-80% Canopy Coverage  | This class characterized by more dense stands of trees where groundcover is not readily apparent on imagery. Example from parcel within the parks and recreation and open space/drainage land use classes. |
| 80-100% Canopy Coverage  | This class characterized by contiguous stands of trees with few breaks in canopy. Common on tracts with near unbroken tree canopy such as undeveloped tracts or riparian corridors, however, may also apply to small parcels (e.g., certain low density residential tracts) with several larger trees relative to lot size. Example from parcel within the |

*Figure 10. Five Classes of Canopy Coverage on Representative Parcels as a Percentage of Land Area on High Resolution Aerial Imagery.*

UTC percentage was calculated with respect to the acreage of each individual parcel, resulting in a UTC percentage for each parcel. Parcels which contain forested riparian corridors, parks and open spaces, or other areas of uninterrupted canopy (e.g., undeveloped lands with continuous stands of trees) have the highest UTC. Parcels of lowest UTC generally coincide with areas such as golf courses, larger commercial developments, and the open water expanses of Joe Poole Lake which have either no trees or small stands of trees/individual trees. Due to generally smaller parcel sizes that range from 0% - 100% UTC, residential lots had the most variability in per parcel UTC percentage.

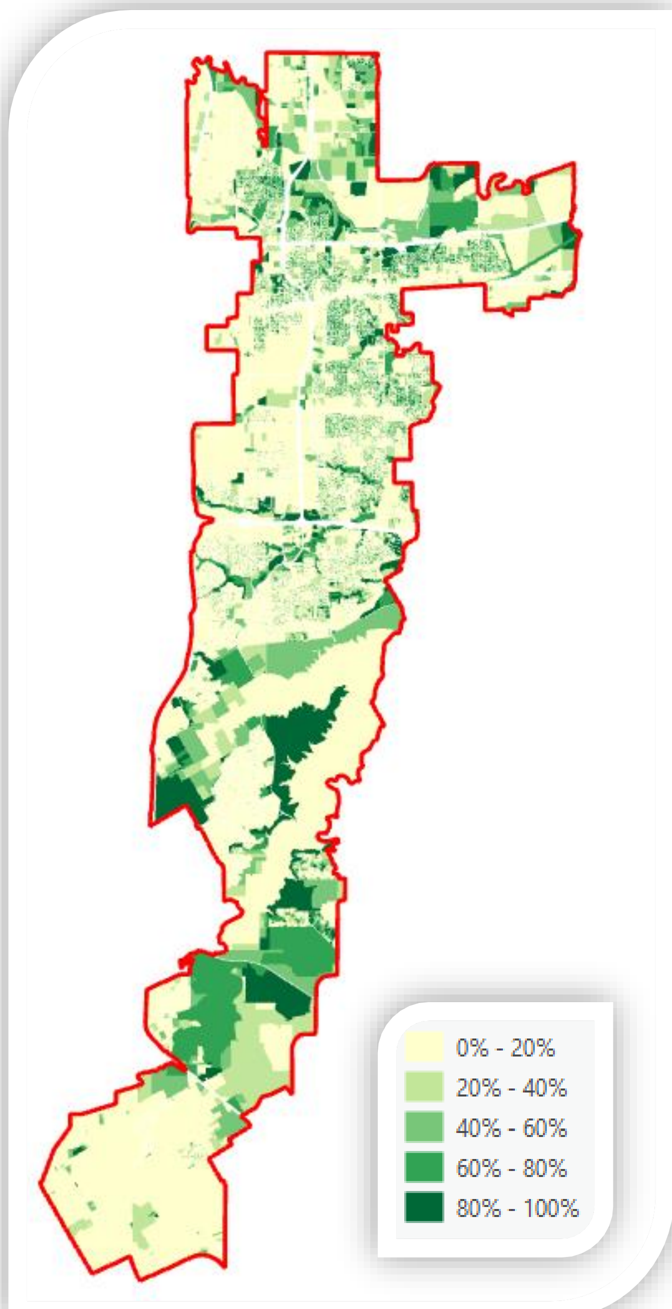
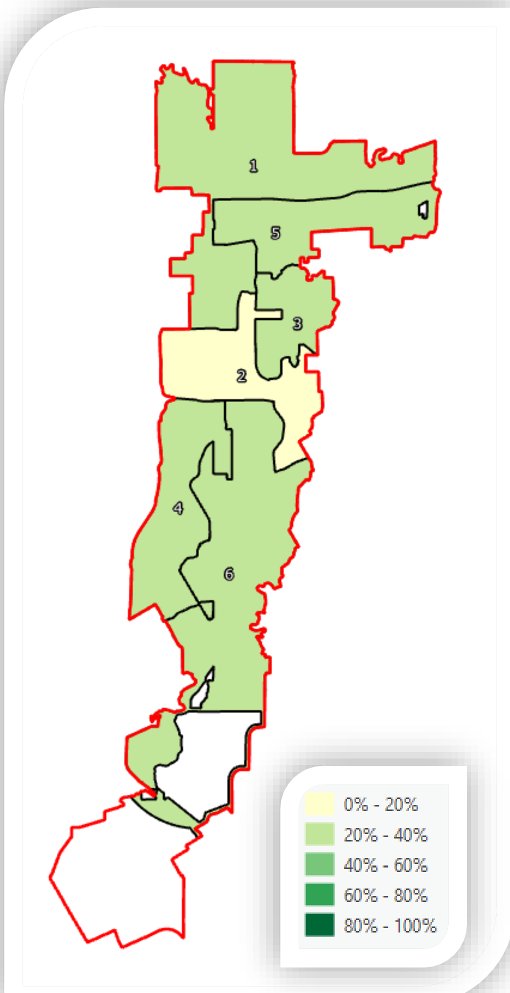
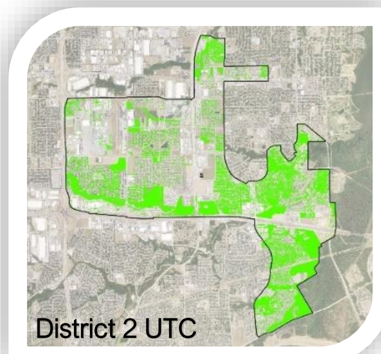


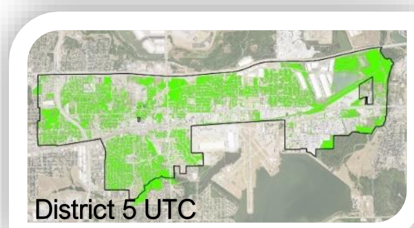

*Figure 11. Percentage of UTC by Parcel within the Study Area.*

## 3.4 City Council Districts

This study analyzed urban tree canopy coverage percentage (UTC) for each of the six city council districts within the City of Grand Prairie with the 2022 canopy dataset. With respect to the land area of each individual city council district, District 5 had the highest UTC coverage (27.2%), followed by District 6 (27%), District 4 (26.4%), District 3 (25.9%), District 1 (24.6%), and District 2 (19%). District 5 contains many low density residential lots with older, larger trees that make up the majority of UTC in this district. District 6 contains large portions of lands under either local or federal government ownership/ and management associated with Joe Poole Lake that have large areas of unbroken tree canopy within parks or open spaces that are likely to remain undeveloped. District 4 also contains large areas of unbroken tree canopy within riparian corridors associated with Fish Creek, Walnut Creek, Lynn Creek, Bowman Branch, and their tributaries; however, also includes a high volume of UTC as individual trees on low density residential properties. District 3 also includes areas of unbroken UTC associated with the riparian corridors of Cottonwood Creek and Kirby Creek; however, the majority of UTC in this district is associated with individual or small groups of trees on low density residential lots. District 1 contains many areas of continuous UTC associated with undeveloped properties, parks, and the riparian corridors of larger stream features such as the West Fork Trinity River, Mountain Creek, Johnson Creek, Cottonwood Creek, Bear Creek, and their tributaries; however, the overall UTC percent per land area of this district remains on the lower end with respect to other districts due to many large commercial developments that have large areas of non-canopy land cover with lower surface area of UTC. It should be noted that again in District 1, a substantial amount of UTC is located within low density residential properties. District 2 contains areas of unbroken UTC associated with the riparian corridors of Fish Creek and Kirby Creek; however, also contains larger commercial/retail/office and industrial developments with larger land areas that contain only scattered areas of UTC. It should be noted that District 2 contains many low density residential lots with variable amounts of UTC.



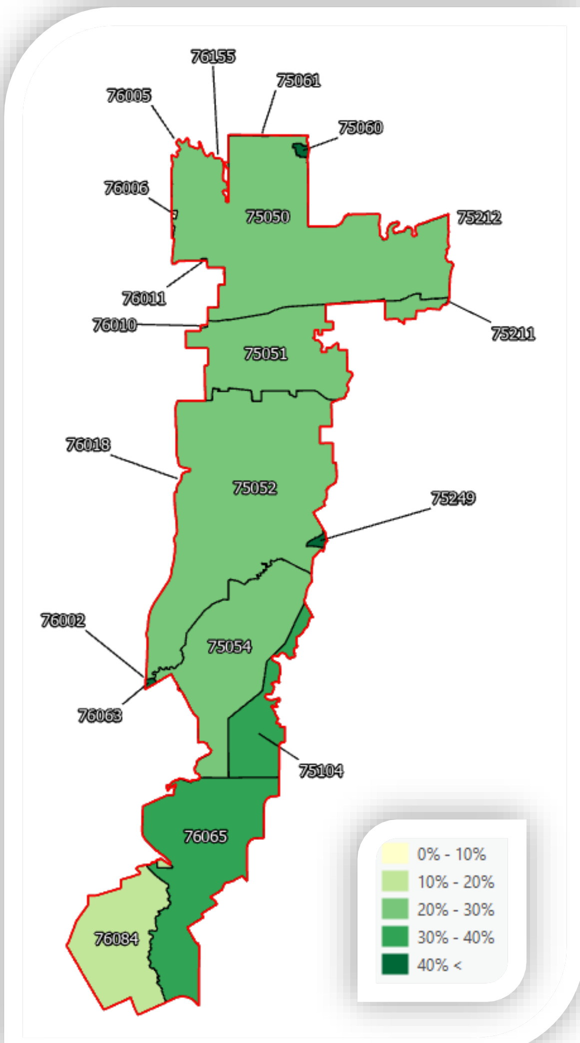




| City Council District (2025) | UTC (% of City Council District Area) |
|---|---|
| 2 | 19.0% |
| 1 | 24.6% |
| 3 | 25.9% |
| 4 | 26.4% |
| 6 | 27.0% |
| 5 | 27.2% |

*Figure 12. Visualized Percentage UTC by Zip Code within the Study Area within the Study Area and Examples of Distribution of UTC. District 5 (highest percent UTC) and District 2 (lowest percent UTC). Note: Areas shown without UTC percent are within the ETJ and not currently within a city council district based on the current council district GIS dataset*

## 3.5 ZIP Codes

This study analyzed urban tree canopy coverage percentage (UTC) for each of the twenty ZIP codes within the study area. ZIP codes 75249, 76063, and 75060 all have greater than 45% UTC coverage per land area; however, have overall smaller acreages which indicates while UTC percent is high, actual acreage of UTC is low relative to the overall study area land area. ZIP codes 75054, 75052, 75211, 75050, 75104, 76065, and 75051 all contain greater than 20% canopy cover per land area of each individual ZIP code and represent the majority of the overall land area within the study area. ZIP codes 76011, 76155, 75061, 76084, 76005, 75212, 76006, 76010, 76018, and 76002 all contain less than 20% UTC, with the average UTC coverage per land area of each ZIP code being 9.3%; however, represent only smaller portions of the overall land area of the study area.




| Zipcode within Study Area (2025) | UTC (% of Zipcode Area) |
|---:|---:|
| 76002 | 0.0% |
| 76018 | 0.0% |
| 76010 | 2.7% |
| 76006 | 4.7% |
| 75212 | 10.8% |
| 76005 | 10.9% |
| 76084 | 11.2% |
| 75061 | 11.3% |
| 76155 | 12.1% |
| 76011 | 17.9% |
| 75051 | 20.4% |
| 75054 | 21.7% |
| 75052 | 23.1% |
| 75211 | 25.1% |
| 75050 | 27.6% |
| 75104 | 34.3% |
| 76065 | 35.9% |
| 75060 | 48.9% |
| 76063 | 54.6% |
| 75249 | 55.1% |

*Figure 13. Visualized Percentage UTC by Zip Code within the Study Area.*

### 3.6 Census Tracts

This study analyzed urban tree canopy coverage percentage (UTC) for each of the 78 Census Tracts wholly or partially within the study area. With respect to the overall study area land area, the Census Tracts which contain the highest UTC percentage per land area unit (>40% UTC) are associated with the parks and recreation or open space/drainage land uses. Census Tracts which contained moderate UTC (20% - 40%) made up over 40% of the overall land area within the study area and generally contain residential areas that have many individual trees across many lots. Census Tracts with the lowest UTC (<15%) generally coincide with areas such as larger industrial/commercial developments or undeveloped areas within the ETJ which have smaller or widespread stands of trees/individual trees that offset areas of denser UTC within low density residential lots and along riparian corridors for an overall lower UTC.

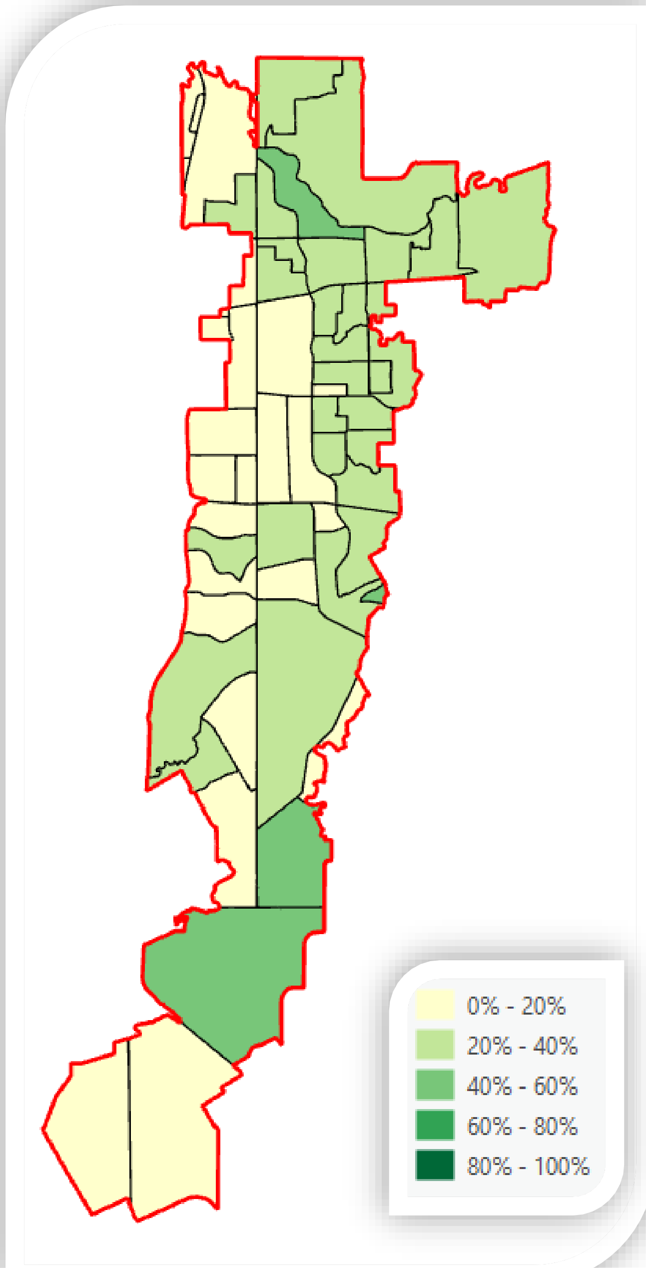
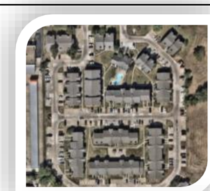
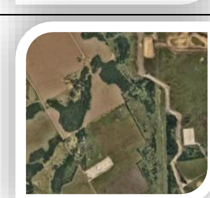



*Figure 14. Percentage UTC by Census Tract within the Study Area.*

## 3.7 Land Use

The City of Grand Prairie provided a 2021 future land use dataset that was further refined to develop a 2025 existing land use dataset. Development of the 2025 land use dataset involved classifying all land areas within the study area into one of nine land use classifications as described below. Land use classifications were refined from those provided in the City's 2018 Comprehensive Plan update for consistency. Of the 10 provided in the 2018 Comprehensive Plan, the Mixed Residential, Mixed Use, Light Industrial, and Heavy Industrial land use classifications had overall small land areas relatively to the study area size and were integrated into one of the nine final land use classifications for simplification of results. The Light and Heavy Industrial land use classes were combined into an "Industrial" land use class. The Mixed Residential and Mixed Use land use classifications represented areas that were of more than one land use type and were integrated into the dominant land use of those land areas for simplification. An additional land use classification, Joe Poole Lake, was added to account for the land area of the surface area of the lake (mostly water). Utilizing several sources of recent aerial imagery, the land use classes from the original data were updated to be consistent with present day land use. While interpretations of present-day land use can be made accurately from aerial imagery, true land use may differ in some areas. It should be noted some land areas such as schools, churches, and hospitals did not have a distinctive land use class; therefore, were integrated into the most similar land use classification in terms of distribution of UTC (e.g. the distribution of UTC at a church or school is generally similar to those of large commercial/retail/office establishments). A summary of the land use classes utilized in the UTC assessment, along with a visual representation, are provided below:

| | | |
|---|---|---|
| *Low Density Residential* | Represents traditional single-family detached neighborhoods and includes housing and living units for people with a range of incomes and needs. Low density residential areas generally range between zero and six dwelling units per acre. Example from a single family residential neighborhood within the study area. |  |
| *Medium Density Residential* | Single-family residential neighborhoods at densities between six and 12 dwelling units per acre. Medium density residential types take the form of townhomes, duplexes, and patio homes. Medium density residential can be used as a transitional use between low density areas and higher intensity uses, such as commercial, retail, and industrial activity. Example of duplex or townhomes within the study area |  |
| *High Density Residential* | Reflective of multi-family apartments. Depending on location, densities in high density residential may vary significantly. Garden style apartments have densities between 12 and 20 dwelling units per acre. Newer construction, particularly if a mixed- use configuration, have densities above 20 dwelling units per acre. Example of multi-family apartments within the study area. |  |
| *Parks and Recreation* | Represents public and private parks. Facilities include recreation centers, golf courses, active and passive outdoor parks. Example from Riverside Golf Course within the northwestern corner of the study area. |  |
| *Open Space/Drainage* | Primarily comprises of floodplains located along the many waterways running through Grand Prairie; however, also includes large, undeveloped private or publicly owned tracts of land throughout the study area. Example from a large tract of undeveloped land with drainageways in the southern portions of the study area. |  |

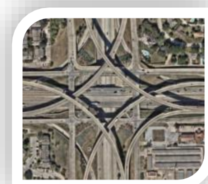
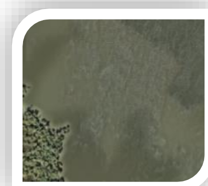
| | | |
|---|---|---|
| *Commercial/Retail/Office* | Commercial uses are more intense than retail establishments yet also provide goods and services for the public. Examples of commercial establishments would include hotels, automotive services, and big box retailers. This land use classification also includes land uses that have similar distribution of UTC such as schools, churches, and hospitals. Example from a mixed business complex within the study area. |  |
| *Industrial* | A combination of the light and heavy industrial land use classifications. Includes refining or manufacturing facilities, indoor warehouse/storage facilities, and industrial business parks of variable uses, appearances, and intensities. Example from an industrial area within the study area |  |
| *Transportation* | Representative of major roadways and right of ways within the study area. Some smaller roadways such as collector or local roads are not included in this land use class and were integrated into surrounding dominate land use. Example of major highways within the study area. |  |
| *Joe Poole Lake* | Represents the surface waters of Joe Poole Lake. It should be noted this land use classification is mostly water but does include some UTC which consists of species that can survive in standing water such as black willow (*Salix nigra*), green ash (*Fraxinus pennsylvanica*), or bald cypress (*Taxodium distichum*). Example from Joe Poole Lake within the study area. |  |

*Figure 15. Description of Land Use Classifications developed and utilized for this study.*

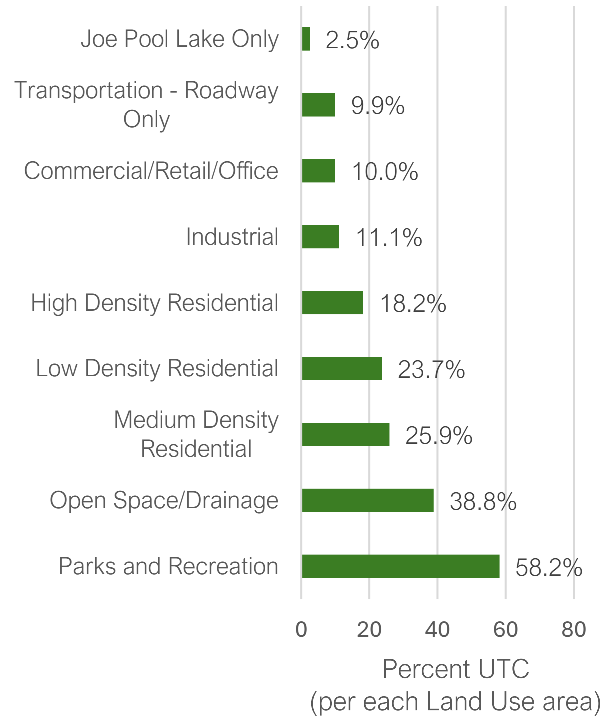



*Figure 16. Percentage UTC within each Land Use Classification per Land Area.*

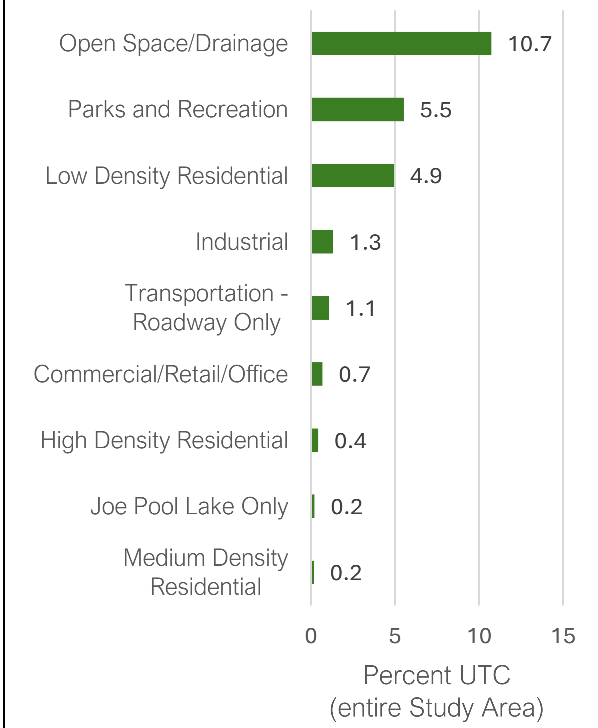



*Figure 17. Percentage UTC within each Land Use Classification per total Percentage UTC of entire Study Area (out of 25.2%)*

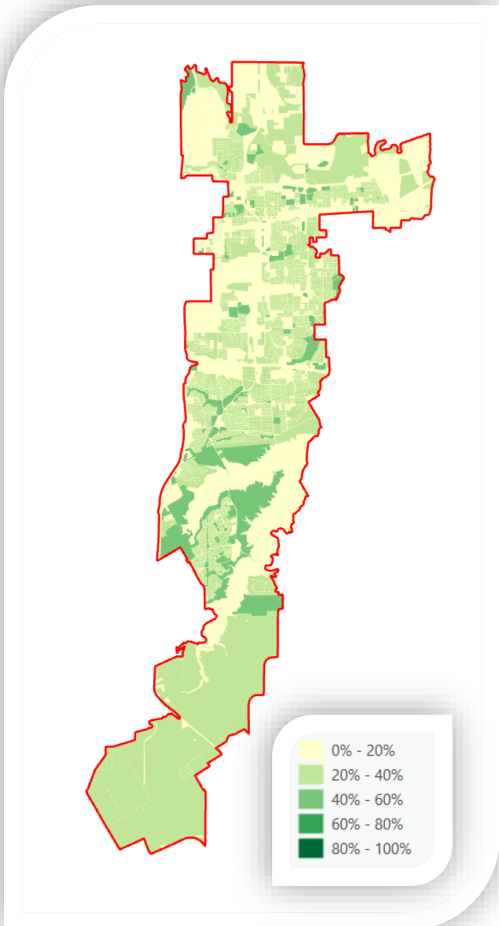



*Figure 18. Percentage UTC within each Land Use Classification per Land Area of each Land Use Classification.*

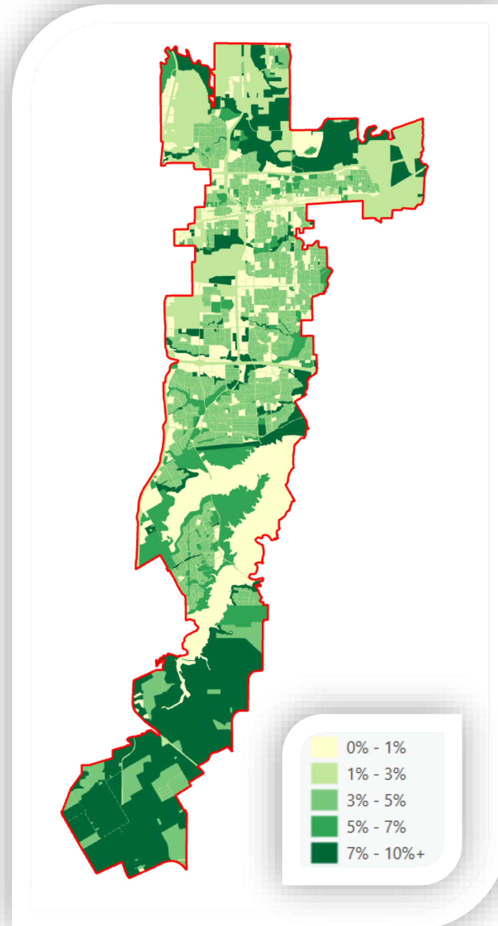



*Figure 19. Percentage UTC within each Land Use Classification per Land Area of each Land Use Classification.*

| Land Use Description | Land Area of Land Use Class within Study Area in Acres | Percent UTC per Land Use Land Area |
|---|---|---|
| Open Space/Drainage | 17,542 | 38.8% |
| Low Density Residential | 13,233 | 23.7% |
| Industrial | 7,538 | 11.1% |
| Transportation | 6,896 | 9.9% |
| Parks and Recreation | 6,026 | 58.2% |
| Joe Pool Lake | 5,752 | 2.5% |
| Commercial/Retail/Office | 4,467 | 10.0% |
| High Density Residential | 1,547 | 18.2% |
| Medium Density Residential | 448 | 25.9% |

*20. Land Area of each Land Use Classification and Percent UTC per Land Area of each Land Use Classification.*

As discussed previously, UTC percent coverage derived from the generated 2022 land cover dataset of the overall study area was 25.2% (approximately 15,969 acres). Of this 25.2%, 10.7% was contained within the Open Space/Drainage land use class, followed by Parks and Recreation at 5.5% and Low Density Residential at 4.9%. The Industrial land use class had the next highest UTC at 1.3%, followed by Transportation at 1%. The remaining 1.8% was distributed between the remaining four land use classes (Medium Density Residential, High Density Residential, Commercial/Retail/Office, and Joe Poole Lake).

s 17 and 19 depict the distribution of UTC per land use class per total percentage UTC of the entire study area (breakdown of each percent UTC per land use class of the 25.2% UTC for the entire study area).

To provide a more individualized representation of the distribution of UTC within each land use class, UTC percentage was calculated for each land use class per land area of each land use class (s 16, 18, and 20). Parks and Recreation had the highest UTC per land area (58.2%). Open Space/Drainage has the next highest UTC per land area at 38.8%, followed by Medium Density Residential at 25.9%, and Low Density Residential at 23.7%. The next highest UTC per land area was High Density Residential at 18.2%, followed by Industrial at 11.1%, then Commercial/Retail/Office at 10%, and Transportation at 9.9%. The lowest UTC per land area was Joe Poole Lake at 2.5%; however, it should be noted that this land use is nearly all lake surface waters.

When considering how to manage an urban forest, an initial first step is determining the distribution of UTC and how that UTC is managed with respect to the surrounding land use. For example, while the Open Space/Drainage has the highest land area within the study area and 38.8% of that land area is UTC, management of this land use is generally "hands off", save for spot maintenance of failing trees or control of invasive species as needed. Another consideration for management of UTC is estimated future land use and how UTC will be affected. For example, the second highest acreage land use classification in the study area was Low Density Residential which had 23.7% UTC. UTC management within this land use classification generally falls to individual homeowners and simply put – people like their trees. Therefore, while the percentage UTC per land area is not the highest, UTC within Low Density Residential areas is likely to slowly increase overtime as homeowners tend to maintain individual trees, or smaller groups of trees on residential properties. The same could be said for management of UTC within the Parks and Recreation land use classification, as these land areas generally include well-maintained individual trees in higher use areas or areas of continuous UTC in lower use areas (such as around major stream features).

In contrast, UTC within areas of the Open Space/Drainage land use class is at higher risk of decreasing in coming years as many of these areas, such as the larger tracts of undeveloped land in the far southern extent of the study area, are at least partially developable. Some land use areas, such as the Commercial/Retail/Office land use classification, may experience increases or decreases in UTC depending on what businesses move in or out of an area. For example, larger retailers generally need large parking lots to accommodate high volumes of visitors and UTC within these areas is generally manifested as individual parking lot trees that are mostly left alone, save for routine maintenance; however, nothing prevents another business from coming in and redoing the building footprint which could potentially increase or decrease UTC depending on landscape design, which is mostly guided by existing tree preservation regulations. Summarily, decreases or increases in UTC on many land use classes are strongly influenced by tree preservation/mitigation requirements and future UTC coverage within the City of Grand Prairie will largely depend on the implementation of effective tree-related municipal regulations.

## *3.8 UTC Coverage Change*

Utilizing the generated 2010 and 2022 land cover datasets, UTC change analysis between 2010 and 2022 was conducted to capture the relationship between canopy growth and canopy loss related to urban development. Similar methods were used for the analysis, yet the image quality between 2010 and 2020 presents a limitation and introduces some margin of error in direct comparisons of canopy. UTC coverage in 2010 was approximately 15,641.3 acres, comprising 24.7% of the study area. Canopy cover in 2022, totaled 15,969.03 acres, comprising 25.2% of the study area. This supposes that the UTC in the city increased by approximately 328 acres or 0.5% in the 12 years between 2010 and 2022. Despite the supposed gain in canopy cover between 2010 and 2020, there were many areas within the city that experienced loss in canopy cover. Much of this loss was clearly attributed to development, and review of most recent imagery shows that loss to development is still occurring. This is most recognizable in the Open Space/Drainage land use which captures a substantial portion of 2022 UTC (over 40% of the total UTC coverage, citywide).


*Figure 21. Example of both UTC loss and sustainment as a direct result of land use changes (or lack thereof). UTC is maintained in the Medium Density Residential land use on the right-hand side of the images; however, UTC is lost due to the conversion of a former Open Space/Drainage area to Industrial and use on the left-hand side of the image.*

In other areas of the city, growth and development of previously non-canopy land or the growth and development of landscape trees in new developments led to an increase in canopy cover. These differences in canopy are individually small but are cumulatively recognized. This is consistent with the canopy per land use results for which canopy gains on individual lots can be observed within the Low Density Residential land use class between 2010 and 2022. Finally, the canopy also increased between 2010 and 2022 as a result of natural growth and maturation of trees.


*Figure 22. Example of UTC increase between 2010 and 2022 within a Low Density Residential land use area.*

As noted, there are slight deviations in data quality between the 2010 and the 2022 canopy datasets due to differences in imagery resolution (e.g., lower quality in 2010, higher quality in 2022). This data is reliable for drawing broader, more generalized assessments of UTC at larger scales such as those mentioned above; however, canopy data was produced utilizing a model that is dependent on input imagery resolution for accuracy and it would be difficult to draw more explicit conclusions from this dataset at smaller scales (e.g., per parcel canopy change). Despite differences in data quality between years, manual side by side inspection of the datasets indicated that although existing canopy will likely continue to slowly increase in stable land uses where removal is less likely (e.g., Parks and Recreation or Low Density Residential), losses due to development of remaining developable lands among the remaining land uses may balance incremental gains over any assessment period.

## 4.0 i-Tree Eco Assessment Results

### *4.1 Species Composition and Distribution*

The canopy assessment focused on quantifying the overall urban tree canopy cover for the city using high-resolution imagery in combination with a GIS-driven deep learning model. By comparison the i-Tree Eco assessment utilizes direct measurements through the collection of field data to better characterize and present data on the species, size, health, and overall composition that compose that same canopy.

Urban forests often have higher species richness (number of species) than surrounding native landscapes, often with a mix of native and exotic tree species. Species diversity, or lack thereof, can influence future management decisions as increased tree diversity, for example, can minimize the overall impact or destruction by a host-specific insect or disease, climate change, or a combination of factors. However, introduced non-natives that might improve species diversity in the short term could pose a long-term risk to species diversity (and increase long term management needs) if the exotic species are invasive plants that displace more desirable native species. In Grand Prairie, most of the trees are species that are native to either the State of Texas or North America. Invasive species make up only 1.7% of the total population, although this value was derived from invasive exotics and does not include native species that may be considered invasive beyond their native range (e.g. mesquite, eastern red cedar). Nonetheless, this is still a reasonable indicator of the overall good health of Grand Prairie's urban forest. This is likely an influence of the high percentage of Low Density Residential land use where noxious species are usually excluded from regular homeowner maintenance and the presence of some larger land areas within the Parks and Recreation and Open Space/Drainage land use classes that contain expanses of contiguous UTC that exist as mostly unmanaged, natural forest stands. These large components of the Grand Prairie UTC are relatively unfragmented and may serve as a barrier to the spread of invasive species.

Based on the data collected from 237 visited sample plots, the i-Tree Eco model calculated that the City of Grand Prairie has an estimated 3,281,000 trees with an estimated density of 52 trees per acre. The three most common tree species in Grand Prairie were sugar hackberry (21.6%), cedar elm (18.1%), and American elm (*Ulmus americana*) (14.4%). Contrary to popular belief, oak species are not nearly as common as these three species. Live oak (*Quercus virginiana*), Shumard red oak (*Quercus shumardii*), bur oak (*Quercus macrocarpa*), sawtooth oak (*Quercus acutissima*), blackjack oak, and lacey oak (*Quercus laceyi*) were all represented across numerous plots, with live oaks most common as a landscape tree in residential settings. Combined, these oak species represented approximately 5.9% of the total canopy. Of note, lacey oak is an oak species native to Texas which has increased in popularity over recent years due to its showy blue-green foliage and tolerance to pests, drought, and high pH soils.

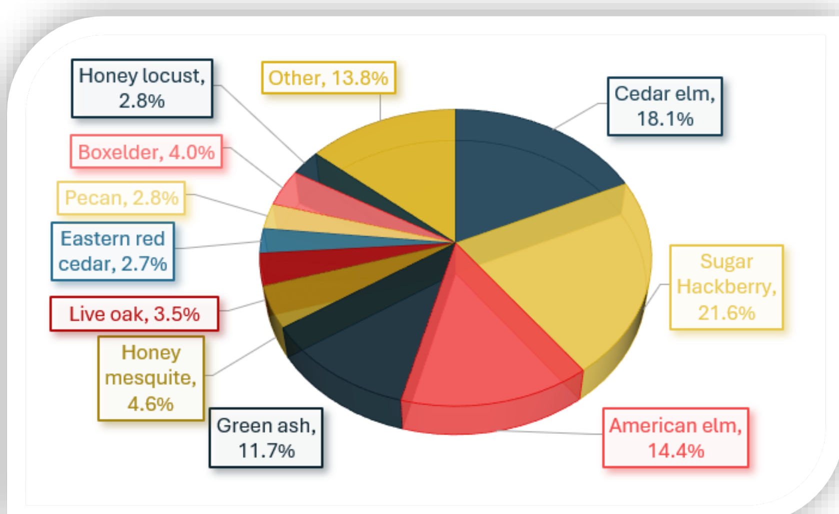



*Figure 23. Percentage of Top 10 Tree Species.*

Sugar hackberry are valuable for wildlife and water quality in native wetland/riparian areas but tend to be most common in natural settings or old fencerows and are not a species generally used for landscaping. In contrast, Cedar elm and American elm were the second and third most common species city-wide. The distribution of all elms observed across land use are provided in 24. Elm species account for nearly 50% of the trees observed within the Transportation and Commercial/Retail/Office land use classes, and above 30% of the observed tree species within the Parks and Recreation and Open Space/Drainage land use classes. Due to the value and public affinity for oak species, a distribution by land use is also provided in 25 for the oak species, a common landscape component in residential communities.

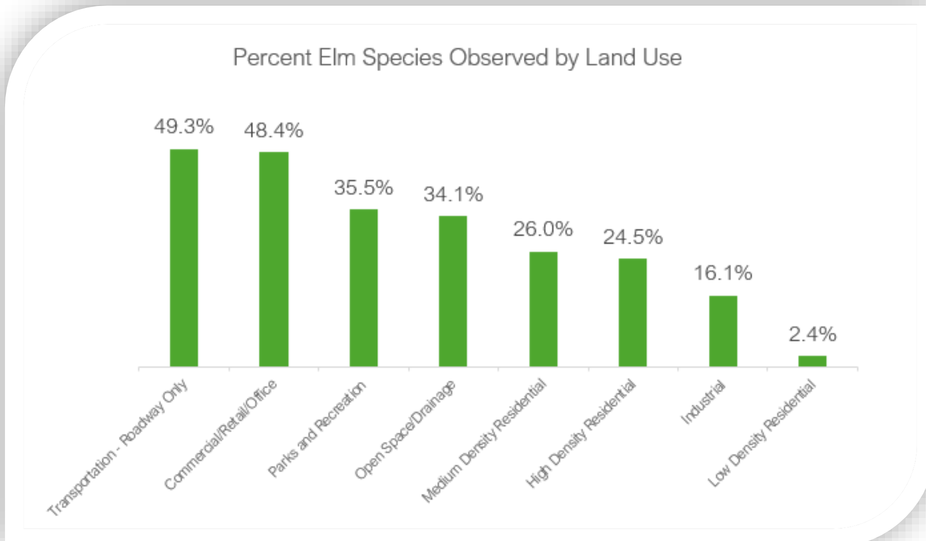



*Figure 24. Percentage of Elm Species Observed by Land Use. Joe Poole Lake is not included a there were no elms within that land use classification.*

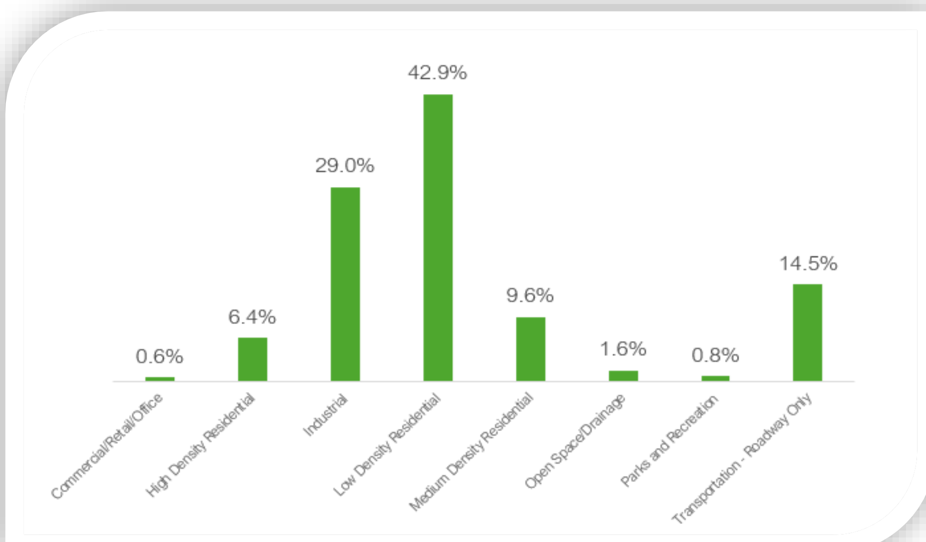



*Figure 25. Percentage of Oak Species Observed by Land Use. Joe Poole Lake is not included a there were no oaks within that land use classification.*

## 4.2 Relative Age and Size

The size class distribution of Grand Prairie's trees can be a good prediction for future trends in the structure and composition of the urban forest. While larger trees provide more ecosystem benefits, the space to grow and maintain large trees in an urban setting can be limited. Results show approximately 63.9% of trees within Grand Prairie have a diameter less than 6 inches. The relative size/age of trees in a community, combined with other observable species trends, enables more informed management and planning for future planting projects. For example, of the 63.9% of the tree population that had less than 6-inches in trunk diameter, approximately 56% are species that will attain a relatively large size at maturity if properly protected and maintained.

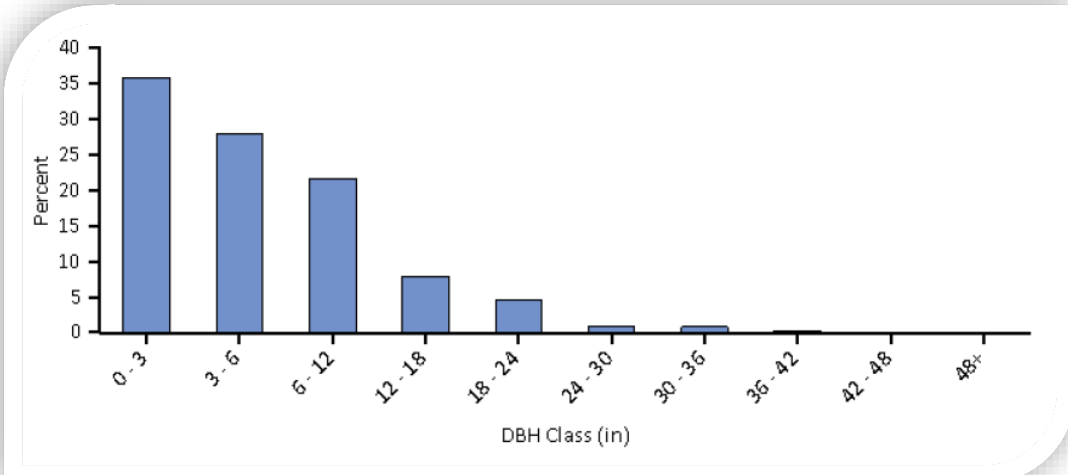



*Figure 26. Percent of Tree Population by Diameter Class (DBH, inches).*

## 4.3 Invasive Tree Species

Exotic species are species introduced to an area by one of many pathways. Exotic species become invasive species when they are known to cause environmental or economic harm. Invasive plant species are often characterized by their vigor, adaptability, and ability to proliferate. These abilities enable them to displace native plants and make them a threat to ecological stability. Of the sampled locations, seven tree species which are considered invasive in Texas were identified by the i-Tree assessment to exist within the City of Grand Prairie. Species determined to be invasive based on Texas' invasive species list, as well as the estimated number of individuals, percent of trees, leaf area, and percent leaf area are provided in 27 below. Note that the only *Ligustrum* observed that was considered a "tree" in this study was glossy privet (*Ligustrum lucidum*). The species composition of other *Ligustrum* spp. were evaluated separately, as they were not considered "trees" by definition in this study.

| Species Name[a] | *Number of Trees* | *% of Trees* | *Leaf Area (ac)* | *Percent Leaf Area* |
|---|---|---|---|---|
| Chinese pistache | 21,954 | 0.7 | 542.2 | 1.4 |
| White mulberry | 12,959 | 0.4 | 329.7 | 0.8 |
| Persian silk tree | 8,353 | 0.3 | 26.2 | 0.1 |
| Chinese tallowtree | 5,585 | 0.2 | 546.7 | 1.4 |
| Chaste tree | 4,926 | 0.2 | 9.4 | 0.0 |
| Chinaberry | 2,232 | 0.1 | 20.2 | 0.1 |
| Glossy privet | 162 | 0.0 | 0.4 | 0.0 |
| **Total** | **56,170** | **1.71** | **1,474.85** | **3.71** |

[a]Species are determined to be invasive if they are listed on the state's invasive species list

*Figure 27. Invasive Tree Species of the Grand Prairie Urban Forest.*

### *4.4 Invasive Privet Assessment*

While not “trees”, the proliferation of invasive privets (*Ligustrum* spp.) in forest understories can have significant ecological impacts, most notably in reducing sapling recruitment which reduces an urban forest’s self-sustainment capacity. The introduction pathway for these species was likely deliberate historical use as ornamentals in landscaping. From introduction points, privet is then normally dispersed to other locations via endozoochory (birds) or through root sprouting which causes more localized invasion. Based on visual observations, invasive *Ligustrum* has spread throughout the City of Grand Prairie, and dense stands can be observed in some areas such as the Fish and Cottonwood Creek riparian corridors. This can raise concern over time if left unmanaged, as it can negatively impact forest structure and function, and in turn, reduces the overall value of the urban forest. Managing invasive species begins with identifying where, and to what extent, a given exotic species has spread. Utilizing the 237 visited tree plots from the i-Tree Eco assessment, the level of privet infestation and species present within each plot was documented utilizing the previously mentioned scoring system of between 0 (no privet) to 4 (dense, tall privet with large stems).

28 depicts privet score and species observed within each plot by land use classification. Privet species observed within each plot were documented and identified to the species level ( 29). The sum of privet scores for each land use classification is provided in  30. The most common privet species in the City of Grand Prairie is waxyleaf privet (*Ligustrum quihoui*) which accounted for approximately 51% of all privet species observations. Chinese privet (*Ligustrum sinense*), a visually similar species to *L. quihoui*, was the next most observed species at 26.5%, followed by Japanese privet (*Ligustrum japonicum*) at 16.3%, then finally glossy privet (*L. lucidum*) at 6.1%. The highest privet scores overall were seen in the High Density Residential and Parks and Recreation land use classes. All residential land uses combined (Low, Medium, and High) had approximately 45% of the overall privet score; however, much of the combined score was higher individual scores (3 or 4) spread across fewer plots. The Low Density Residential land use had one of the lowest overall privet scores, likely due to routine land area maintenance by neighborhood homeowners. The Parks and Recreation land use classification had lower individual scores (mostly 1 or 2), but privet was present in more plots, indicating potential for future invasion if left unmanaged as maintenance of much of that land use is “hands off”, save for higher use areas.

*Figure 28. Privet Score and Species Observed in Plots where Privet was Present.*

| Land Use Class | Privet Score | Species Observed 1 | Species Observed 2 | Species Observed 3 |
|---|---|---|---|---|
| High Density Residential | 4 | *Ligustrum sinense* | | |
| High Density Residential | 4 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| Open Space/Drainage | 4 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| High Density Residential | 3 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| High Density Residential | 3 | *Ligustrum quihoui* | *Ligustrum sinense* | |
| Medium Density Residential | 3 | *Ligustrum lucidum* | *Ligustrum sinense* | |
| High Density Residential | 3 | *Ligustrum quihoui* | | |
| Parks and Recreation | 3 | *Ligustrum quihoui* | | |
| Commercial/Retail/Office | 2 | *Ligustrum quihoui* | | |
| Commercial/Retail/Office | 2 | *Ligustrum quihoui* | | |
| Commercial/Retail/Office | 2 | *Ligustrum quihoui* | | |
| Low Density Residential | 2 | *Ligustrum lucidum* | *Ligustrum quihoui* | |
| Medium Density Residential | 2 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| Medium Density Residential | 2 | *Ligustrum quihoui* | *Ligustrum sinense* | *Ligustrum japonicum* |
| Open Space/Drainage | 2 | *Ligustrum quihoui* | | |
| Open Space/Drainage | 2 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| Parks and Recreation | 2 | *Ligustrum quihoui* | *Ligustrum sinense* | |
| Parks and Recreation | 2 | *Ligustrum quihoui* | *Ligustrum japonicum* | |
| Parks and Recreation | 2 | *Ligustrum quihoui* | | |
| Parks and Recreation | 2 | *Ligustrum quihoui* | | |
| Commercial/Retail/Office | 1 | *Ligustrum quihoui* | | |
| High Density Residential | 1 | *Ligustrum quihoui* | | |
| Commercial/Retail/Office | 1 | *Ligustrum lucidum* | | |
| High Density Residential | 1 | *Ligustrum japonicum* | | |
| Industrial | 1 | *Ligustrum sinense* | | |
| Medium Density Residential | 1 | *Ligustrum sinense* | | |
| Medium Density Residential | 1 | *Ligustrum sinense* | | |
| Open Space/Drainage | 1 | *Ligustrum sinense* | | |
| Parks and Recreation | 1 | *Ligustrum sinense* | | |
| Parks and Recreation | 1 | *Ligustrum quihoui* | | |
| Parks and Recreation | 1 | *Ligustrum quihoui* | *Ligustrum sinense* | |
| Parks and Recreation | 1 | *Ligustrum quihoui* | | |
| Parks and Recreation | 1 | *Ligustrum sinense* | | |
| Parks and Recreation | 1 | *Ligustrum quihoui* | | |
| Transportation | 1 | *Ligustrum quihoui* | | |
| Transportation | 1 | *Ligustrum sinense* | | |

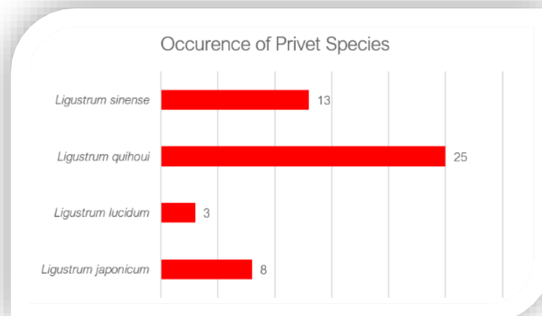



*Figure 29.Count of Privet Species Observed in Plots where Privets was Present.*

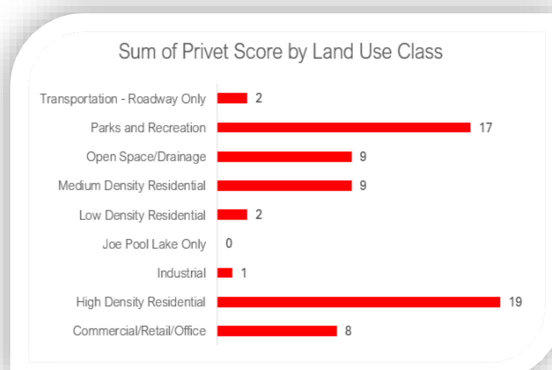



*Figure 30.Sum of Total Privet Score for each Land Use Classification.*

## *4.5 Value of the Urban Forest*

Data from the 237 surveyed field plots were analyzed utilizing the i-Tree Eco modeling software. i-Tree Eco quantifies forest structure, associated ecosystem services, and associated monetary values using standardized field data. The forest structure is a measure of many physical attributes of the urban forest, including species, number of trees in the inventory, density, tree health, leaf characteristics, and diversity. Ecosystem services are determined based on the measure of forest structure. Monetary values are estimates of economic valuation of the various benefits of urban forest functions. i-Tree calculates totals, averages, and standard errors by species, land cover, and city for forest structure and associated ecosystem services and values such as carbon storage and sequestration, air pollution removal and tree value, tree effects on building and energy use and compensatory value. Please refer to Appendix A for the full i-Tree report and the methodology. A summary of the valuation of the ecosystem services provided by the City of Grand Prairie's urban forest based on the collected sample plot data below:

- Pollution Removal: 308.4 tons/year ($1.46 million/year)
- Carbon Storage: 494.6 thousand tons ($214 million)
- Carbon Sequestration: 21.88 thousand tons ($9.47 million/year)
- Oxygen Production: 46.14 thousand tons/year
- Avoided Surface Runoff: 100.6 million gallon/year ($899 thousand/year)
- Building Energy Savings: $2,240,000/year
- Replacement values: $2.2 billion

In densely populated urban areas, air pollution can be of great concern to the community. Human health, ecosystem processes, visibility and safety are all risks associated with the impacts of poor air quality. The urban forest can improve air quality by reducing air temperature, removing pollutants from the air and reducing energy consumption in buildings. This ultimately reduces emissions from building power sources. An increase in urban canopy can also lead to reduced ozone formation. The pollutants identified for removal included ozone ($O_3$), carbon monoxide (CO), nitrogen dioxide ($NO_2$), particulate matter less than 2.5 microns (PM2.5), particulate matter less than 10 microns and greater than 2.5 microns (PM10), and sulfur dioxide ($SO_2$). Pollution removal was greatest for PM2.5 within the study area.

It is important to note that trees emit volatile organic compounds (VOCs) that can contribute to the formation of ozone. In 2025, an estimated 943.1 tons of VOCs will be emitted by the trees in the i-Tree Eco assessment. 85% of the urban forest's VOC emissions were from live oak and Shumard oak.

Carbon storage and sequestration is another service in which the urban forest can offset the impacts of climate change. Trees reduce the amount of carbon entering the atmosphere by sequestering carbon in new growth each year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of the trees is about 21.88 thousand tons of carbon per year with an associated valuation of $9.47 million. Net carbon sequestration in the urban forest is about 17.3 thousand tons. Carbon storage is also essential to mitigate the effects of a changing climate.

Within the study area, trees store an estimated 495,000 tons of carbon ($214 million). Of the species sampled, pecan stores the most carbon (approximately 18.1% of the total carbon stored) and live oak sequesters the most (approximately 20.1% of all sequestered carbon).

Annual oxygen production is one of the most cited benefits of an urban forest. Oxygen production is directly related to the amount of carbon sequestered by a tree and the accumulation of tree biomass. Trees within the study area produce an estimated 46.14 thousand tons of oxygen per year. Live oak produced the highest amount of oxygen within the urban forest at 10.19 thousand tons of oxygen per year.

Stormwater and surface runoff throughout urbanized areas can contribute to pollution and increase flooding. Street trees and shrubs are beneficial in avoiding surface runoff, as they intercept precipitation via their canopy while their root systems increase infiltration and soil storage. Trees of Grand Prairie help to reduce runoff by an estimated 101 million gallons a year with an associated value of $900,000.

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. Trees of Grand Prairie are estimated to reduce energy-related costs from residential buildings by $2,240,000 annually.

Urban forests have a replacement 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 replacement value of an urban forest tends to increase with a rise in the number and size of healthy trees. Urban trees within the City of Grand Prairie were estimated to have a replacement value of $2.2 billion and a carbon storage value of $214 million. The top three tree species with the greatest replacement value are live oak, sugar hackberry and cedar elm.

# 5.0 Discussion

## *5.1 Urban Forest Structure*

Based on the results of the UTC and i-Tree Eco analyses, the Grand Prairie's urban forest provides immense ecological and socioeconomic value. Understanding the structure and function of the urban forest is vital to planning and executing effective management. A summary of the structure and function of Grand Prairie's urban forest is provided below, along with how it compares to other cities both within and outside of the Dallas-Fort Worth area.

Important characteristics from i-Tree Eco analysis regarding the structure of Grand Prairie's urban forest are summarized below:

- Trees surveyed across all plots: 1,247
- Species richness (n) across surveyed trees: 52
- Percentage of surveyed trees below 6 inches DBH: 63.9%
- Percent native status (Texas and North America) of trees surveyed: 94%
- Estimated tree density: 52 trees/acre
- Estimated number of trees found within the City: 3,281,000

It is estimated that the City of Grand Prairie's urban forest consists of approximately 3,281,000 trees. These trees are further estimated to have a density of 52 trees per acre within the study area.

Based on all collected data, the structure of the City of Grand Prairie's urban forest follows trends seen in other cities throughout the Dallas-Fort Worth area. Approximately 63.9% of trees within Grand Prairie's urban forest are under 6 inches DBH. This is an indication that many stands of trees within the city are of a younger age class or contain many trees of a younger age class. While a higher number of younger trees provides indication that older trees are likely to be replaced, planned urban forest management actions must include directed efforts to ensure those younger trees reach maturity to maximize replacement value.

Urban foresters generally recommend no more than 10% of an urban forest's tree population be made up of a single species nor should 20% of the tree population be made up of a single genus. Grand Prairie's urban forest is made up of approximately 52 species of tree. Despite a high species richness, sugar hackberry (21.6%), cedar elm (18.1%), American elm (14.4%), and green ash (11.7%) each surpass 10% of the total urban forest tree population. While sugarberry provides important ecosystem services such as oxygen production and a wildlife food source, outside of continuous stands of trees this species is prone to structural failure and relatively short-lived. Based on this information, urban forest management must include a plan to replace these trees over time to ensure growth and sustainment of the overall urban forest.

As mentioned above, 52 species of tree are found in Grand Prairie's urban forest. Of these 52 species, 94% were determined to be native to both Texas and North America. The remaining 6% are exotic to both Texas and North America. In planning urban forest management actions for the City of Grand Prairie's urban forest, one must distinguish between introduced and invasive species, as species and size diversity are both indications of a healthy urban forest. Invasive species are introduced species which have been determined to cause economic or environmental harm due to prolific or ecological destructive tendencies. However, many introduced species which are not considered invasive do in fact provide measurable structural and functional value to an urban forest, such as common crape myrtle which is in the top 20 oxygen producing species within the study area. While adding to species diversity and providing ecosystem services, introduced species are generally less adapted to regional conditions than native species. Based on this information, management objectives for Grand Prairie's urban forest should focus on both planting and replacing introduced species with a diverse selection of native alternatives which will continue to maintain high species richness and ecosystem service value within Grand Prairie's urban forest. Additionally, invasive *Ligustrum* presents an established threat to the long-term health of the urban forest. Management should also focus on effective removal and suppression of invasive *Ligustrum*, where it can be effectively controlled.

Forest structure must be considered when managing an urban forest for resilience against pests and disease. Within Grand Prairie's urban forest, over 50% of all trees are represented by only two genera (elms (cedar and American) at 32.5% and hackberry at 21.6%). Three major pest problems were identified by the i-Tree Eco model to potentially affect susceptible Grand Prairie trees: Dutch elm disease, heterobasidion root disease, and oak wilt. These diseases are capable of indiscriminate mortality in applicable genera where they occur. Based on this information, it should be noted that an outbreak of these diseases could have a substantial impact on Grand Prairie's urban forest.

In terms of how urban forest structure is distributed per land use area, the top three land uses in terms of canopy coverage within the study area are Open Space/Drainage (42.6% of the overall city canopy coverage), followed by Parks and Recreation (21.9% of the overall city canopy coverage), and finally Low Density Residential (19.6% of the overall city canopy coverage). This is supported in both the UTC and i-Tree Eco analyses, as these three classes were depicted to contain the most leaf area in both datasets. Threats to canopy loss must account for the susceptibility of lands to development; an activity which generally includes clearing of trees.

Open Space/Drainage has the highest percentage of urban tree canopy within the study area. Some of these lands are under public ownership (e.g., city-owned or managed); however, large areas of this land use class are under private ownership. For portions of the Open Space/Drainage land use class under public ownership or management, such as those associated with Joe Poole Lake, there is a regulatory barrier against tree removal on these lands. Many of lands classified as Open Space Drainage are also associated with the floodplain of major tributaries to the Trinity River within the study area (e.g. Fish Creek, Cottonwood Creek, Mountain Creek, Johnson Creek, etc.). Some of these areas are narrow; however, in most instances contain stretches of near continuous canopy coverage. These relatively fragmented components of the urban forest are somewhat protected by floodplain requirements associated with developing large tracts of land within the floodplains of larger tributaries river; however, due to near "hands off" management in this areas, invasion of *Ligustrum* is also an issue, as downcutting of stream channels causes floodplain disconnection, which in turn creates conditions for increase in woody plant cover due to partial or total loss of natural disturbance (flooding) which historically influenced the diversity and density of understory vegetation. Despite challenges which discourage development within major floodplains which inadvertently prevents tree canopy loss, land clearing for utility crossings within floodplains still occurs. This is most visible on aerial imagery as large, linear gaps in tree canopy cleared for power lines and other utilities. An additional consideration is the distribution of tree canopy within the southern portion of the study area, which includes the ETJ. Much of these lands are larger acreage, under private ownership, and otherwise developable, which makes them vulnerable to canopy loss in the future. Summarily, while some of these areas are unlikely to experience large losses of tree canopy (e.g. areas under public ownership and management, bulk canopy loss within the southern portion of the study area is possible in the near future, as land use changes from undeveloped to residential is already observable in recent years. It should be noted that while residential areas generally require replanting of trees that, if properly maintained, will mature and increase UTC, these UTC gains would likely not be seen for several years as canopy increase was observed in newer Low Density Residential areas between 2010 and 2022 (a 12-year period).

The second highest percentage of urban tree canopy within the study was determined to be in the Parks and Recreation land use classification. The land area under this land use classification is under public ownership and management, mostly as City parks scattered through the City or USACE project lands associated with Joe Poole Lake. Management of UTC within these areas is variable, as high use areas with many individual or scattered groups of trees such as golf courses or ball fields require routine maintenance to maintain clearance and minimize risk of a tree or tree part failure impacting a target (e.g. people or property). In contrast, areas that contain more contiguous tree canopy such as those which surround Joe Poole Lake or in parks that contain major tributaries, and portions of their floodplains, such as Fish Creek Linear Park, Kirby Creek Park, or Fish Creek Forest Preserve are mostly left alone, with minimal management. Of note, the many of the visited i-Tree plots within this land use classification contained invasive privets; however, the privet infestation scores were distributed as mostly 1s or 2s. As these areas are under public ownership and management, the forest stands in this land use classification present strong candidates for localized control of *Ligustrum*, as results of the privet assessment indicate the level of *Ligustrum* infestation is likely manageable, at least in portions of these areas. Lower privet scores indicate less dense and smaller stands of privet that, in some cases, are limited to sapling-sized individuals that could be managed by hand with minimally trained volunteers or removal by specialized contractor.

Tree canopy within the Low Density Residential land use class was somewhat high (19.6% of the overall city canopy coverage) and is generally characterized by individual trees in yards in Low Density Residential areas. A notable observation is the difference in species assemblages between older and newer neighborhoods. In older neighborhoods, tree species such as Callery pear (*Pyrus calleryana*) or Arizona ash *(Fraxinus velutina*) were observed – many of which displayed signs of past or near-future tree part failure such as bark scarring indicative of previous large branch failures, cracking, or poor growth habit which can facilitate either partial or total tree failure under the right conditions. These species can be found in older neighborhoods throughout the Dallas-Fort Worth area and are generally short-lived and prone to failure. Species assemblages in newer neighborhoods generally include longer-lived species with more favorable growth habits such as live oak and cedar elm. Based on this information, threats to canopy loss within the Low Density Residential land use class include the eventual loss of larger, short-lived tree species, such as those mentioned herein, in older neighborhoods. A management strategy to mitigate for this eventual loss of tree canopy would be to encourage the planting of long-lived, native tree species in newer residential areas to offset anticipated future canopy loss in older neighborhoods.

Summarily, residential areas are generally losing and gaining canopy at comparable rates. UTC within the Parks and Recreation land use class areas is generally protected from canopy loss due to regulations and inaccessibility to development; however, while some of the Open Space/Drainage land use class is under public ownership or management, large areas are also under private ownership and are more susceptible to large scale canopy loss once developed. It should be noted that amongst the remaining land use classes, percentage of the overall UTC within the study area did not exceed 6% for any one land use class in contrast to the three highest percentage UTC covered land uses classes that all had around 20% or higher UTC. This indicates that urban forest management of UTC within the remaining land use classes is likely nuanced, and each should be further scrutinized to determine effective UTC management techniques and practices which consider the general trends of progression and growth of each land use class.

## *5.2 Urban Forest Function*

The functionality of an urban forest can be best described as the quantifiable economic and environmental benefits it provides. Urban forest functionality is directly related to urban forest structure, as different species and age classes of trees provide discrete benefits. Urban forest managers can best use this information to develop strategic planting plans to address community-specific issues. Urban forest functional values include oxygen production, carbon storage and sequestration, air pollution removal, avoided runoff, and energy savings. A detailed discussion of these values is provided in the i-Tree Eco report found at the end of the document. These functional values contribute to a replacement value for each species which considers both the cost of replacing each tree with a similar tree and the functional values each tree species provides.

In Grand Prairie's urban forest, the overall replacement value for all trees combined is estimated at $2.2 billion. The top three trees with the highest replacement value are live oak, sugar hackberry, and cedar elm. Cedar elm and live oak are used throughout the Dallas-Fort Worth area as landscaping trees due to both aesthetic and functional value. These two species can be purchased and planted from most local nurseries making them excellent choices for replacement or new plantings. Sugar hackberry is generally avoided as a landscaping tree due to a tendency to develop structural problems, susceptibility to various pests and diseases, and simply because it drops larger quantities of leaves and berries that can be aesthetically unappealing/require more maintenance to manage. While sugar hackberry has significant ecological value as wildlife food source, pollinator host plant, and dominant component of many forest stands in north central Texas, other native alternatives should be used instead, in consideration of species-specific tendencies that many increase maintenance costs over time. This issue is addressed in the urban forest management recommendations found at the end of this document.

While not truly quantified in the i-Tree Eco analysis, Grand Prairie's urban forests provide high wildlife value. On a basic level, wildlife requires habitats which provide food, cover, water, and space. In urban settings, these resources are sometimes separated by expanses of developed areas, which forces wildlife to move between "habitat islands" to acquire these necessary resources. This separation of vital life resources in urban environments emphasizes the importance of forested corridors to wildlife by providing a means to safely navigate between habitat components and contain vegetation mosaics which can provide food, cover, and space. Evidence of wildlife use is found throughout the Grand Prairie urban forest in the form of tracks, nests, or even the organisms themselves. Summarily, while a quantifiable value for wildlife was not calculated in this study, overwhelming evidence of wildlife use found throughout the study area indicates that the urban forest provides high wildlife use value, even in areas with high human activity.

### *5.3 Urban Forest Comparison*

Comparing the structural or functional values of urban forests across various communities is challenging because many physical, social, and natural attributes influence the level and quality of any community's urban forest. This is easily recognizable at a national scale, but even still at a regional scale. Comparing data for other studies in north central Texas demonstrates this notion. For example, the City of Dallas documented far greater numbers of individual trees and functional value based on the size of the study area alone. Canopy cover percentage was comparable, albeit with greater stems per acre and more documented species. All results were influenced by the Greater Trinity Forest which occupied one-sixth of the assessment area (Dallas, 2015). One sees similar influences with the City of Arlington, which includes the West Fork Trinity River and numerous major tributaries in its assessment area. Although a larger study area, percent canopy cover and stems per acre were comparable to the City of Grand Prairie (Arlington, 2009). The City of Mesquite showed higher percentage canopy coverage and had higher estimated stems per acre; however, also a higher percentage of trees below 6 inches DBH (Mesquite, 2012). The City of Denton had higher percentage canopy cover, lower stems per acre, and a lower number of species; however, it had a higher percentage of native species and post oak (a tree with high replacement value) as a common tree species (Denton, 2016). The City of Lewisville had comparable canopy cover, the same three most common tree species as in Grand Prairie, and a higher percentage of trees under 6 inches DBH. Sugar hackberry, cedar elm, and American elm in some combinations are listed as the most common species across the suite of regional studies. Summarily, Grand Prairie's urban forest generally follows regional trends seen in other cities in the region, such as similar most common tree species and higher percentage of stems below 6 inches DBH. See Appendix A for list of similar statistics with other North American cities.

# 6.0 Recommendations

## *6.1 Refine Municipal Urban Forest Management Strategies and Objectives*

Implementation of any of the following recommendations will require a unified effort between city staff and departments. An Urban Forester or Program Manager (and certified arborist) may be best suited to unify and coordinate urban forest goals and objectives between the city manager, public works, development services, transportation and storm water, parks and recreation, planning, economic development, and elected officials. This is the first step towards measures such as:

- Developing a comprehensive tree management program for the care of trees on city-managed property;
- Formalizing a policy for ongoing training for staff working in urban forestry;
- Implementing a training program for city staff and/or contractors working near trees on city property;
- Establishing a policy that all tree work on city property be supervised by a certified arborist; and
- Developing annual work plans for routine operations to establish a budget dedicated to urban tree care.

Goals and objectives towards balancing tree preservation and development should be developed, followed by a collaborative review of the portions of the development code that influence the maintenance of the urban forest (e.g. tree replacement; tree mitigation fees). If desired, the Tree Board (or an urban forestry advisory council) can educate the citizens at large on the importance of trees, interact directly with elected officials in support of the program, assist in maintenance tasks like isolated tree maintenance, mulching, planting, and watering, and apply for grants and generate private financial donations.

## *6.2 Improve and Modify Existing Tree Protection Regulations*

In planning urban forest management objectives, historic forest composition must be considered when creating effective, longevity-based management actions. Within the City of Grand Prairie, the three highest replacement value trees are live oak, sugar hackberry and cedar elm. Historic accounts of the region indicate that cedar elm and sugar hackberry were important components of pre-settlement ecosystems within the lands which would become the City of Grand Prairie. Sugar hackberry is not a favorable choice in terms of landscape maintenance; however, should receive equal protection to other native species when considering tree preservation requirements, provided the species makes up over 21.6% of the tree population in Grand Prairie. Despite a native range that may not quite extend into the Grand Prairie city limits, live oaks are hardy, drought tolerant trees which are well adapted to both the high and low temperature extremes of the region and are important staples of urban forests throughout Texas. While deliberately replanting sugar hackberry in landscaping is not recommended, this species has pathways to natural dispersal through birds and other means that allow the species to persist in natural forest stands, meaning that while it is not the ideal choice as a landscape tree, it should be given equal protection to other locally important species such as cedar elm or American elm, where it is found. While sugar hackberry is not a desirable specie for landscaping, live oak and cedar elm are both sound choices. Summarily, these trees provide high structural and functional value to the urban forest and should be protected, if possible, as the cost of replacement is higher than other species.

Localized tree regulations in urban areas (e.g. municipal tree protection or preservation requirements) must consider the composition and structure of the urban forest. Sustainment of the urban forest must consider not only trees that have attained a size to manifest as UTC, but also those trees that would eventually attain those sizes. This study identified that over 60% of the trees in Grand Prairie are very likely under 6 inches DBH, and many are likely Protected Trees (American elm or cedar elm), as currently defined (e.g. any species of tree eight caliper inches or more in size that is not an Unprotected Tree). Currently, the City requires a tree survey of all trees in disturbance areas that have attained a size of 8 inches or greater DBH. The current 8-inch DBH standard leaves many younger canopy and understory trees largely unprotected, except when used selectively for credit (e.g. 3-to-8-inch desirable species). Ecologically, this somewhat undervalues forest regeneration, understory diversity, and could undermine long term canopy preservation. In collaboration with the City and in consideration of study results and the above discussion, it was determined that the tree survey size requirement should be reduced to 6 inches, to better reflect the current composition and structure of the current urban forest (e.g. (e.g. a high percentage of trees under 6” that are likely Protected Trees, as current defined in existing tree protection requirements).

Further collaboration with the City yielded that current tree survey requirements do not include an validity period on tree surveys. Simply put, trees grow larger in diameter over time and older stands of desirable trees have a higher mitigation cost under current regulations. A challenge in determining a tree survey validity period is identifying the action threshold where trees on a given site have increased in size enough to warrant another tree survey. Primary sources on the growth rates of economically profitable tree species such as loblolly pine (*Pinus taeda*) are common; however, studies on the growth rates on other tree species with lesser economic value, in terms of DBH, are far fewer. While an older and limited study, Bull (1945) provides 10-year growth rates for the four most common tree species in the City of Grand Prairie (sugar hackberry, cedar elm, American elm, and green ash). The 10-year growth rates provided in Bull (1945) for trees cut in an improvement cutting are provided below for each species:

| Species (Common and Scientific Name) | Average 10-year Growth Rate (DBH) | Maximum 10-year Growth Rate in Improvement Cutting (DBH) |
|---|---|---|
| American elm (*Ulmus americana*) | 3.3 | 6 |
| Sugar hackberry (*Celtis laevigata*) | 2.0 | 4 |
| Cedar elm (*Ulmus crassifolia*) | 2.1 | 3 |
| Green ash (*Fraxinus pennsylvanica*) | 1.0 | 2 |

Utilizing this information from Bull (1945), the estimated 5-year growth rates for each species are provided in the table below:

| Species (Common and Scientific Name) | Average 5-year Growth Rate (DBH) | Maximum 5-year Growth Rate in Improvement Cutting (DBH) |
|---|---|---|
| American elm (*Ulmus americana*) | 0.7 | 1.2 |
| Sugar hackberry (*Celtis laevigata*) | 0.4 | 0.8 |
| Cedar elm (*Ulmus crassifolia*) | 0.4 | 0.6 |
| Green ash (*Fraxinus pennsylvanica*) | 0.2 | 0.4 |

Based on these diameter growth rate estimates, all species, save for green ash, have the potential to increase in size by at least 0.5 inches over a 5-year period. While 5-year DBH gains are individually small per tree, these trees are often found in forest stands alongside each other and would likely exhibit a notable increase in the overall caliper inches on a given site. Provided current tree mitigation requirements are based on caliper inches of Protected Trees to be removed and the estimated growth rates for a 5-year period for the most common tree species in the City provided above, it is recommended that tree surveys should only be valid for 5 years, in consideration of long-term sustainability of the urban forest.

A small portion of the study area occurs within the Cross Timbers ecoregion of Texas. At the local level, concentrated stands of post oak and blackjack oak which are characteristic of this ecoregion can be found across Grand Prairie, and should be preserved whenever possible, as the presence of these trees in tandem generally indicates a historic stand of Cross Timbers forest, which is gradually disappearing from its native range. Additionally, in terms of ecological succession, both post oaks and blackjack oaks are intolerant of shade and competition, and grow slowly, Post oaks do not transplant well, adding to replacement complexity. This makes existing post oaks and blackjack oaks of high ecological value and protection of individual post oaks and blackjack oaks of any size should be incentivized.

Major objectives of tree protection or preservation requirements generally align with maintaining or increasing UTC. Within the City of Grand Prairie, Protected Trees, as currently defined, generally consist of native tree species that attain a substantial size at maturity (e.g. provide a substantial amount of UTC at maturity). Per i-Tree results, the most important native tree species within the City include sugar hackberry, cedar elm, green ash, American elm, live oak, pecan, Shumard oak, eastern cottonwood, honey mesquite, and boxelder (*Acer negundo*). Of these species, sugar hackberry, green ash, honey mesquite, and eastern cottonwood are currently considered “Unprotected Trees”. This follows regional trends in terms of tree regulations, as major municipalities in the DFW area generally do not protect these species for various reasons; however, at the local level, tree protection and mitigation regulations must consider the composition and structure of the urban forest.

Sugar hackberry encompasses over 20% of trees in Grand Prairie, indicating these trees are also a substantial component of the overall UTC. Eastern cottonwood is in the top three oxygen producing species in the City and provides numerous ecological benefits, including in riparian areas. Based on this information, mitigation for sugar hackberry and eastern cottonwood should include mature trees that are most likely to manifest as UTC. For sugar hackberry, mature trees are generally 18 inches DBH (Sullivan, 1993). For eastern cottonwood, mature trees are generally 35 years old, and DBH is highly variable at 10 inches to more than 6 feet (Taylor, 2001). Based on this information, and in consideration of the importance of the two species to Grand Prairie's urban forest, it is recommended that eastern cottonwoods and sugar hackberries 18 inches or greater should be considered Protected Trees in the interest of urban forest longevity. In the case of sugar hackberry, leaving individuals of this species Unprotected below 18 inches may help reduce the current 21.6% to a percentage closer to 10%, as urban foresters generally recommend no more than 10% of an urban forest's tree population be made up of a single species nor should 20% of the tree population be made up of a single genus.

Honey mesquite and green ash are also ecologically important species; however, both have biological characteristics that must be considered when evaluating protective measures for these species. Honey mesquite generally assumes one of three growth forms (a single-stemmed tree reaching 20 to 40 feet in height, with crooked, drooping branches or an erect, multiple-stemmed bush or small tree, often 10 to 15 feet tall or a decumbent or running bush (Steinberg, 2001)). Based on the current definition of a "tree" in City regulations, honey mesquites should only selectively be protected, based on growth habit consistent with the current definition (e.g. any self-supporting woody perennial plant which will attain a trunk diameter of three inches or more when measured at a point four and one-half feet above ground level and normally an overall height of at least 15 feet at maturity, usually with one main stem or trunk and many branches). Similar to eastern cottonwood and sugar hackberry, honey mesquites that have achieved a size of 18 inches or more, consisting of one or multiple trunks, that have attained a height of at least 15 feet, should be considered Protected Trees. This recommendation considers that some areas of the City, such as those within the ETJ, have a substantial amount of honey mesquite that likely may have reached sizes to manifest as UTC. Green ash is addressed in section 6.3.

Another consideration is that current tree regulations state "*Protected trees that are preserved shall not count towards mitigation*"; however, required landscaping trees do count toward mitigation. This policy unintentionally rewards removal and replanting over saving existing trees, and in turn UTC. It is recommended that entities be awarded partial or full mitigation credit for preserving Protected Trees. It is further recommended that healthy, Protected Trees 20 inches or greater be considered "Significant Trees", with higher mitigation requirements or incentives for preservation. This prioritizes protection of larger caliper, native trees. "Significant Trees" should also include post oak and blackjack oak, wherever found.

## *6.3 Develop and Maintain Integrated Pest Management Program*

In the context of urban forest management, a pest is any living organism (insect, plant, etc.) that damages the overall health of the urban forest. This includes invasive species but also includes vectors for problematic diseases that may be of either native or non-native origin. Integrated Pest Management (IPM) can be defined as a management plan to effectively deal with pest problems in ways that fully consider ecological and sociological impacts.

There are five general steps to an effective IPM plan:

- Identify – Document pest occurrence and range
- Monitor – Routinely observe and document pest populations
- Action Thresholds – Determine when pest activity or levels require action to prevent further damages
- Intervention – Utilize pest-specific, effective treatments that are ecologically and sociologically acceptable
- Evaluation and Assessment – Determine effectiveness of intervention, monitor pest populations, consult with specialists, set attainable goals which consider budgetary limitations

This study represents the first steps in IPM (e.g. identifying pests that cause problems) that can be utilized to develop more in-depth management plans to protect and improve the health of the urban forest. Study data indicated that seven species of tree are currently found within Grand Prairie that are considered invasive in Texas. These species were Chinese pistache, white mulberry, Persian silk tree (*Albizia julibrissin*), Chinese tallowtree (*Triadica sebifera*), lilac chaste tree (*Vitex agnus-castus*), Chinaberry (*Melia azedarach*), and glossy privet. White mulberry, Persian silk tree, Chinese tallowtree, lilac chaste tree, chinaberry, and glossy privet are pests identified to be ecologically destructive in the north central Texas area. It should be noted that while Chinese pistache is considered to be "invasive" in Texas as a whole, the introduced species does provide clear utility as a landscaping plant due to its resistance to pests and disease, while also being drought tolerant and low maintenance. While native species are the ideal choice, Chinese pistache is used in landscaping through the Dallas-Fort Worth area and does not normally proliferate locally.

Due to a relatively low percentage of invasive trees (approximately 6%), the Action Threshold may be to replace these trees with native alternatives as they decline and die. Another starting point is to remove non-native trees with invasive tendencies from existing recommended planting lists. The following species which are currently considered invasive in Texas are examples of species that should be reconsidered on the current City recommended planting list:

- Golden raintree (*Koelreuteria paniculata*) – outcompetes natives, poor growth habit
- Variegated Chinese privet (*Ligustrum sinense* 'Variegata') – allegedly sterile, but potentially invasive
- Heavenly bamboo (*Nandina domestica*) – outcompetes natives, readily escapes captivity due to birds
- Lilac chaste tree (*Vitex agnus-castus*) – competition with native species, drops plant parts creating a mess in certain circumstances

It should also be noted that many species are included on the planting list that are native to Texas yet are found in environmentally dissimilar regions of the state that may not always be the best fit for the Dallas-Fort Worth area. Some plants, while "native" on paper, may not have the necessary hardiness (ability to endure environmental extremes) to make it through extreme temperature events, most notably an abnormally cold winter, such as winter storm Uri in 2021 which saw temperatures fall below 0 degrees Fahrenheit in the Dallas-Fort Worth area. For example, the current City recommended planting list contains species such as Roemer's acacia (*Senegalia roemeriana*), catclaw acacia (*Senegalia wrightii*), and weeping bottlebrush (*Callistemon viminalis*) which have U.S. Department of Agriculture (USDA) hardiness zones that either do not overlap the DFW area or the DFW area is at the far edges of their minimal cold tolerance. This becomes problematic as when these, or other plants that are native to more arid parts of Texas, are used in landscaping and experience periods of very cold temperatures. They may, either immediately or through gradual decline, succumb to the climatic extremes and potentially become a host for pests as they decay and die. Summarily, part of the IPM may be to update the recommended planting list to only include species that are likely to healthily persist, in consideration of the environmental extremes generally seen in Grand Prairie.

Results of the directed privet assessment provide a generalized overview of the distribution of a highly destructive, known pest (invasive *Ligustrum*) within Grand Prairie. Within the DFW area, invasive *Ligustrum* is a well-known, ecologically destructive pest that can reduce an urban forest's health over time. An IPM plan developed as part of urban forest management planning should include intervention and monitoring for this identified group of pests. Based on results of the privet assessment, ideal candidates for privet removal are tracts within the Parks and Recreation land use classification that may have smaller, less dense stands of privet that could be removed by coordinated groups of volunteer or specialized contractors. Summarily, studies have demonstrated that native plants and pollinators return when invasive *Ligustrum* is removed and within the City of Grand Prairie, effective removal and suppression can be an effective IPM strategy which will improve the health and longevity of the urban forest.

Green ash is an ecologically important species that is generally found throughout floodplains in the southeastern United States. Green ash is found in abundance in the DFW area and is a vector for the invasive, ecologically destructive, wood boring pest emerald ash borer (EAB; *Agrilus planipennis*). EAB has killed millions of ash trees (*Fraxinus* spp.) across the United States. Current EAB recommendations include reduction of *Fraxinus* spp. populations to prevent spread of EAB (USDA-APHIS, 2015). At this time, the i-Tree model indicated that over 382,462 green ash trees exist in Grand Prairie with a leaf area of 10.13 square miles, making up 11.7% of the current estimated number of trees within City. While a vector for EAB, healthy ash trees in natural settings provide ecological benefits such as food and shelter for various wildlife species; however, urban foresters generally recommend no more than 10% of an urban forest's tree population be made up of a single species nor should 20% of the tree population be made up of a single genus. The current urban forest consists of 11.7% green ash trees. To reduce this percentage to the 10% threshold, it is recommended that the City remove all *Fraxinus* spp. from existing planting lists to prevent spread of EAB. Additionally, it is further recommended to incentivize removal of declining *Fraxinus* spp. wherever found, as evaluated by a Qualified Professional (ideally a Certified Arborist). These two practices alone may reduce ash population over time; however, there are ecological benefits of healthy green ash in natural settings. Therefore, it is recommended that green ash be considered a Protected Tree, unless determined to be declining by a Qualified Professional, or displaying signs or symptoms of infestation by EAB (e.g. the organism itself, D-shaped exit holes, epicormic sprouting, crown dieback, serpentine galleries, bark splits, or woodpecker damage; (USDA-APHIS, 2015)).

It should be noted that IPM is an ongoing process, and these recommendations are the starting point. The IPM program should change and evolve over time as new pest issues arise or existing problems reach Action Thresholds, emphasizing the need for routine, active pest monitoring efforts. Furthermore, the IPM program could also address pests outside of trees, providing utility past solely a UTC management tool.

## *6.4 Enhance Urban Forest Health by Organizational or Community Involvement*

Successful urban forest management goals must include plans to ensure they are replaced by trees of comparable structural and functional value. The structure of Grand Prairie's urban forest generally follows regional trends and was determined to be relatively young and contain many trees under 6 inches DBH (approximately 63.9%). One approach to sustainably managing the urban forest for longevity (e.g., self-sustaining replacement of larger trees) is to identify and actively manage younger stands of long-lived, native trees with high functional and structural value to ensure these trees reach maturity. At times, this might consider the preservation of properly placed, healthy and young trees on developing sites, rather than a few individual large old trees. Young trees are often less expensive and easier to preserve and will better serve as the future generation of trees. As trees age in older developed parts of the city, promoting inclusiveness, equity and communication will be key to encouraging individual citizens to become engaged in the process. This may include:

- Continued participation in Tree City USA program
- Educate and empower Tree Board members (Park Board members) to support urban forest management goals
- Pursue and/or maintain partnerships with non-profit or other community organizations to benefit the urban forest
- Organize and support tree-centric events such as Arbor Day and Earth Day that involve and recognize partnerships
- Train and work with volunteers and non-profits to plant and maintain new trees
- Provide affordable young trees for citizens, specifically to encourage plantings in residential areas
- Start municipal nursery to self-produce trees

## 6.5 Conduct Urban Forest Monitoring and Follow-up Studies

Urban forests are unique to their natural counterparts due to higher species richness and variable forest structure. These unique conditions require equally as unique management plans backed by scientific data. The results presented in this study provide a snapshot of the structural and functional values of the current urban forest. These results present what is true for present day conditions; however, parameters are likely to change over time. Effective urban forest management must account for this change and management objectives must be adjusted to reflect these changes. Based on this information, the final recommendation for the sustainment and management of Grand Prairie's urban forest is to recommend future studies to both monitor and adjust urban forest management practices, as these will be required to sustainably manage Grand Prairie's urban forest for longevity. Follow up studies may include subsequent UTC assessments following the framework provided by this, and other regional studies, to gauge parameters such as canopy change over time or invasive species spread and distribution within Grand Prairie.

## 6.6 Protect and Maintain Riparian Forest Buffers

Riparian forest buffers provide a variety of benefits including improved wildlife habitat, reduced erosive "flux flows" from rapid surface runoff, and streambank stabilization. A single fallen dead tree within a stream channel can provide important ecosystem services such as wildlife, fish, and aquatic invertebrate habitat, as well as an instream source of raw elements released from decomposition which can improve water quality. The City of Grand Prairie contains many major tributaries which ultimately flow to the greater Trinity River. Components of the Grand Prairie urban forest which are associated with these watercourses should be protected, if possible, to conserve important ecosystem services these buffer areas provide to aquatic resources. The City should maintain existing regulations that follow these recommendations.

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# APPENDIX A

# i-Tree
# Ecosystem Analysis

## City of Grand Prairie iTree Eco Assessment

Urban Forest Effects and Values
November 2025

## 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 vegetation structure, function, and value of the City of Grand Prairie iTree Eco Assessment urban forest was conducted during 2025. Data from 237 field plots located throughout City of Grand Prairie iTree Eco Assessment were analyzed using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station.

- Number of trees: 3,281,000
- Tree Cover: 22.6 %
- Most common species of trees: Sugarberry, Cedar elm, American elm
- Percentage of trees less than 6" (15.2 cm) diameter: 63.9%
- Pollution Removal: 308.4 tons/year ($1.46 million/year)
- Carbon Storage: 494.6 thousand tons ($214 million)
- Carbon Sequestration: 21.88 thousand tons ($9.47 million/year)
- Oxygen Production: 46.14 thousand tons/year
- Avoided Runoff: 100.6 million gallon/year ($899 thousand/year)
- Building energy savings: $2,240,000/year
- Carbon Avoided: 3.306 thousand tons/year ($1430000/year)
- Replacement values: $2.2 billion

Ton: short ton (U.S.) (2,000 lbs)
Monetary values $ are reported in US Dollars throughout the report except where noted.
Ecosystem service estimates are reported for trees.
With Complete Inventory Projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition. Oxygen production in Plot Inventory Projects is estimated from net carbon sequestration.

The estimate of Tree Cover is derived from user estimations of percent tree cover over plots and extrapolated to the whole study area. For more precise tree cover estimates please use i-Tree Canopy or i-Tree Landscape.

For an overview of i-Tree Eco methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control. Additionally, some of the plot and tree information may not have been collected, so not all of the analyses may have been conducted for this report.

# Table of Contents

# I. Tree Characteristics of the Urban Forest

The urban forest of City of Grand Prairie iTree Eco Assessment has an estimated 3,281,000 trees with a tree cover of 22.6 percent. The three most common species are Sugarberry (21.6 percent), Cedar elm (18.1 percent), and American elm (14.4 percent).

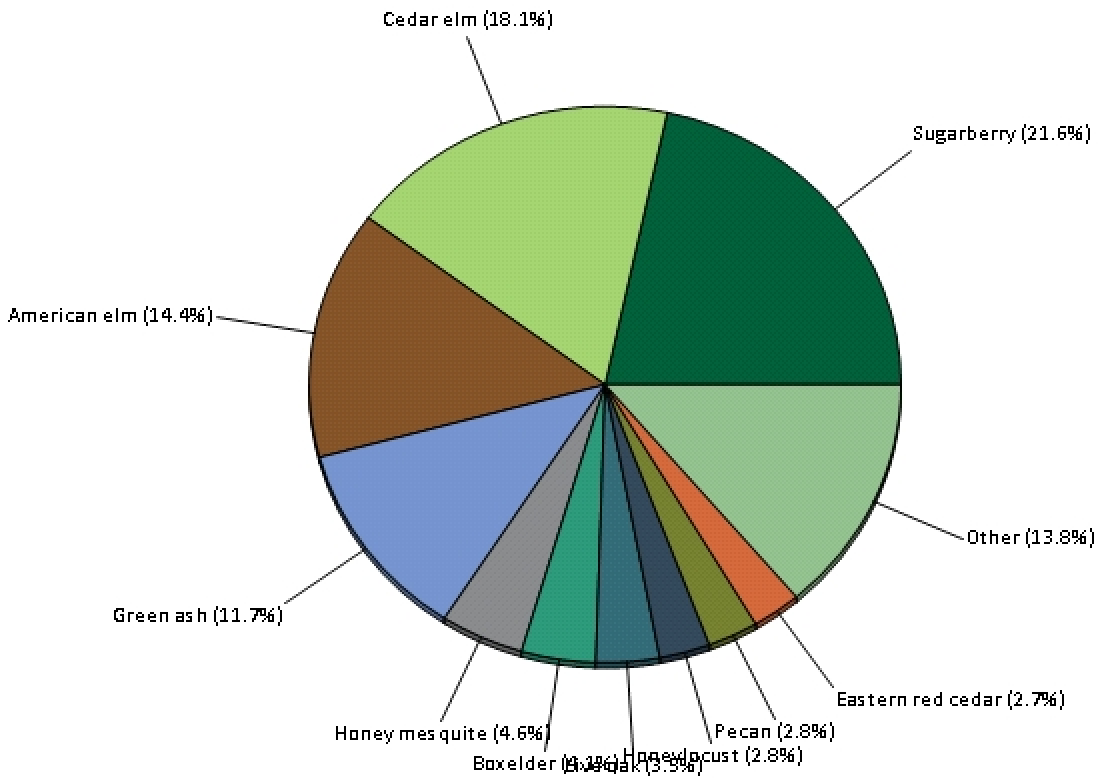



**Figure 1. Tree species composition in City of Grand Prairie iTree Eco Assessment**

The overall tree density in City of Grand Prairie iTree Eco Assessment is 52 trees/acre (see Appendix III for comparable values from other cities). For stratified projects, the highest tree densities in City of Grand Prairie iTree Eco Assessment occur in Parks and Recreation followed by Open Space/Drainage and High Density Residential.

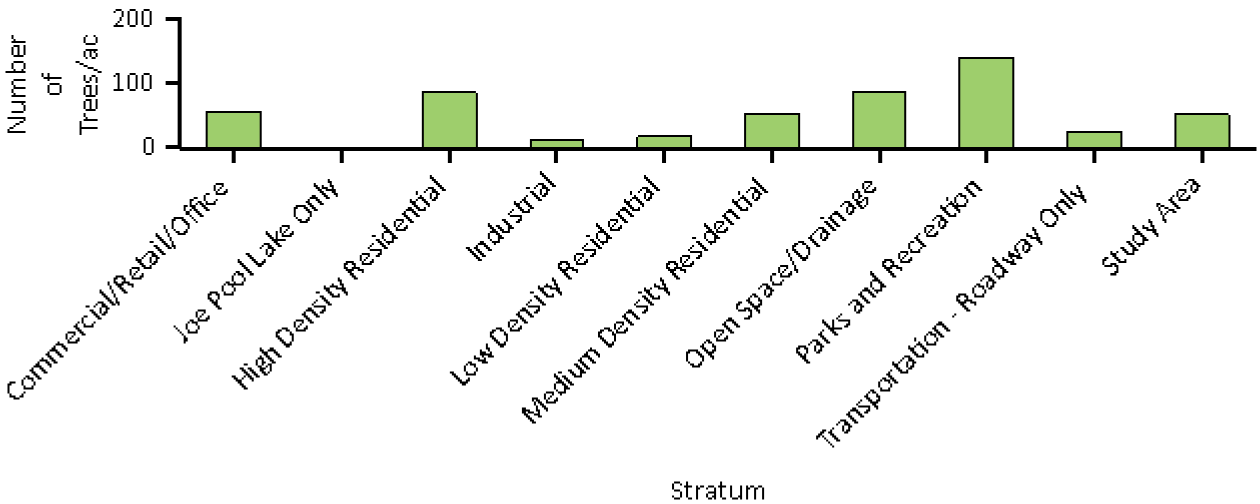



**Figure 2. Number of trees/ac in City of Grand Prairie iTree Eco Assessment by stratum**

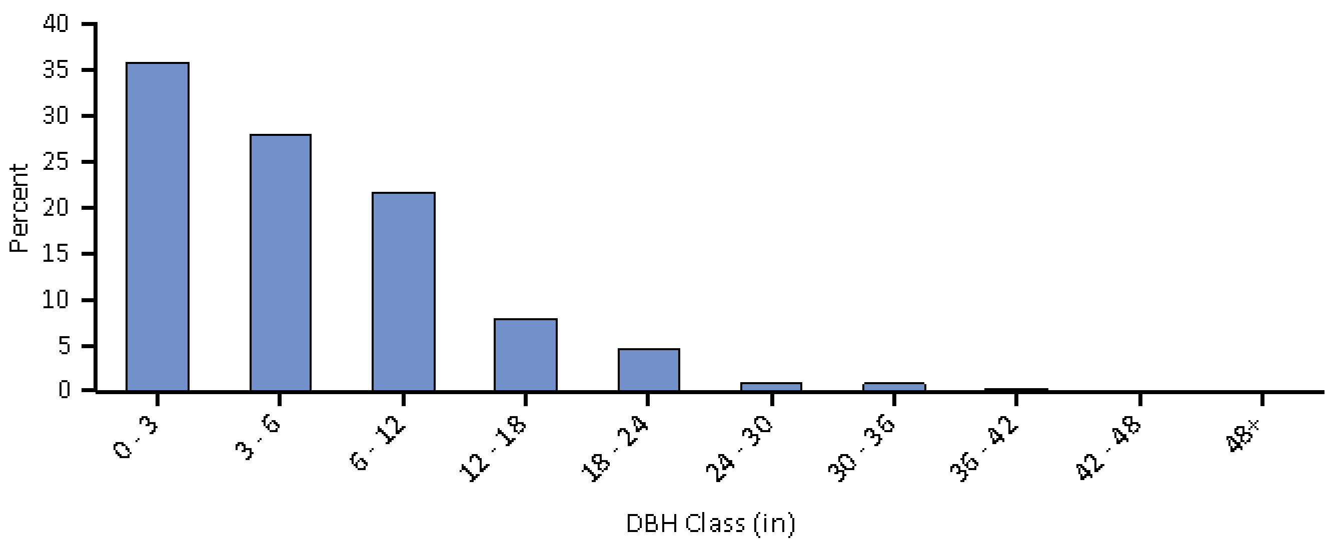



**Figure 3. Percent of tree population by diameter class (DBH - stem diameter at 4.5 feet)**

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. 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 City of Grand Prairie iTree Eco Assessment, about 94 percent of the trees are species native to North America, while 94 percent are native to Texas. Species exotic to North America make up 6 percent of the population. Most exotic tree species have an origin from Asia (4 percent of the species).

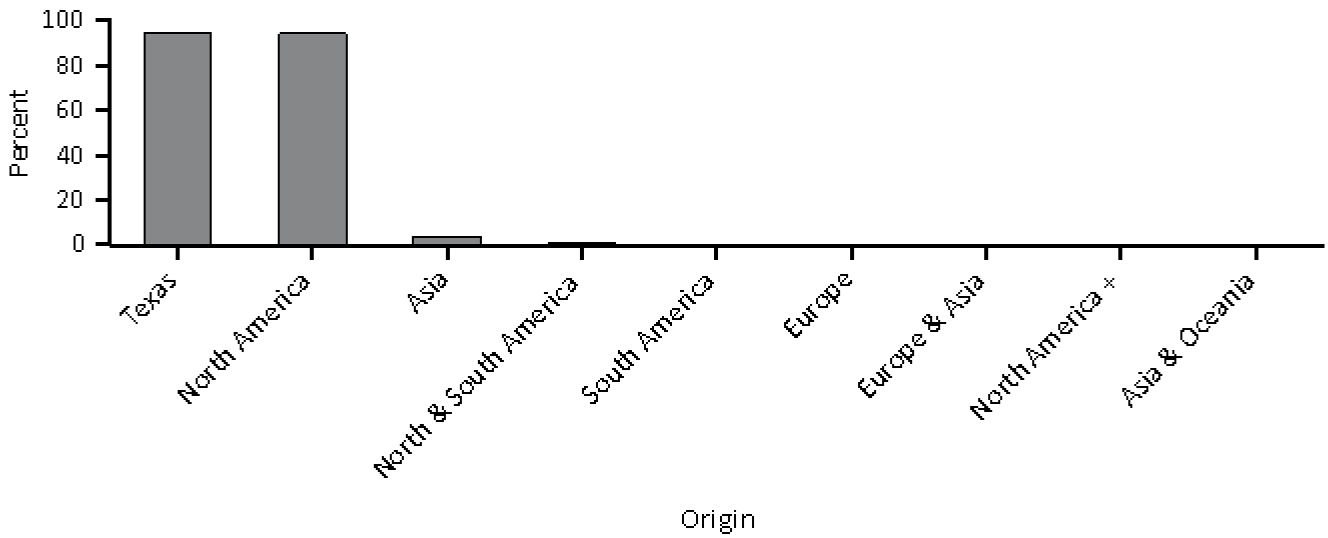



**Figure 4. Percent of live tree population by area of native origin, City of Grand Prairie iTree Eco Assessment**

The plus sign (+) indicates the tree species is native to another continent other than the ones listed in the grouping.

Invasive plant species are often characterized by their vigor, ability to adapt, reproductive capacity, and general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas. Seven of the 52 tree species in City of Grand Prairie iTree Eco Assessment are identified as invasive on the state invasive species list (Watershed Protection Development Review). These invasive species comprise 1.7 percent of the tree population though they may only cause a minimal level of impact. The three most common invasive species are Chinese pistache (0.7 percent of population), White mulberry (0.4 percent), and Persian silk tree (0.3 percent) (see Appendix V for a complete list of invasive species).

## II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. Trees cover about 23 percent of City of Grand Prairie iTree Eco Assessment and provide 62.11 square miles of leaf area. Total leaf area is greatest in Open Space/Drainage followed by Low Density Residential and Parks and Recreation.

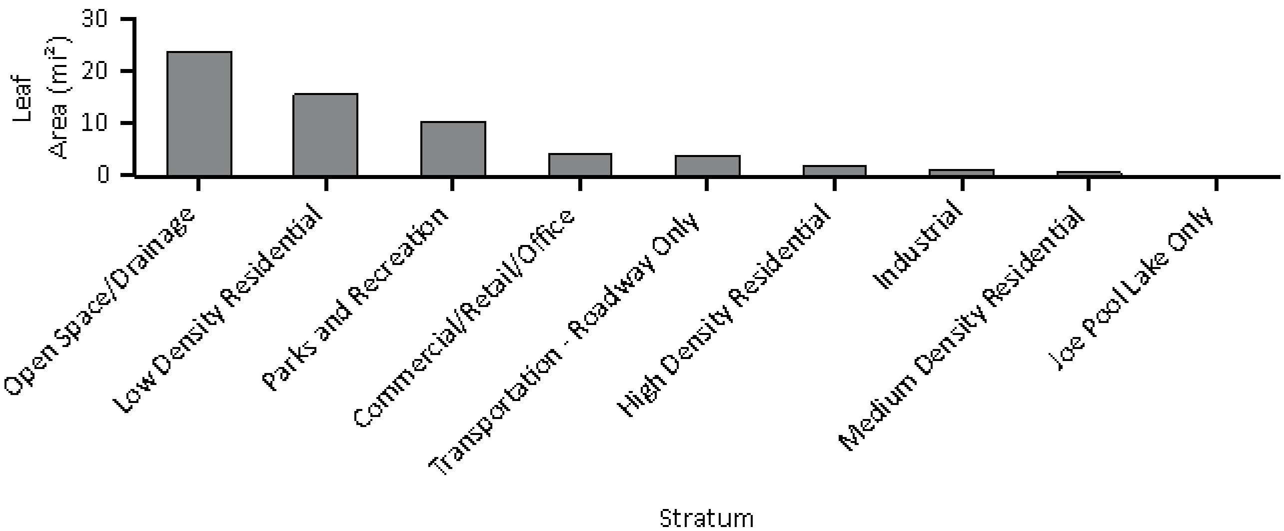



**Figure 5. Leaf area by stratum, City of Grand Prairie iTree Eco Assessment**

In City of Grand Prairie iTree Eco Assessment, the most dominant species in terms of leaf area are Green ash, Sugarberry, and Live oak. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

**Table 1. Most important species in City of Grand Prairie iTree Eco Assessment**

| *Species Name* | *Percent Population* | *Percent Leaf Area* | *IV* |
|---|---|---|---|
| Sugarberry | 21.6 | 15.2 | 36.8 |
| Cedar elm | 18.1 | 10.0 | 28.1 |
| Green ash | 11.7 | 16.3 | 28.0 |
| American elm | 14.4 | 12.5 | 26.9 |
| Live oak | 3.5 | 13.3 | 16.7 |
| Pecan | 2.8 | 8.4 | 11.1 |
| Shumard oak | 0.9 | 5.0 | 5.8 |
| Honey mesquite | 4.6 | 1.2 | 5.8 |
| Eastern cottonwood | 1.0 | 3.7 | 4.7 |
| Boxelder | 4.1 | 0.4 | 4.5 |

Common ground cover classes (including cover types beneath trees and shrubs) in City of Grand Prairie iTree Eco Assessment are not available since they are configured not to be collected.

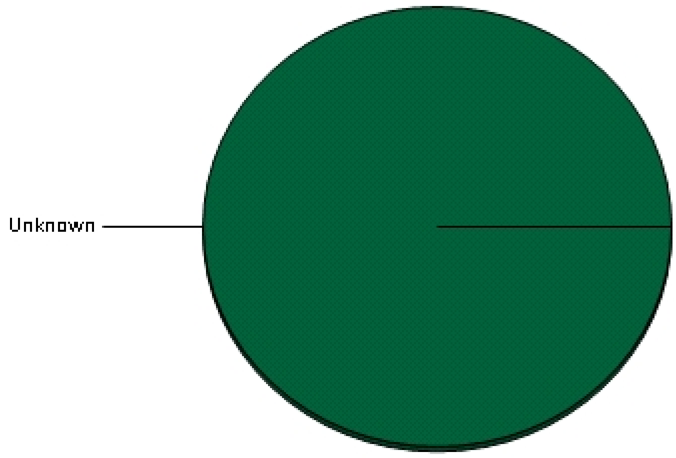



**Figure 6. Percent of land by ground cover classes, City of Grand Prairie iTree Eco Assessment**

## III. Air Pollution Removal by Urban 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 sources. 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 (Nowak and Dwyer 2000).

Pollution removal[1] by trees in City of Grand Prairie iTree Eco Assessment was estimated using field data and recent available pollution and weather data available. Pollution removal was greatest for ozone (Figure 7). It is estimated that trees remove 308.4 tons of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5), particulate matter less than 10 microns and greater than 2.5 microns (PM10*)[2], and sulfur dioxide (SO2)) per year with an associated value of $1.46 million (see Appendix I for more details).

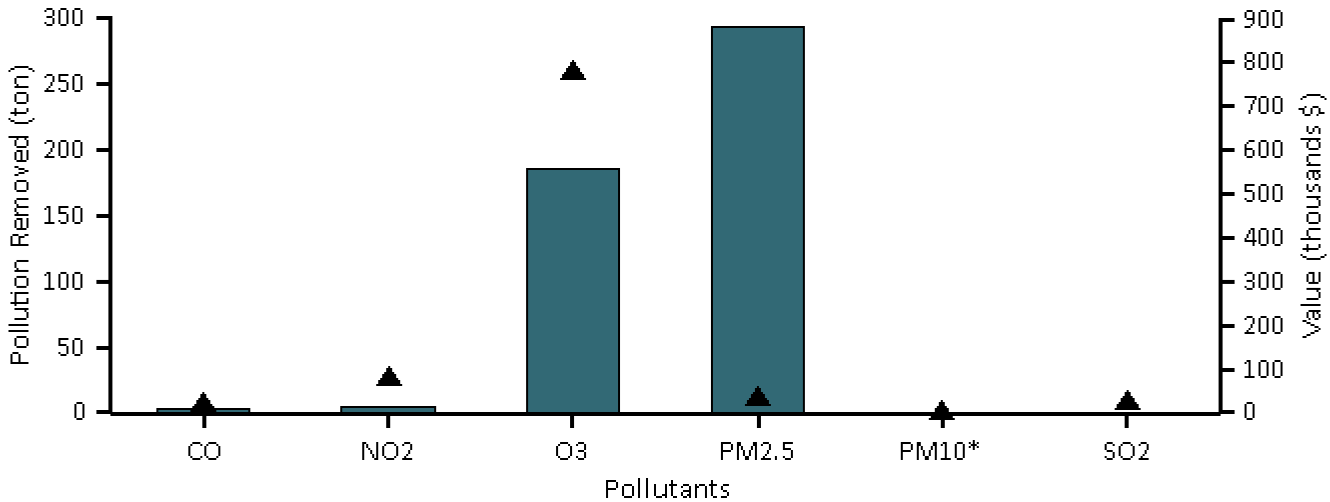



**Figure 7. Annual pollution removal (points) and value (bars) by urban trees, City of Grand Prairie iTree Eco Assessment**

[1] PM10* is particulate matter less than 10 microns and greater than 2.5 microns. PM2.5 is particulate matter less than 2.5 microns. If PM2.5 is not monitored, PM10* represents particulate matter less than 10 microns. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

[2] Trees remove PM2.5 and PM10* when particulate matter is deposited on leaf surfaces. This deposited PM2.5 and PM10* can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors (see Appendix I for more details).

In 2025, trees in City of Grand Prairie iTree Eco Assessment emitted an estimated 943.1 tons of volatile organic compounds (VOCs) (553.3 tons of isoprene and 389.8 tons of monoterpenes). Emissions vary among species based on species characteristics (e.g. some genera such as oaks are high isoprene emitters) and amount of leaf biomass. Eighty- five percent of the urban forest's VOC emissions were from Live oak and Shumard oak. These VOCs are precursor chemicals to ozone formation.[3]

General recommendations for improving air quality with trees are given in Appendix VIII.

[3] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000), but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations.

## IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. 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 sources (Abdollahi et al 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of City of Grand Prairie iTree Eco Assessment trees is about 21.88 thousand tons of carbon per year with an associated value of $9.47 million. Net carbon sequestration in the urban forest is about 17.3 thousand tons. See Appendix I for more details on methods.

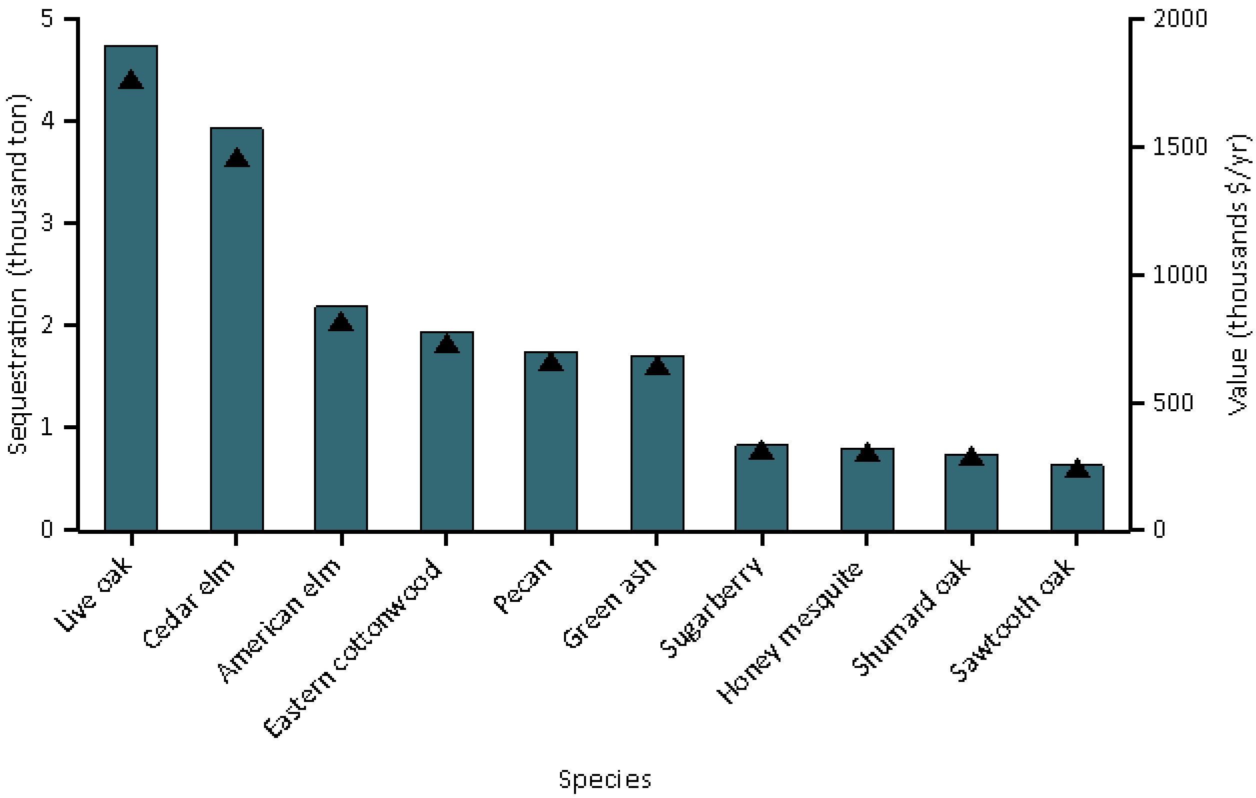



**Figure 8. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration, City of Grand Prairie iTree Eco Assessment**

Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak et al 2002c). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees in City of Grand Prairie iTree Eco Assessment are estimated to store 495000 tons of carbon ($214 million). Of the species sampled, Pecan stores the most carbon (approximately 18.1% of the total carbon stored) and Live oak sequesters the most (approximately 20.1% of all sequestered carbon.)

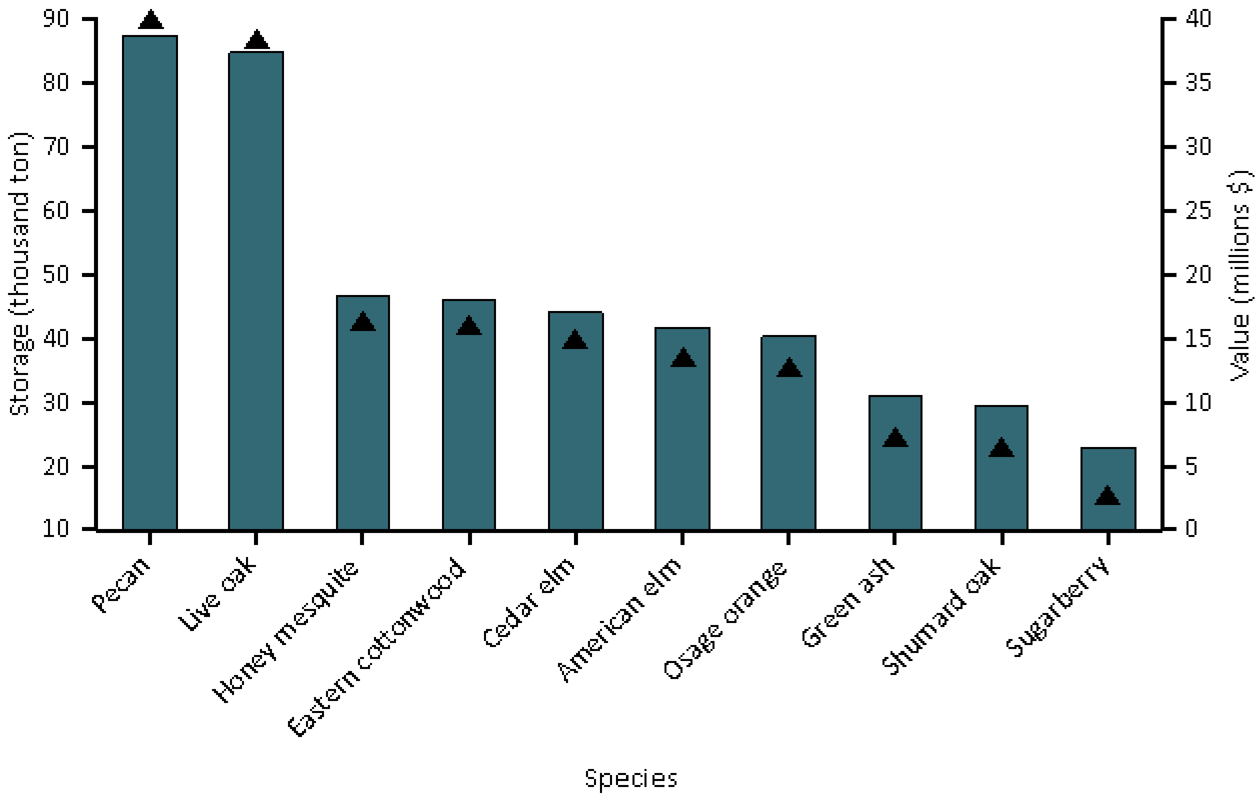



**Figure 9. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage, City of Grand Prairie iTree Eco Assessment**

## V. Oxygen Production

Oxygen production is one of the most commonly cited benefits of urban trees. The net annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in City of Grand Prairie iTree Eco Assessment are estimated to produce 46.14 thousand tons of oxygen per year.[4] However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

**Table 2. The top 20 oxygen production species.**

| *Species* | *Oxygen (thousand ton)* | *Net Carbon Sequestration (ton/yr)* | *Number of Trees* | *Leaf Area (square mile)* |
|---|---:|---:|---:|---:|
| Live oak | 10.19 | 3,821.04 | 113,618 | 8.24 |
| Cedar elm | 8.50 | 3,185.99 | 595,272 | 6.19 |
| Eastern cottonwood | 4.36 | 1,636.73 | 31,646 | 2.32 |
| Green ash | 4.04 | 1,516.67 | 382,462 | 10.13 |
| American elm | 3.45 | 1,294.74 | 473,747 | 7.75 |
| Pecan | 3.44 | 1,289.12 | 90,892 | 5.20 |
| Shumard oak | 1.64 | 616.26 | 28,118 | 3.07 |
| Sugarberry | 1.61 | 605.10 | 709,821 | 9.44 |
| Sawtooth oak | 1.56 | 586.33 | 16,707 | 1.00 |
| Chinese tallowtree | 1.18 | 440.90 | 5,585 | 0.85 |
| Red mulberry | 0.89 | 332.61 | 10,847 | 0.65 |
| Chinese pistache | 0.78 | 292.81 | 21,954 | 0.85 |
| Common crapemyrtle | 0.72 | 270.17 | 43,535 | 0.22 |
| Honeylocust | 0.70 | 262.76 | 90,962 | 0.36 |
| Loblolly pine | 0.52 | 193.82 | 10,349 | 0.61 |
| Boxelder | 0.51 | 191.01 | 133,161 | 0.25 |
| Osage orange | 0.48 | 180.38 | 49,685 | 0.94 |
| Eastern red cedar | 0.41 | 154.21 | 87,884 | 0.95 |
| Baldcypress | 0.36 | 135.89 | 10,847 | 0.43 |
| Bur oak | 0.33 | 124.80 | 23,984 | 0.19 |

[4] A negative estimate, or oxygen deficit, indicates that trees are decomposing faster than they are producing oxygen. This would be the case in an area that has a large proportion of dead trees.

## VI. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi 2012). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees and shrubs, however, are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of City of Grand Prairie iTree Eco Assessment help to reduce runoff by an estimated 101 million gallons a year with an associated value of $900 thousand (see Appendix I for more details). Avoided runoff is estimated based on local weather from the user-designated weather station. In City of Grand Prairie iTree Eco Assessment, the total annual precipitation in 2023 was 31.1 inches.

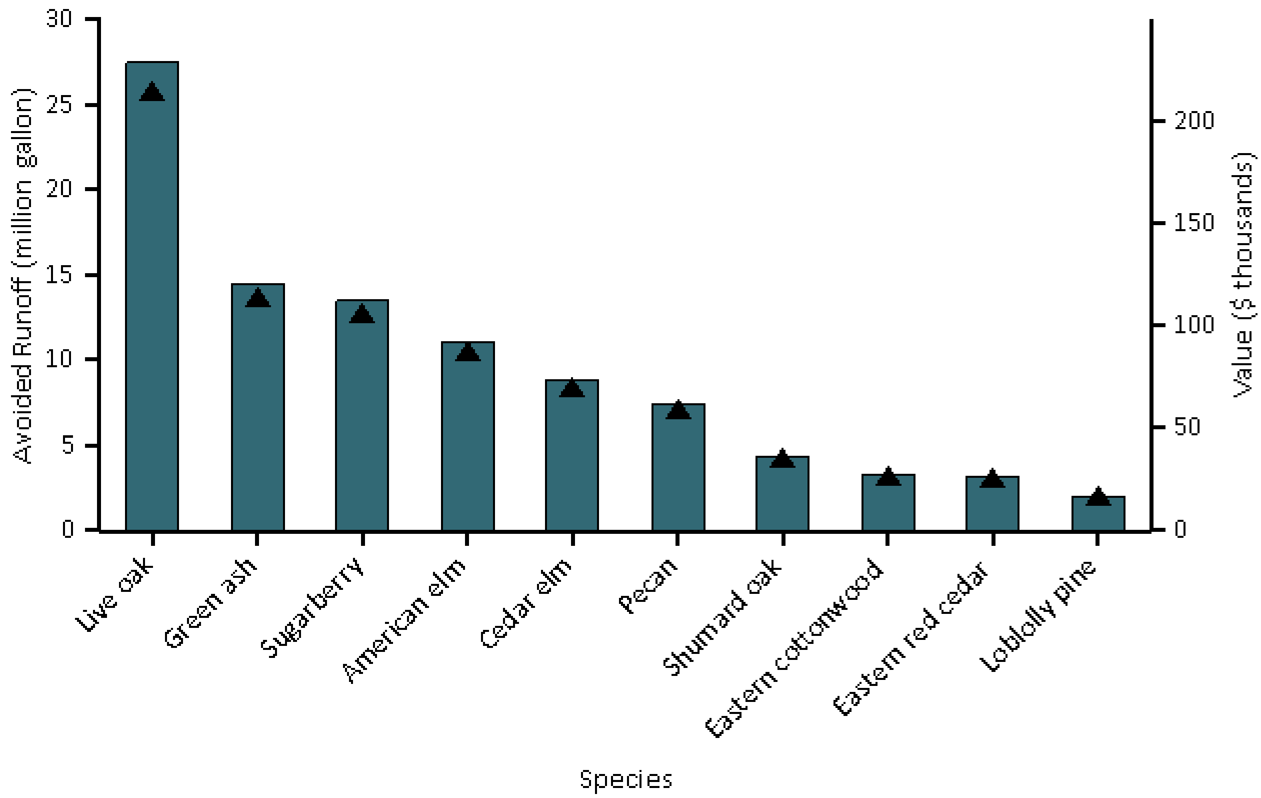



**Figure 10. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff, City of Grand Prairie iTree Eco Assessment**

## VII. 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 (McPherson and Simpson 1999).

Trees in City of Grand Prairie iTree Eco Assessment are estimated to reduce energy-related costs from residential buildings by $2,240,000 annually. Trees also provide an additional $1,430,000 in value by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of 3310 tons of carbon emissions).

Note: negative numbers indicate that there was not a reduction in carbon emissions and/or value, rather carbon emissions and values increased by the amount shown as a negative value.[5]

**Table 3. Annual energy savings due to trees near residential buildings, City of Grand Prairie iTree Eco Assessment**

| | *Heating* | *Cooling* | *Total* |
|---|---|---|---|
| MBTU[a] | 2,226 | N/A | 2,226 |
| MWH[b] | 330 | 17,648 | 17,978 |
| Carbon Avoided (tons) | 110 | 3,196 | 3,306 |

[a]MBTU - one million British Thermal Units

[b]MWH - megawatt-hour

**Table 4. Annual savings [a]($) in residential energy expenditure during heating and cooling seasons, City of Grand Prairie iTree Eco Assessment**

| | *Heating* | *Cooling* | *Total* |
|---|---|---|---|
| MBTU[b] | 31,391 | N/A | 31,391 |
| MWH[c] | 40,614 | 2,170,735 | 2,211,349 |
| Carbon Avoided | 47,493 | 1,383,029 | 1,430,522 |

[b]Based on the prices of $123 per MWH and $14.0999600394705 per MBTU (see Appendix I for more details)

[c]MBTU - one million British Thermal Units

[c]MWH - megawatt-hour

[5] Trees modify climate, produce shade, and reduce wind speeds. Increased energy use or costs are likely due to these tree-building interactions creating a cooling effect during the winter season. For example, a tree (particularly evergreen species) located on the southern side of a residential building may produce a shading effect that causes increases in heating requirements.

## VIII. Replacement and Functional Values

Urban forests have a replacement 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 replacement value of an urban forest tends to increase with a rise in the number and size of healthy trees (Nowak et al 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. 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.

Urban trees in City of Grand Prairie iTree Eco Assessment have the following replacement values:

- Replacement value: $2.2 billion
- Carbon storage: $214 million

Urban trees in City of Grand Prairie iTree Eco Assessment have the following annual functional values:

- Carbon sequestration: $9.47 million
- Avoided runoff: $899 thousand
- Pollution removal: $1.46 million
- Energy costs and carbon emission values: $3.67 million

(Note: negative value indicates increased energy cost and carbon emission value)

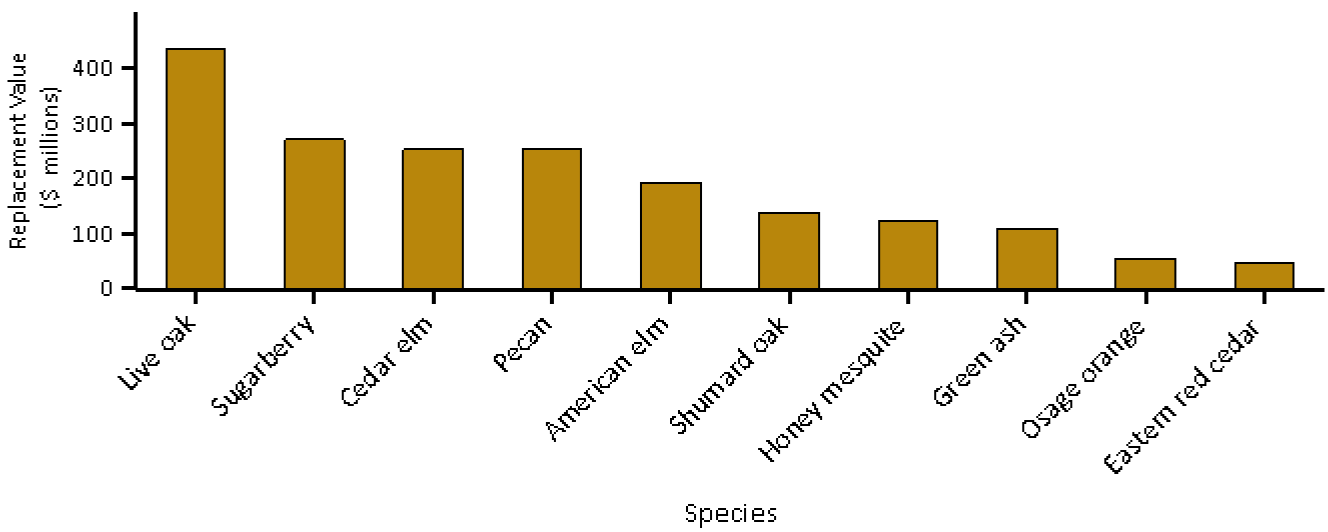



**Figure 11. Tree species with the greatest replacement value, City of Grand Prairie iTree Eco Assessment**

## IX. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, replacement 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 among cities.Fifty-three pests were analyzed for their potential impact and compared with pest range maps (Forest Health Technology Enterprise Team 2014) for the conterminous United States to determine their proximity to Dallas County. Four of the fifty-three pests analyzed are located within the county. For a complete analysis of all pests, see Appendix VII.

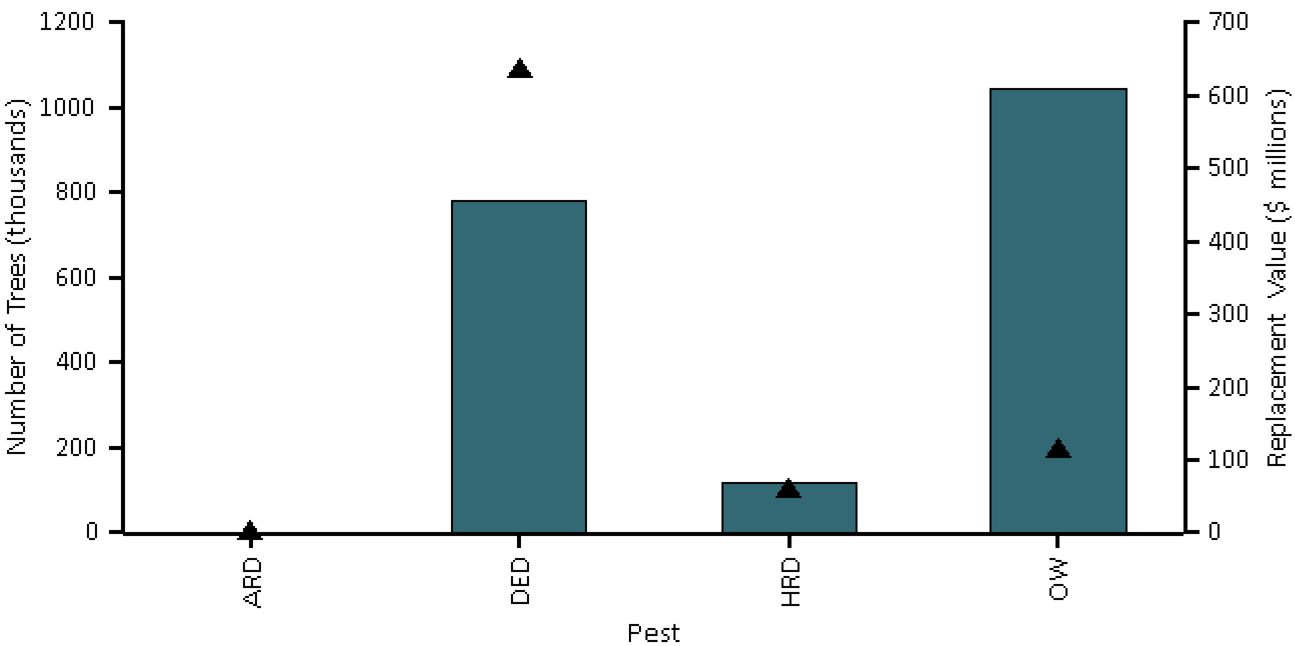



**Figure 12. Number of trees at risk (points) and associated compensatory value (bars) for most threatening pests located in the county, City of Grand Prairie iTree Eco Assessment**

Armillaria Root Disease (ARD) poses a threat to 0.0 percent of the City of Grand Prairie iTree Eco Assessment urban forest, which represents a potential loss of $0 in replacement value.

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch elm disease (DED) (Northeastern Area State and Private Forestry 1998). 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, City of Grand Prairie iTree Eco Assessment could possibly lose 33.1 percent of its trees to this pest ($455 million in replacement value).

Heterobasidion Root Disease (HRD) poses a threat to 3.0 percent of the City of Grand Prairie iTree Eco Assessment urban forest, which represents a potential loss of $69.2 million in replacement value.

Oak wilt (OW) (Rexrode and Brown 1983), which is caused by a fungus, is a prominent disease among oak trees. OW poses a threat to 5.9 percent of the City of Grand Prairie iTree Eco Assessment urban forest, which represents a potential loss of $611 million in replacement value.

# Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco 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 (Nowak and Crane 2000), including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Replacement value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, spongy moth, and Dutch elm disease.

Typically, all field data are collected during the leaf-on season to properly assess tree canopies. 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 (Nowak et al 2005; Nowak et al 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g., ash) or species groups (e.g., hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

<u>Tree Characteristics:</u>

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., invasive species are identified using an invasive species list (Watershed Protection Development Review)for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

<u>Air Pollution Removal:</u>

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, particulate matter less than 2.5 microns, and particulate matter less than 10 microns and greater than 2.5 microns. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

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 (Baldocchi 1988; Baldocchi et al 1987). 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 (Bidwell and Fraser 1972; Lovett 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke 1967). Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi et al 2011; Hirabayashi et al 2012; Hirabayashi 2011).

Trees remove PM2.5 and PM10* when particulate matter is deposited on leaf surfaces (Nowak et al 2013). This deposited PM2.5 and PM10* can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 and PM10* removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g., with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 and PM10* concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 and PM10* but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen.

For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak et al 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray et al 1994).

For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen et al 2011) or BenMAP regression equations (Nowak et al 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of $1,622 per ton (carbon monoxide), $2,150 per ton (ozone), $558 per ton (nitrogen dioxide), $133 per ton (sulfur dioxide), $84,645 per ton (particulate matter less than 2.5 microns), $0 per ton (particulate matter less than 10 microns and greater than 2.5 microns).

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. 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 (Nowak 1994). 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.

Carbon sequestration is the removal of carbon dioxide from the air by plants. 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.

Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (U.S. Environmental Protection Agency 2015, Interagency Working Group on Social Cost of Carbon 2015) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on $433 per ton.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak et al 2007). For complete inventory projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition.

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper et al 2009; 2010; Vargas et al 2007a; 2007b; 2008).

For this analysis, avoided runoff value is calculated based on the price of $0.01 per gallon.

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

For this analysis, energy saving value is calculated based on the prices of $123.00 per MWH and $14.10 per MBTU.

Replacement Values:

Replacement value is the value of a tree based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Replacement values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b). Replacement value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analyzed is reported, though the list of pests is based on known insects and disease in the United States.

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

Relative Tree Effects:

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions.

Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions.

Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs et al 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle.

Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014)

- CO2, SO2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO2, NOx, SO2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry 2005; Georgia Forestry Commission 2009).

## Appendix II. Relative Tree Effects

The urban forest in City of Grand Prairie iTree Eco Assessment 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, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in City of Grand Prairie iTree Eco Assessment in 166 days
- Annual carbon (C) emissions from 350,000 automobiles
- Annual C emissions from 143,000 single-family houses

Carbon monoxide removal is equivalent to:

- Annual carbon monoxide emissions from 50 automobiles
- Annual carbon monoxide emissions from 137 single-family houses

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 3,740 automobiles
- Annual nitrogen dioxide emissions from 1,680 single-family houses

Sulfur dioxide removal is equivalent to:

- Annual sulfur dioxide emissions from 79,300 automobiles
- Annual sulfur dioxide emissions from 210 single-family houses

Annual carbon sequestration is equivalent to:

- Amount of carbon emitted in City of Grand Prairie iTree Eco Assessment in 7.4 days
- Annual C emissions from 15,500 automobiles
- Annual C emissions from 6,340 single-family houses

# Appendix III. 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 i-Tree Eco model.

## I. City totals for trees

| *City* | *% Tree Cover* | *Number of Trees* | *Carbon Storage (tons)* | *Carbon Sequestration (tons/yr)* | *Pollution Removal (tons/yr)* |
|---|---|---|---|---|---|
| Toronto, ON, Canada | 26.6 | 10,220,000 | 1,221,000 | 51,500 | 2,099 |
| Atlanta, GA | 36.7 | 9,415,000 | 1,344,000 | 46,400 | 1,663 |
| Los Angeles, CA | 11.1 | 5,993,000 | 1,269,000 | 77,000 | 1,975 |
| New York, NY | 20.9 | 5,212,000 | 1,350,000 | 42,300 | 1,676 |
| London, ON, Canada | 24.7 | 4,376,000 | 396,000 | 13,700 | 408 |
| Chicago, IL | 17.2 | 3,585,000 | 716,000 | 25,200 | 888 |
| Phoenix, AZ | 9.0 | 3,166,000 | 315,000 | 32,800 | 563 |
| Baltimore, MD | 21.0 | 2,479,000 | 570,000 | 18,400 | 430 |
| Philadelphia, PA | 15.7 | 2,113,000 | 530,000 | 16,100 | 575 |
| Washington, DC | 28.6 | 1,928,000 | 525,000 | 16,200 | 418 |
| Oakville, ON , Canada | 29.1 | 1,908,000 | 147,000 | 6,600 | 190 |
| Albuquerque, NM | 14.3 | 1,846,000 | 332,000 | 10,600 | 248 |
| Boston, MA | 22.3 | 1,183,000 | 319,000 | 10,500 | 283 |
| Syracuse, NY | 26.9 | 1,088,000 | 183,000 | 5,900 | 109 |
| Woodbridge, NJ | 29.5 | 986,000 | 160,000 | 5,600 | 210 |
| Minneapolis, MN | 26.4 | 979,000 | 250,000 | 8,900 | 305 |
| San Francisco, CA | 11.9 | 668,000 | 194,000 | 5,100 | 141 |
| Morgantown, WV | 35.5 | 658,000 | 93,000 | 2,900 | 72 |
| Moorestown, NJ | 28.0 | 583,000 | 117,000 | 3,800 | 118 |
| Hartford, CT | 25.9 | 568,000 | 143,000 | 4,300 | 58 |
| Jersey City, NJ | 11.5 | 136,000 | 21,000 | 890 | 41 |
| Casper, WY | 8.9 | 123,000 | 37,000 | 1,200 | 37 |
| Freehold, NJ | 34.4 | 48,000 | 20,000 | 540 | 22 |

## II. Totals per acre of land area

| *City* | *Number of Trees/ac* | *Carbon Storage (tons/ac)* | *Carbon Sequestration (tons/ac/yr)* | *Pollution Removal (lb/ac/yr)* |
|---|---|---|---|---|
| Toronto, ON, Canada | 64.9 | 7.8 | 0.33 | 26.7 |
| Atlanta, GA | 111.6 | 15.9 | 0.55 | 39.4 |
| Los Angeles, CA | 19.6 | 4.2 | 0.16 | 13.1 |
| New York, NY | 26.4 | 6.8 | 0.21 | 17.0 |
| London, ON, Canada | 75.1 | 6.8 | 0.24 | 14.0 |
| Chicago, IL | 24.2 | 4.8 | 0.17 | 12.0 |
| Phoenix, AZ | 12.9 | 1.3 | 0.13 | 4.6 |
| Baltimore, MD | 48.0 | 11.1 | 0.36 | 16.6 |
| Philadelphia, PA | 25.1 | 6.3 | 0.19 | 13.6 |
| Washington, DC | 49.0 | 13.3 | 0.41 | 21.2 |
| Oakville, ON , Canada | 78.1 | 6.0 | 0.27 | 11.0 |
| Albuquerque, NM | 21.8 | 3.9 | 0.12 | 5.9 |
| Boston, MA | 33.5 | 9.1 | 0.30 | 16.1 |
| Syracuse, NY | 67.7 | 10.3 | 0.34 | 13.6 |
| Woodbridge, NJ | 66.5 | 10.8 | 0.38 | 28.4 |
| Minneapolis, MN | 26.2 | 6.7 | 0.24 | 16.3 |
| San Francisco, CA | 22.5 | 6.6 | 0.17 | 9.5 |
| Morgantown, WV | 119.2 | 16.8 | 0.52 | 26.0 |
| Moorestown, NJ | 62.1 | 12.4 | 0.40 | 25.1 |
| Hartford, CT | 50.4 | 12.7 | 0.38 | 10.2 |
| Jersey City, NJ | 14.4 | 2.2 | 0.09 | 8.6 |
| Casper, WY | 9.1 | 2.8 | 0.09 | 5.5 |
| Freehold, NJ | 38.3 | 16.0 | 0.44 | 35.3 |

## Appendix IV. General 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 (Nowak 1995):

- 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 (Nowak 2000). Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include (Nowak 2000):

| *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 |

# Appendix V. Invasive Species of the Urban Forest

The following inventoried tree species were listed as invasive on the Texas invasive species list (Watershed Protection Development Review):

| Species Name[a] | *Number of Trees* | *% of Trees* | *Leaf Area (ac)* | *Percent Leaf Area* |
|---|---|---|---|---|
| Chinese pistache | 21,954 | 0.7 | 542.2 | 1.4 |
| White mulberry | 12,959 | 0.4 | 329.7 | 0.8 |
| Persian silk tree | 8,353 | 0.3 | 26.2 | 0.1 |
| Chinese tallowtree | 5,585 | 0.2 | 546.7 | 1.4 |
| Chaste tree | 4,926 | 0.2 | 9.4 | 0.0 |
| Chinaberry | 2,232 | 0.1 | 20.2 | 0.1 |
| Glossy privet | 162 | 0.0 | 0.4 | 0.0 |
| **Total** | **56,170** | **1.71** | **1,474.85** | **3.71** |

[a]Species are determined to be invasive if they are listed on the state's invasive species list

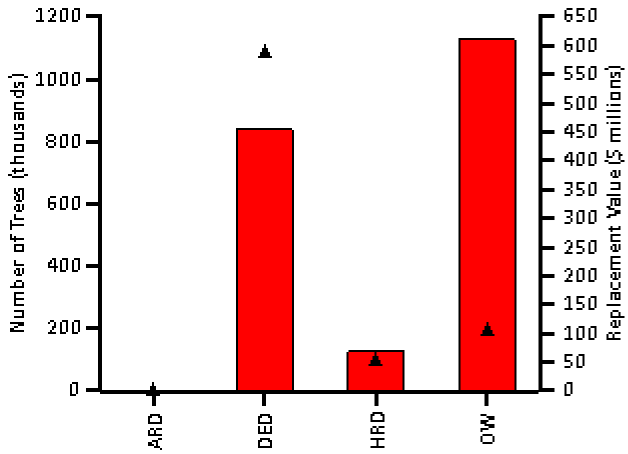
# Appendix VI. Potential Risk of Pests

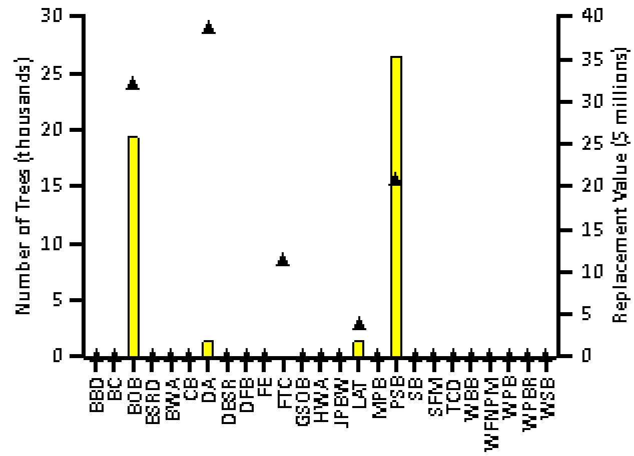
Fifty-three insects and diseases were analyzed to quantify their potential impact on the urban forest. As each insect/ disease is likely to attack different host tree species, the implications for {0} will vary. The number of trees at risk reflects only the known host species that are likely to experience mortality.

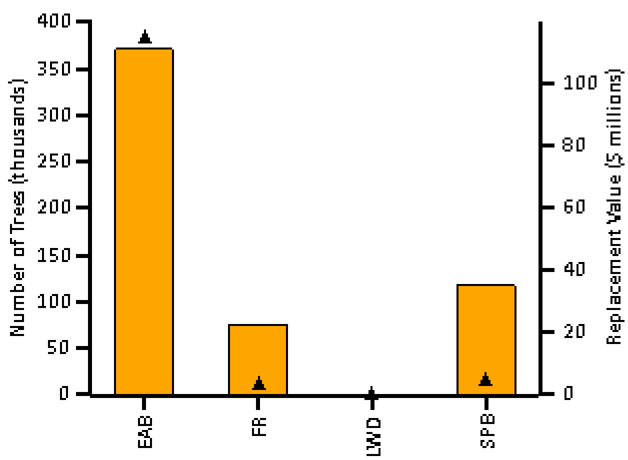
| Code | Scientific Name | Common Name | Trees at Risk (#) | Value ($ millions) |
|---|---|---|---|---|
| AL | Phyllocnistis populiella | Aspen Leafminer | 2,777 | 1.83 |
| ALB | Anoplophora glabripennis | Asian Longhorned Beetle | 1,647,825 | 622.58 |
| ARCA | Neodothiora populina | Aspen Running Canker | 0 | 0.00 |
| ARD | Armillaria spp. | Armillaria Root Disease | 0 | 0.00 |
| BBD | Neonectria faginata | Beech Bark Disease | 0 | 0.00 |
| BC | Sirococcus clavigignenti juglandacearum | Butternut Canker | 0 | 0.00 |
| BLD | Litylenchus crenatae mccannii | Beech Leaf Disease | 0 | 0.00 |
| BM | Euproctis chrysorrhoea | Browntail Moth | 8,460 | 0.00 |
| BOB | Tubakia iowensis | Bur Oak Blight | 23,984 | 25.82 |
| BSRD | Leptographium wageneri | Black Stain Root Disease | 0 | 0.00 |
| BWA | Adelges piceae | Balsam Woolly Adelgid | 0 | 0.00 |
| CB | Cryphonectria parasitica | Chestnut Blight | 0 | 0.00 |
| DA | Discula destructiva | Dogwood Anthracnose | 28,865 | 1.82 |
| DBSR | Leptographium wageneri var. pseudotsugae | Douglas-fir Black Stain Root Disease | 0 | 0.00 |
| DED | Ophiostoma novo-ulmi | Dutch Elm Disease | 1,086,638 | 454.71 |
| DFB | Dendroctonus pseudotsugae | Douglas-Fir Beetle | 0 | 0.00 |
| EAB | Agrilus planipennis | Emerald Ash Borer | 383,197 | 111.31 |
| FE | Scolytus ventralis | Fir Engraver | 0 | 0.00 |
| FR | Cronartium quercuum f. sp. Fusiforme | Fusiform Rust | 10,349 | 22.89 |
| FTC | Malacosoma disstria | Forest Tent Caterpillar | 8,460 | 0.00 |
| GSOB | Agrilus auroguttatus | Goldspotted Oak Borer | 0 | 0.00 |
| HRD | Heterobasidion irregulare/ occidentale | Heterobasidion Root Disease | 98,233 | 69.25 |
| HS | Neodiprion tsugae | Hemlock Sawfly | 0 | 0.00 |
| HWA | Adelges tsugae | Hemlock Woolly Adelgid | 0 | 0.00 |
| JPB | Dendroctonus jeffreyi | Jeffrey Pine Beetle | 0 | 0.00 |
| JPBW | Choristoneura pinus | Jack Pine Budworm | 0 | 0.00 |
| LAT | Choristoneura conflictana | Large Aspen Tortrix | 2,777 | 1.83 |
| LWD | Raffaelea lauricola | Laurel Wilt | 0 | 0.00 |
| MOB | Xyleborus monographus | Mediterranean Oak Borer | 0 | 0.00 |
| MPB | Dendroctonus ponderosae | Mountain Pine Beetle | 0 | 0.00 |
| NSE | Ips perturbatus | Northern Spruce Engraver | 0 | 0.00 |
| OW | Bretziella fagacearum | Oak Wilt | 193,820 | 610.55 |
| PBSR | Leptographium wageneri var. ponderosum | Pine Black Stain Root Disease | 0 | 0.00 |
| POCRD | Phytophthora lateralis | Port-Orford-Cedar Root Disease | 0 | 0.00 |
| PSB | Tomicus piniperda | Pine Shoot Beetle | 15,447 | 35.31 |

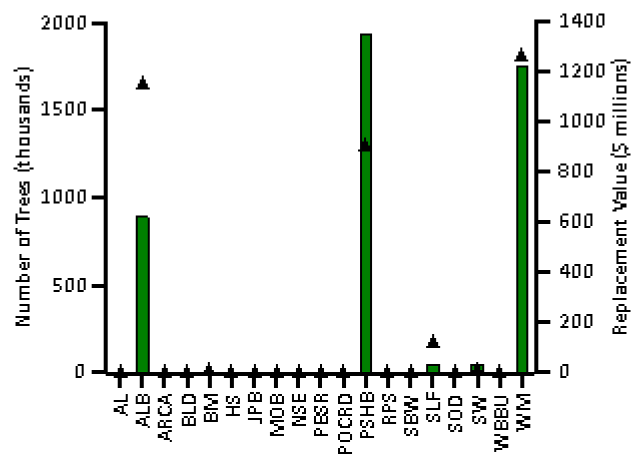
| Code | Scientific Name | Common Name | Trees at Risk (#) | Value ($ millions) |
|---|---|---|---|---|
| PSHB | Euwallacea nov. sp. | Polyphagous Shot Hole Borer | 1,295,041 | 1,351.87 |
| RPS | Matsucoccus resinosae | Red Pine Scale | 0 | 0.00 |
| SB | Dendroctonus rufipennis | Spruce Beetle | 0 | 0.00 |
| SBW | Choristoneura fumiferana | Spruce Budworm | 0 | 0.00 |
| SFM | subalpine fir mortality summary | Subalpine Fir Mortality | 0 | 0.00 |
| SLF | Lycorma delicatula | Spotted Lanternfly | 171,235 | 34.50 |
| SOD | Phytophthora ramorum | Sudden Oak Death | 0 | 0.00 |
| SPB | Dendroctonus frontalis | Southern Pine Beetle | 15,447 | 35.31 |
| SW | Sirex noctilio | Sirex Wood Wasp | 15,447 | 35.31 |
| TCD | Geosmithia morbida | Thousand Canker Disease | 0 | 0.00 |
| WBB | Dryocoetes confusus | Western Balsam Bark Beetle | 0 | 0.00 |
| WBBU | Acleris gloverana | Western Blackheaded Budworm | 0 | 0.00 |
| WFNPM | western five-needle pine mortality summary | Western Five-Needle Pine Mortality | 0 | 0.00 |
| WM | Operophtera brumata | Winter Moth | 1,803,467 | 1,221.80 |
| WPB | Dendroctonus brevicomis | Western Pine Beetle | 0 | 0.00 |
| WPBR | Cronartium ribicola | White Pine Blister Rust | 0 | 0.00 |
| WSB | Choristoneura occidentalis | Western Spruce Budworm | 0 | 0.00 |

In the following graph, the pests are color coded according to the county's proximity to the pest occurrence in the United States. Red indicates that the pest is within the county; orange indicates that the pest is within 250 miles of the county; yellow indicates that the pest is within 750 miles of the county; and green indicates that the pest is outside of these ranges.




Note: points - Number of trees, bars - Replacement value

Based on the host tree species for each pest and the current range of the pest (Forest Health Technology Enterprise Team 2014), it is possible to determine what the risk is that each tree species in the urban forest could be attacked by an insect or disease.

| Spp. Risk | Risk Weight | Species Name | AL | ALB | ARCA | ARD | BBD | BC | BLD | BM | BOB | BSRD | BWA | CB | DA | DBSR | DED | DFB | EAB | FE | FR | FTC | GSOB | HRD | HS | HWA | JPB | JPBW | LAT | LWD | MOB | MPB | NSE | OW | PBSR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | Loblolly pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Elm spp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | Bur oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7 | American elm | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7 | Winged elm | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | Cedar elm | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | Live oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | Shumard oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | Turkish pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Green ash | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Eastern red cedar | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Sawtooth oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Blackjack oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Black willow | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Velvet ash | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | Boxelder | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | Lacey oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | Persian silk tree | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | Peach | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | Silver maple | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | Eastern cottonwood | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | Roughleaf dogwood | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | White mulberry | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | Chinese elm | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | Chinaberry | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Honey mesquite | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Honeylocust | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Pecan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Chinese pistache | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Baldcypress | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Chinese tallowtree | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Carolina laurelcherry | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Callery pear | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Purple blow maple | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Glossy privet | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | Oriental arborvitae | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Spp. Risk | Risk Weight | Species Name | POCRD | PSB | PSHB | RPS | SB | SBW | SFM | SLF | SOD | SPB | SW | TCD | WBB | WBBU | WFNPM | WM | WPB | WPBR | WSB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | Loblolly pine | | | | | | | | | | | | | | | | | | | |
| | 9 | Elm spp | | | | | | | | | | | | | | | | | | | |
| | 8 | Bur oak | | | | | | | | | | | | | | | | | | | |

| Spp. Risk | Risk Weight | Species Name | POCRD | PSB | PSHB | RPS | SB | SBW | SFM | SLF | SOD | SPB | SW | TCD | WBB | WBBU | WFNPM | WM | WPB | WPBR | WSB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Red | 7 | American elm | | | Green | | | | | | | | | | | | | Green | | | |
| Red | 7 | Winged elm | | | Green | | | | | | | | | | | | | Green | | | |
| Red | 6 | Cedar elm | | | | | | | | | | | | | | | | Green | | | |
| Red | 6 | Live oak | | | Green | | | | | | | | | | | | | Green | | | |
| Red | 6 | Shumard oak | | | Green | | | | | | | | | | | | | Green | | | |
| Orange | 6 | Turkish pine | | Yellow | | | | | | | | Orange | Green | | | | | | | | |
| Orange | 5 | Green ash | | | | | | | | | | | | | | | | Green | | | |
| Red | 5 | Eastern red cedar | | | Green | | | | | | | | | | | | | | | | |
| Red | 5 | Sawtooth oak | | | Green | | | | | | | | | | | | | | | | |
| Red | 5 | Blackjack oak | | | | | | | | | | | | | | | | Green | | | |
| Yellow | 5 | Black willow | | | | | | | | | | | | | | | | Green | | | |
| Orange | 5 | Velvet ash | | | Green | | | | | | | | | | | | | Green | | | |
| Green | 4 | Boxelder | | | Green | | | | | Green | | | | | | | | Green | | | |
| Red | 4 | Lacey oak | | | | | | | | | | | | | | | | | | | |
| Green | 3 | Persian silk tree | | | Green | | | | | Green | | | | | | | | | | | |
| Green | 3 | Peach | | | Green | | | | | Green | | | | | | | | Green | | | |
| Green | 3 | Silver maple | | | | | | | | Green | | | | | | | | Green | | | |
| Green | 2 | Eastern cottonwood | | | | | | | | | | | | | | | | Green | | | |
| Yellow | 2 | Roughleaf dogwood | | | | | | | | | | | | | | | | | | | |
| Green | 2 | White mulberry | | | Green | | | | | Green | | | | | | | | | | | |
| Green | 2 | Chinese elm | | | Green | | | | | | | | | | | | | | | | |
| Green | 2 | Chinaberry | | | Green | | | | | Green | | | | | | | | | | | |
| Green | 1 | Honey mesquite | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Honeylocust | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Pecan | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Chinese pistache | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Baldcypress | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Chinese tallowtree | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Carolina laurelcherry | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Callery pear | | | Green | | | | | | | | | | | | | | | | |
| Green | 1 | Purple blow maple | | | | | | | | | | | | | | | | | | | |
| Green | 1 | Glossy privet | | | | | | | | Green | | | | | | | | | | | |
| Green | 1 | Oriental arborvitae | | | | | | | | Green | | | | | | | | | | | |

Note:
Species that are not listed in the matrix are not known to be hosts to any of the pests analyzed.

Species Risk:

- Red indicates that tree species is at risk to at least one pest within county
- Orange indicates that tree species has no risk to pests in county, but has a risk to at least one pest within 250 miles from the county
- Yellow indicates that tree species has no risk to pests within 250 miles of county, but has a risk to at least one pest that is 250 and 750 miles from the county
- Green indicates that tree species has no risk to pests within 750 miles of county, but has a risk to at least one pest that is greater than 750 miles from the county

Risk Weight:
Numerical scoring system based on sum of points assigned to pest risks for species. Each pest that could attack tree species is scored as 4 points if red, 3 points if orange, 2 points if yellow and 1 point if green.

Pest Color Codes:

- Red indicates pest is within Dallas county
- Red indicates pest is within 250 miles county
- Yellow indicates pest is within 750 miles of Dallas county
- Green indicates pest is outside of these ranges

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