TREE MANAGEMENT PLAN

City of North Kansas City, Missouri

May 2017

Prepared for:
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ACKNOWLEDGEMENTS

The City of North Kansas City's vision to promote and preserve the urban forest and improve the management of public trees was a fundamental inspiration for this project. This vision will ensure canopy continuity, which will reduce stormwater runoff and improve air quality, public health, and aesthetic values.

North Kansas City is thankful for the grant funding it received from the Missouri Department of Conservation (MDC) in cooperation with the U.S. Forest Service through its Tree Resource Improvement and Maintenance (TRIM) cost-share program. The TRIM grant program is designed to encourage communities to create and support sustained and long-term urban and community forestry programs.

The city also recognizes the support of its Public Works Director Patrick A. Hawver.

EXECUTIVE SUMMARY

This plan was developed for the City of North Kansas City by Davey Resource Group with a focus on addressing short-term and long-term maintenance needs for inventoried public trees. Davey Resource Group completed a tree inventory to gain an understanding of the needs of the existing urban forest and to project a recommended maintenance schedule for tree care. Analysis of inventory data and information about the city's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*. Also included in this plan are economic, environmental, and social benefits provided by the trees in North Kansas City.

State of the Existing Urban Forest

The March and April 2017 inventory included trees and stumps sites along public street rights-of-way (ROW) and in public parks. A total of 3,060 sites were recorded during the inventory: 2,959 trees and 101 stumps. Analysis of the tree inventory data found the following:

- Two species, *Gleditsia triacanthos inermis* (thornless honeylocust) and *Acer rubrum* (red maple), comprise a large percentage of the street ROW (19% and 12%, respectively) and threaten biodiversity.
- On the street ROW, *Acer* (maple) was found in abundance (28%), which is a concern for the city's biodiversity.
- The diameter size class distribution of the inventoried tree population trends towards the ideal, with a greater number of young trees than established, maturing, or mature trees.
- The overall condition of the inventoried tree population is rated Good.
- The presence of overhead utilities interfering with street trees occurs among 8% of the inventoried population.
- Asian longhorned beetle (*Anoplophora glabripennis*), emerald ash borer (*Agrilus planipennis*), and gypsy moth (*Lymantria dispar dispar*) pose the biggest potential threats to the health of the inventoried population.
- North Kansas City's trees have an estimated replacement value of $3,919,933.
- Trees provide approximately $322,564 in the following annual benefits:
  - *Aesthetic and other benefits*: valued at $91,235 per year.
  - *Air quality*: 6,984 pounds of pollutants removed valued at $19,592 per year.
  - *Carbon sequestered and avoided*: 2,156,152 pounds valued at $16,171 per year.
  - *Energy*: 565 megawatt-hours (MWh) and 75,979 therms valued at $52,863 per year.
  - *Stormwater peak flow reductions*: 5,265,794 gallons valued at $142,703 per year.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Recommended maintenance needs include: Tree Removal (5%); Stump Removal (3%); Routine Pruning (75%); and Young Tree Train (17%). These percentages exclude all ash trees.

Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted some High Risk trees and many Moderate Risk trees; these trees should be removed or pruned immediately to promote public safety. Low Risk trees should be addressed after all elevated risk tree maintenance has been completed. Trees should be planted to mitigate removals and create canopy. These percentages exclude all ash trees. The management of ash trees is addressed in the EAB strategy section.

North Kansas City's urban forest will benefit greatly from a three-year young tree training cycle and a five-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 172 young trees should be structurally pruned each year during the young tree training cycle, and approximately 359 trees should be cleaned each year during the routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events, such as drought, flooding, ice, snow, storms, and wind). Davey Resource Group recommends planting at least 70 trees (46 trees from the budget of Estimated Costs for Five-Year Tree Management Program and 24 trees from the budget of Costs Associated with Combination Treatment and Removal EAB Strategy) of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

Citywide tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Acer* spp. (maple) should be limited until the species distribution normalizes. Additionally, due to impending threats from emerald ash borer (EAB, *Agrilus planipennis*), all *Fraxinus* spp. (ash) trees should be temporarily removed from the planting list.

Urban Forest Program Needs

Adequate funding will be needed for the city to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $89,624. This total will increase to approximately $90,500 per year by Year 4 of the program. High-priority removal and pruning and its recovery by replanting trees can be costly. After high-priority work has been completed, the urban forestry program will involve recovery and proactive maintenance.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree care management costs and potentially minimize the costs to build, manage, and support certain city infrastructure. Keeping the inventory up-to-date using *TreeKeeper*® or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

FY 2018 $89,624

- 12 High or Moderate Risk Removals
- 249 High or Moderate Risk Prunes
- 7 Low Risk Removals
- 120 Stump Removals
- YTT Cycle: 1/3 of Public Tree Trained
- 46 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2019 $89,305

- 59 Low Risk Removals
- 59 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 46 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2020 $89,580

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 46 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2021 $90,500

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 46 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY2022 $90,500

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 46 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

North Kansas City has many opportunities to improve its urban forest. Planned tree planting and a systematic approach to tree maintenance will help ensure a cost-effective, proactive program. Investing in this tree management program will promote public safety, improve tree care efficiency, and increase the economic and environmental benefits the community receives from its trees.

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INTRODUCTION

The City of North Kansas City is home to more than 4,000 full-time residents who enjoy the beauty and benefits of their urban forest. The city's forestry program manages and maintains trees on public property, including trees, stumps, and planting sites in public parks and facilities and along public street rights-of-way (ROW). For more than 10 years, North Kansas City's Department of Public Works has maintained staff committed to developing a robust urban forest.

Funding for the city's urban forestry program comes from the general fund and other grants. North Kansas City has conducted multiple public tree inventories, the latest of which was completed in 2017. The city has a tree ordinance, maintains a budget of more than $2 per capita for tree-related expenses, celebrates Arbor Day, and has been a Tree City USA community for 21 years.

Approach to Tree Management

The best approach to managing an urban forest is to develop an organized, proactive program using tools (such as a tree inventory and tree management plan) to set goals and measure progress. These tools can be utilized to establish tree care priorities, build strategic planting plans, draft cost-effective budgets based on projected needs, and ultimately minimize the need for costly, reactive solutions to crises or urgent hazards.

In March and April 2016, North Kansas City worked with Davey Resource Group to inventory trees and develop a management plan. This plan considers the diversity, distribution, and general condition of the inventoried trees, but also provides a prioritized system for managing public trees. The following tasks were completed:

- Inventory of trees and stumps along the street ROW and within public parks.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

This plan is divided into four sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community. This section presents statistics of an i-Tree Streets benefits analysis conducted for North Kansas City.
- *Section 3: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a five-year period.
- Section 4 *Emerald Ash Borer Strategy* presents proactive maintenance and policy strategies for the prevention and mitigation of an emerald ash borer infestation.

SECTION 1: TREE INVENTORY ANALYSIS

In March and April 2017, Davey Resource Group arborists assessed and inventoried trees and stumps along the street ROW and in public parks. A total of 3,060 sites were collected during the inventory: 2,959 trees and 101 stumps. Figure 1 provides a detailed breakdown of the number and type of sites inventoried. See Appendix A for data collection and site location methodology.

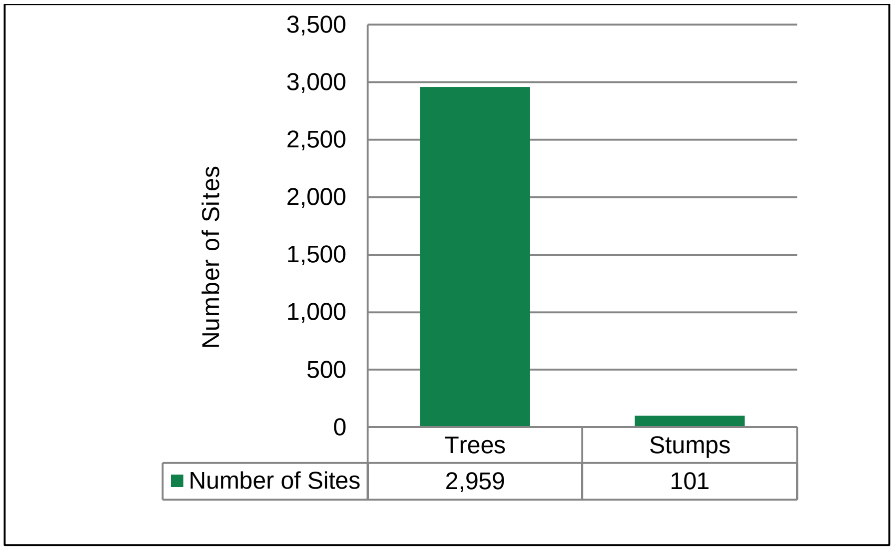


Figure 1. Sites collected during the 2017 inventory.

Assessment of Tree Inventory Data

Data analysis and professional judgment are used to make generalizations about the state of the inventoried tree population. Recognizing trends in the data can help guide short-term and long-term management planning. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

Photograph 1. *Davey's ISA*-Certified Arborists inventoried trees along street ROW and in community parks to collect information about trees that could be used to assess the state of the urban forest.

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Diameter Size Class Distribution Data*, the statistical distribution of a given tree population's trunk-size class, is used to indicate the relative age of a tree population. The diameter size class distribution affects the valuation of tree-related benefits as well as the projection of maintenance needs and costs, planting goals, and canopy continuity.
- *Condition*, the general health of a tree population, indicates how well trees are performing given their site-specific conditions. General health affects both short-term and long-term maintenance needs and costs as well as canopy continuity.

- *Street ROW Stocking Level* is the portion of existing street trees compared to the total number of potential street trees (number of inventoried trees plus the number of potential planting spaces); stocking level can help determine tree planting needs and budgets.
- *Overhead Utilities and Infrastructure Conflicts* provide insight into how well the city has modified its tree planting plans to consider the impact of overhead wires and other infrastructure on city trees.
- *Potential Threats from Pests* represent identification of pests and/or diseases—and their associated trends—to which the inventoried tree population could be susceptible.

Species Diversity

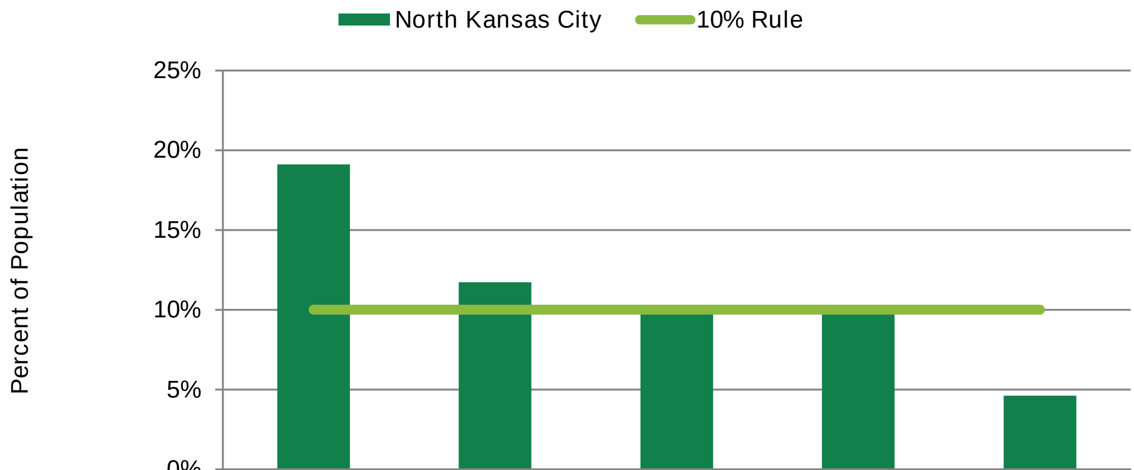
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devastating results of Dutch elm disease (*Ophiostoma novo-ulmi*) throughout New England and the Midwest. Due to the spread of Dutch elm disease in the 1930s, combined with the disease's prevalence today, massive numbers of *Ulmus americana* (American elm), a popular street tree in Midwestern cities and towns, have perished (Karnosky 1979). Several Midwestern communities were stripped of most of their mature shade trees, creating a drastic void in canopy cover. Many of these communities have replanted to replace the lost elm trees. Ash and maple trees were popular replacements for American elm in the wake of Dutch elm disease. Unfortunately, some of the replacement species for American elm trees are now overabundant, which is a biodiversity concern. EAB and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are non-native insect pests that attack some of the most prevalent urban shade trees and certain agricultural trees throughout the country.

The composition of a tree population should follow the 10-20-30 Rule for species diversity: a single species should represent no more than 10% of the urban forest, a single genus no more than 20%, and a single family no more than 30%.

Findings

Analysis of North Kansas City's tree inventory data indicated that the street and park tree population had 40 genera and 56 species represented.

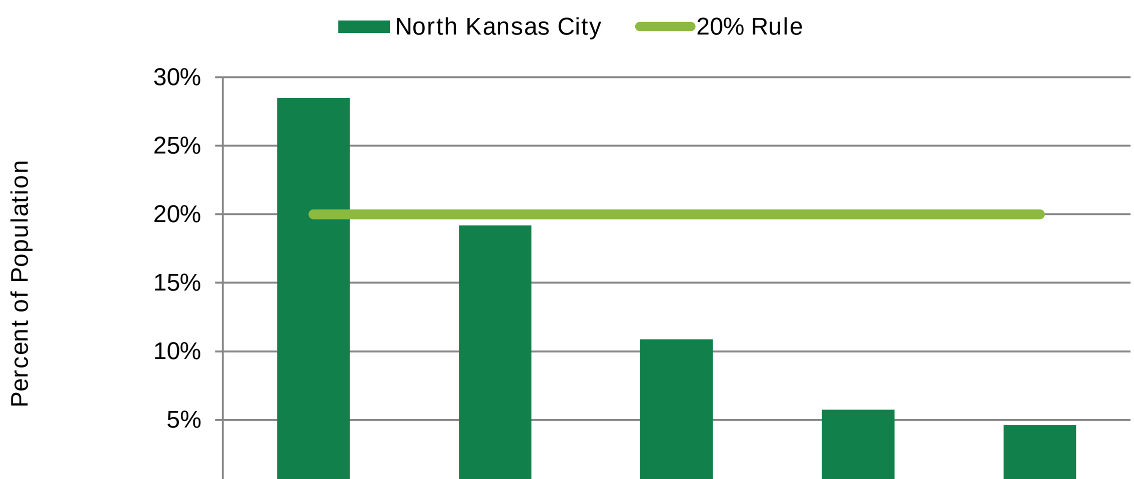
Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the park and street tree populations. *Gleditsia triacanthos inermis* (thornless honeylocust) and *Acer rubrum* (red maple) exceed the recommended 10% maximum for a single species in a population, comprising 19% and 12% of the inventoried tree population. *A. saccharum* (sugar maple) and *Fraxinus pennsylvanica* (green ash) meet the 10% threshold.



	thornless honeylocust	red maple	green ash	sugar maple	callery pear
North Kansas City	19%	12%	10%	10%	5%
10% Rule	10%	10%	10%	10%	10%

Figure 2. Five most abundant species of the inventoried population compared to the 10% Rule.

Figure 3 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the street and park tree populations. *Acer* (maple) exceeds the recommended 20% maximum for a single genus in a population, comprising 28% of the inventoried tree population. *Gleditsia* (honeylocust) is approaching the 20% threshold.



	maple	honeylocust	ash	elm	pear
North Kansas City	28%	19%	11%	6%	5%
20% Rule	20%	20%	20%	20%	20%

Figure 3. Five most abundant genera of the inventoried population compared to the 20% Rule.

Discussion/Recommendations

Maple and honeylocust dominate the streets and parks. This is a biodiversity concern because their abundance in the landscape makes them limiting species. Continued diversity of tree species is an important objective that will ensure North Kansas City's urban forest is sustainable and resilient to future invasive pest infestations.

Considering the large quantity of maple and ash in the city's population, along with their respective susceptibility to ALB and EAB, the planting of maple should be limited and the planting of ash should be stopped to minimize the potential for loss in the event that ALB or EAB threatens North Kansas City's urban tree population. See Appendix B for a recommended tree species list for planting.

Diameter Size Class Distribution

Analyzing the diameter size class distribution provides an estimate of the relative age of a tree population and offers insight into maintenance practices and needs.

The inventoried trees were categorized into the following diameter size classes: young trees (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature trees (greater than 24 inches DBH). These categories were chosen so that the population could be analyzed according to Richards' ideal distribution (1983). Richards proposed an ideal diameter size class distribution for street trees based on observations of well-adapted trees in Syracuse, New York. Richards' ideal distribution suggests that the largest fraction of trees (approximately 40% of the population) should be young (less than 8 inches DBH), while a smaller fraction (approximately 10%) should be in the large-diameter size class (greater than 24 inches DBH). A tree population with an ideal distribution would have an abundance of newly planted and young trees, and lower numbers of established, maturing, and mature trees.

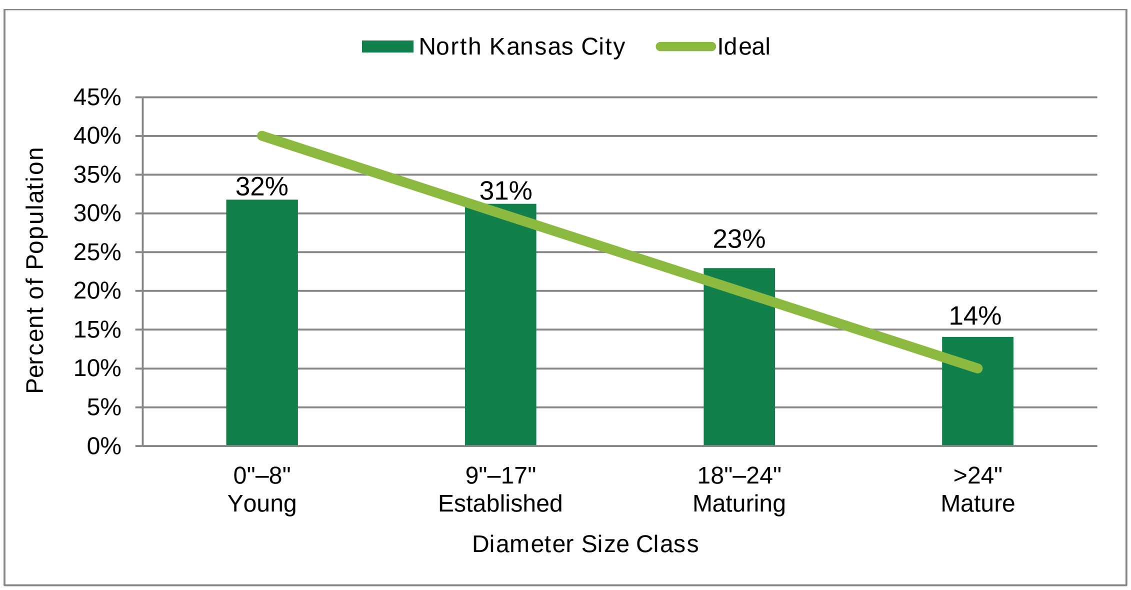


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares North Kansas City's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). North Kansas City's distribution trends towards the ideal; young trees fall below the ideal by 8%, while larger diameter size classes exceed the ideal. The diameter size class distribution of the street and park tree populations trends to the ideal; however, more trees need to be planted so that the young population has a slightly larger distribution than established trees.

Discussion/Recommendations

One of North Kansas City's objectives is to have an uneven-aged distribution of trees at the street, park, and citywide levels. Davey Resource Group recommends that North Kansas City support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and replace older declining trees. The city must promote tree preservation and proactive tree care to ensure the long-term survival of older trees. Tree planting and tree care will allow the distribution to normalize over time.

Planting trees is necessary to increase canopy cover and replace trees lost to natural mortality (expected to be 1%–3% per year) and other threats (for example, invasive pests or impacts from weather events such as storms, wind, ice, snow, flooding, and drought). Planning for the replacement of existing trees and identifying the best places to create new canopy is critical.

Condition

Davey Resource Group assessed the condition of individual trees based on methods defined by the International Society of Arboriculture (ISA). Several factors were considered for each tree, including: root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated Excellent, Very Good, Good, Fair, Poor, Critical, or Dead.

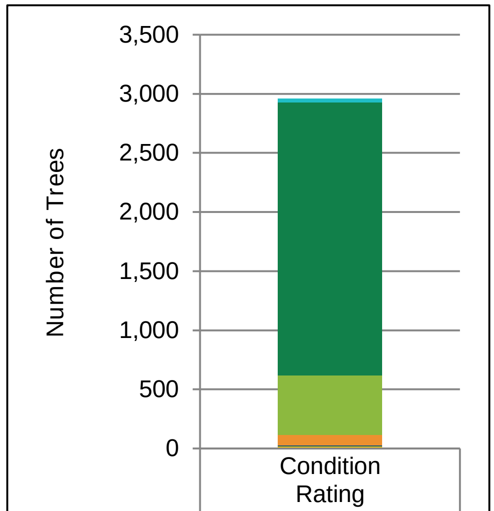
In this plan, the general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. Since tree species have different lifespans and mature at different diameters, heights, and crown spreads, actual tree age cannot be determined from diameter size class alone. However, general classifications of size can be extrapolated into relative age classes. The following categories are used to describe the relative age of a tree: young (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature (greater than 24 inches DBH).

Figures 5 and 6 illustrate the general health and distribution of young, established, mature, and maturing trees relative to their condition.

Findings

Most of the inventoried trees were recorded to be in Good or better condition, 79% (Figure 6). Based on these data, the general health of the overall inventoried tree population is rated Good. Figure 6 illustrates that most of the young, established, maturing, and mature trees were rated to be in Good to Excellent condition.



	Condition Rating
Excellent	-
Very Good	32
Good	2,308
Fair	502
Poor	90
Critical	9
Dead	18

Figure 5. Conditions of inventoried trees.

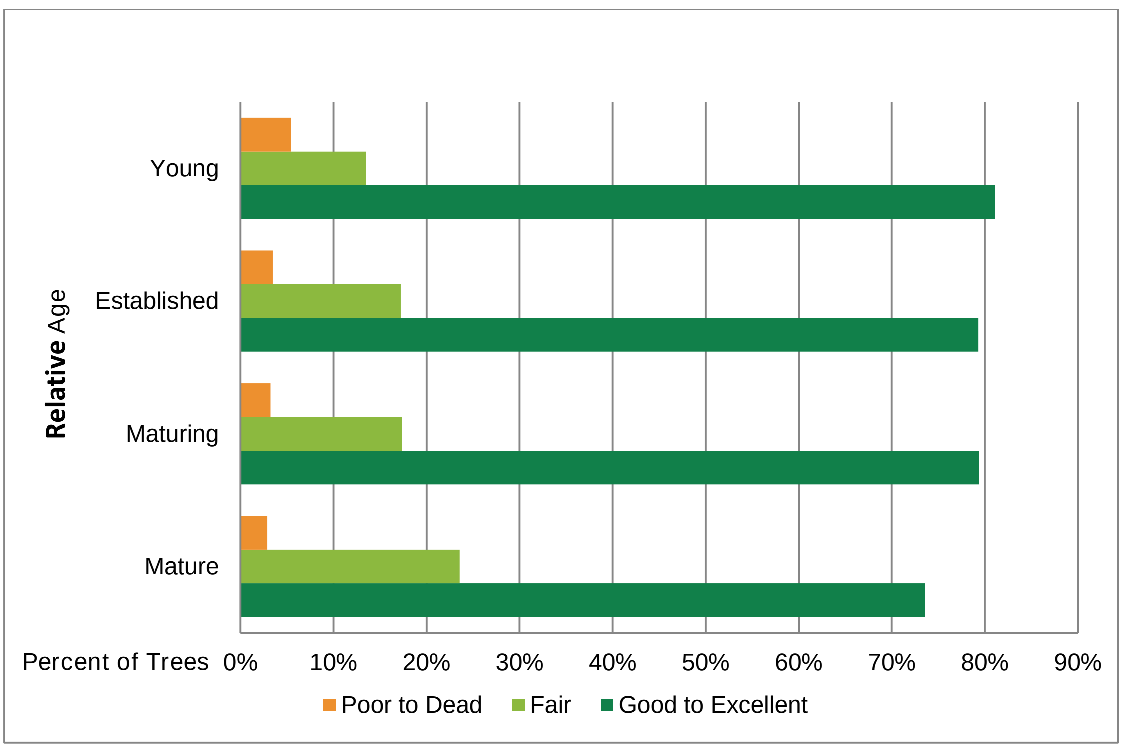


Figure 6. Tree condition by relative age during the 2017 inventory.

Discussion/Recommendations

Even though the condition of North Kansas City's inventoried tree population is typical, data analysis has provided the following insight into maintenance needs and historical maintenance practices:

- The similar trend in condition across street and park trees reveals that growing conditions and/or past management of trees were consistent.
- Dead trees and trees in Critical condition should be removed because of their failed health; these trees will likely not recover, even with increased care.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Many of the newly planted trees were improperly mulched or had staking hardware attached to them long after they should have been removed. Following guidelines developed by ISA and those recommended by *ANSI A300 (Part 6)* (ANSI 2012) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Replacement Value

Replacement value describes the historical investment in trees over time. Replacement value on a species level gives urban forest managers a glimpse into the landscape value of their species populations. Values will reflect species population, stature, and condition.

Findings

North Kansas City's street and park trees are an important municipal asset valued at $3,919,933. If trees are properly maintained over time, this value could increase as trees mature and grow in number. The average replacement value is approximately $1,325 per tree. Silver maple has the highest replacement value of all inventoried species at $680,020, or 17% of North Kansas City's historical investment.

Discussion/Recommendations

A healthy, well-placed tree will become more valuable over time as it grows from a young tree to a mature tree. Davey Resource Group recommends that the city focus on tree care practices that will optimize species diversity, size distribution, and the health of the urban forest. Focusing on these components can provide a greater return on investment.

Street ROW Stocking Level

Stocking is a traditional forestry term used to measure the density and distribution of trees. For an urban/community forest such as North Kansas City's, stocking level is used to estimate the total number of sites along the street ROW that could contain trees. Park trees (338 trees and stumps) are excluded from this measurement.

Stocking level is the ratio of street ROW spaces occupied by trees to the total street ROW spaces suitable for trees. For example, a street tree inventory of 1,000 total sites with 750 existing trees and 250 planting sites would have a stocking level of 75%.

For an urban area, Davey Resource Group recommends that the street ROW stocking level be at least 90% so that no more than 10% of the potential planting sites along the street ROW are vacant.

Street ROW stocking levels may be estimated using information about the community, tree inventory data, and common street tree planting practices. Inventory data that contain the number of existing trees and planting sites along the street ROW will increase the accuracy of the projection. However, street ROW stocking levels can be estimated using only the number of trees present and the number of street miles in the community.

To estimate stocking level based on total street ROW miles and the number of existing trees, it is assumed that any given street ROW should have room for 1 tree for every 50 feet along each side of the street. For example, 10 linear miles of street ROW with spaces for trees to grow at 50-foot intervals along each side of the street account for a potential 2,110 trees. If the inventory found that 1,055 trees were present, the stocking level would be 50%.

The potential stocking level for a community with 10 street miles is as follows:

5,280 feet/mile ÷ 50 feet = 106 trees/mile

106 trees/mile × 2 sides of the street = 212 trees/mile

212 trees per street mile × 10 miles = 2,120 potential sites for trees

1,055 inventoried trees ÷ 2,120 potential sites for trees = 50% stocked

When the estimated stocking level is determined using theoretical assumptions, the actual number of planting sites may be significantly less than estimated due to unknown growing space constraints, including inadequate growing space size, proximity of private trees, and utility conflicts.

North Kansas City's inventory data set did not include planting sites. Since the data did not include planting sites, only the theoretical stocking level for the city is presented.

Findings

Based on a theoretical stocking level, the city has 37.45 linear miles of street ROW (*City of North Kansas City, 2017*) and 2,621 street ROW trees, which comes to an average of 70 trees per street mile. In theory, any given street should have growing space for 1 tree every 50 feet along each side of a street, or 212 trees per mile. This suggests that there is room for an additional 1,348 street trees in North Kansas City to reach full stocking potential.

Discussion/Recommendation

Fully stocking the street ROW with trees is an excellent goal. Inadequate tree planting and maintenance budgets, along with tree mortality, will result in lower stocking levels. Nevertheless, working to attain a fully stocked street ROW is important to promote canopy continuity and environmental sustainability. The city should consider improving its street ROW population's stocking level of 66% and work towards achieving the ideal of 90% or better. Generally, this entails a planned program of planting, care, and maintenance for the city's street trees.

The City of North Kansas City estimates that it plants approximately 75 trees per year. With a current estimate of 1,348 planting sites along the street ROW, it would take approximately 13 years for the city to reach the recommended stocking level of 90%. If budgets allow, North Kansas City should continue to plant 75 trees per year. Davey Resource Group recommends planting at least 70 trees (46 tree from the budget of Estimated Costs for Five-Year Tree Management Program and 24 trees from the budget of Costs Associated with Combination Treatment and Removal EAB Strategy) of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss. If possible, exceed this recommendation to better prepare for impending threats and to increase the benefits provided by the urban forest. Appendix C contains additional information about tree planting guidelines.

Calculations of trees per capita are important in determining the density of a city's urban forest. The more residents and greater housing density a city possesses, the greater the need for trees to provide benefits.

North Kansas City's ratio of street trees per capita is 0.6, which exceeds the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the citywide study, there is 1 tree for every 3.3 residents. North Kansas City's potential is 1 tree for every 1.7 residents.

Infrastructure Conflicts

In an urban setting, space is limited both above and below ground. Trees in this environment may conflict with infrastructure such as buildings, sidewalks, and utility wires and pipes, which may pose risks to public health and safety. Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting.

Findings

There were 240 trees with utilities directly above, or passing through, the tree canopy. Of those trees, 87% were large- or medium-size trees.

Table 1. Trees Noted to be Conflicting with Infrastructure

Conflict	Presence	Number of Trees	Percent
Overhead Utilities	Present	240	8%
	Not Present	2,719	92%
Total		2,959	100%

Discussion/Recommendations

Planting only small-growing trees within 20 feet of overhead utilities, medium-size trees within 20–40 feet, and large-growing trees outside 40 feet will help improve future tree conditions, minimize future utility line conflicts, and reduce the costs of maintaining trees under utility lines.

Further Inspection

This data field indicates whether a particular tree requires further inspection, such as a Level III risk inspection in accordance with ANSI A300, Part 9 (ANSI, 2011), or periodic inspection due to particular conditions that may cause it to be a safety risk and, therefore, hazardous. If a tree was noted for further inspection, city staff should investigate as soon as possible to determine corrective actions.

Findings

Davey Resource Group recommended 20 trees for further inspection.

Discussion/Recommendations

An ISA-Certified Arborist should perform additional inspections of the 20 trees. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

The 13 inventoried ash trees that showed possible symptoms of EAB should be monitored. If signs of EAB manifest, the tree should be removed and the site should be inspected for potential replacement.

Potential Threats from Pests

Insects and diseases pose serious threats to tree health. Awareness and early diagnosis are essential to ensuring the health and continuity of street and park trees. Appendix D provides information about some of the current potential threats to North Kansas City's trees and includes websites where more detailed information can be found.

Many pests target a single species or an entire genus. The inventory data were analyzed to provide a general estimate of the percentage of trees susceptible to some of the known pests in Missouri (Figure 7). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout North Kansas City, including those on public and private property, may be susceptible to these invasive pests.

Findings

Asian longhorned beetle (ALB or *Anoplophora glabripennis*), emerald ash borer (EAB or *Agrilus planipennis*), and gypsy moth (*Lymantria dispar dispar*) are known threats to a large percentage of the inventoried street trees (26% 8%, and 8%, respectively). ALB and gypsy moth were not detected in North Kansas City, but if they were detected, the city could see severe losses in its tree population. There were 322 ash trees inventoried along North Kansas City's street ROW and in parks, but only 13 of these trees showed potential symptoms.

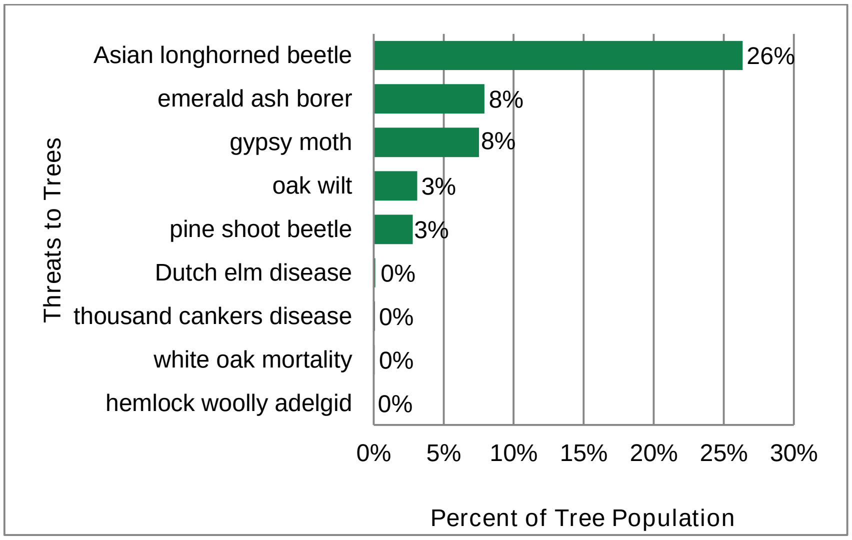


Figure 7. Potential impact of insect and disease threats noted during the 2017 inventory.

Discussion/Recommendations

North Kansas City should be aware of the signs and symptoms of potential infestations and should be prepared to act if a significant threat is observed in its tree population or a nearby community. An integrated pest management plan should be established. The plan should focus on identifying and monitoring threats, understanding the economic threshold, selecting the correct treatment, properly timing management strategies, recordkeeping, and evaluating results. Davey Resource Group's recommendations for managing the ash tree population and mitigating EAB will be discussed in detail in Section 4.

SECTION 2: BENEFITS OF THE URBAN FOREST

The urban forest plays an important role in supporting and improving the quality of life in urban areas. A tree's shade and beauty contributes to a community's quality of life and softens the often hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide communities abundant environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Environmental Benefits

- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini-reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. One hundred mature tree crowns intercept roughly 100,000 gallons of rainfall per year (U.S. Forest Service 2003a).
- Trees help reduce noise levels, cleanse atmospheric pollutants, produce oxygen, and absorb carbon dioxide.
- Trees can reduce street-level air pollution by up to 60% (Coder 1996). Lovasi (2008) suggested that children who live on tree-lined streets have lower rates of asthma.
- Trees stabilize soil and provide a habitat for wildlife.

Economic Benefits

- Trees in a yard or neighborhood increase residential property values by an average of 7%.
- Commercial property rental rates are 7% higher when trees are on the property (Wolf 2007).
- Trees moderate temperatures in the summer and winter, saving on heating and cooling expenses (North Carolina State University 2012, Heisler 1986).
- On average, consumers will pay about 11% more for goods in landscaped areas, with this figure being as high as 50% for convenience goods (Wolf 1998b, Wolf 1999, and Wolf 2003).
- Consumers also feel that the quality of products is better in business districts surrounded by trees than those considered barren (Wolf 1998b).
- The quality of landscaping along the routes leading to business districts had a positive influence on consumers' perceptions of the area (Wolf 2000).

Social Benefits

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001a).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001b).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see trees from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a).
- Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).
- When surrounded by trees, physical signs of personal stress, such as muscle tension and pulse rate, were measurably reduced within three to four minutes (Ulrich 1991).

The trees growing along the public streets constitute a valuable community resource. They provide numerous tangible and intangible benefits such as pollution control, energy reduction, stormwater management, property value increases, wildlife habitat, education, and aesthetics.

The services and benefits of trees in the urban and suburban setting were once considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the City of North Kansas City's tree inventory data are summarized in this report using the i-Tree's Streets application. The results of North Kansas City's tree inventory provide insight into the overall health of the city's public trees and the management activities needed to maintain and increase the benefits of trees into the future.

Tree Benefit Analysis

i-Tree Streets

In order to identify the dollar value provided and returned to the community, the city's street tree inventory data were formatted for use in the i-Tree Streets benefit-cost assessment tool.

i-Tree Streets, a component of i-Tree Tools, analyzes an inventoried tree population's structure to estimate the costs and benefits of that tree population. The assessment tool creates an annual benefit report that demonstrates the value public trees provide to a community:

These quantified benefits and the reports generated are described below.

- **Aesthetic/Other Benefits:** Shows the tangible and intangible benefits of trees reflected by increases in property values (in dollars).
- **Stormwater:** Presents reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons.
- **Energy:** Presents the contribution of the urban forest towards conserving energy in terms of reduced natural gas use in the winter (measured in therms [thm]) and reduced electricity use for air conditioning in the summer (measured in Megawatt-hours ([MWh]).
- **Carbon Sequestered:** Presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reductions in energy use measured in pounds. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.
- **Air Quality:** Quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces, and reduced emissions from power plants (NO_2, PM_{10}, volatile organic compounds [VOCs], SO_2) due to reduced electricity use in pounds. The potential negative effects of trees on air quality due to biogenic volatile organic compounds (BVOC) emissions is also reported.

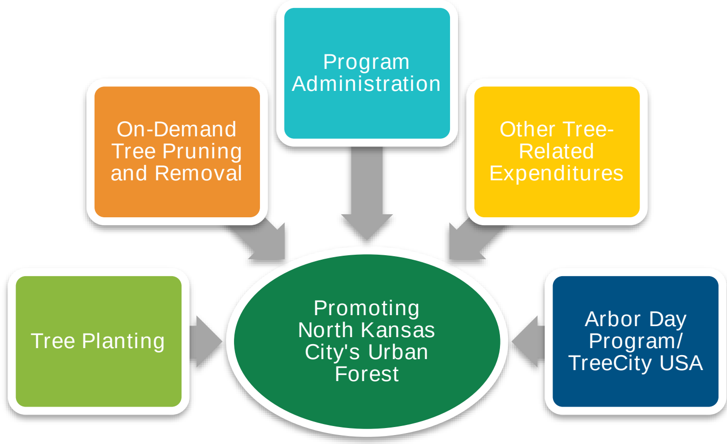
- **Importance Value (IV):** IVs are calculated for species that comprise more than 1% of the population. The Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population but have an IV of 25% due to its substantial benefits, indicating that the loss of those trees would be more significant than just their population percentage would suggest.

i-Tree Tools

i-Tree Tools software was developed by the U.S. Department of Agriculture, Forest Service (USDA FS) with the help of several industry partners, including The Davey Tree Expert Company. Learn more at www.itreetools.org.

THE BENEFITS OF NORTH KANSAS CITY'S URBAN FOREST

i-Tree Streets Inputs



In addition to tree inventory data, i-Tree Streets requires cost-specific information to manage a community's tree management program—including administrative costs and costs for tree pruning, removal, and planting. Regional data, including energy prices, property values, and stormwater costs, are required inputs to generate the environmental and economic benefits trees provide. If community program local economic data are not available, i-Tree Streets uses default economic inputs from a reference city selected by USDA FS for the climate zone in which your community is located. Any default value can be adjusted for local conditions.

North Kansas City's Inputs

Local data were available at the time of this plan and were used to the greatest extent possible with i-Tree Streets to calculate the benefits North Kansas City's trees provide its citizens.

Annual Benefits

i-Tree Tools

A common example of a natural BVOC is the gas emitted from pine trees, which creates the distinct smell of a pine forest.

The i-Tree Streets model estimated that the inventoried street trees provide a total annual benefit of $322,564. Essentially, $322,564 was saved to cool buildings, manage stormwater, and clean the air. In addition, community aesthetics were improved and property values increased because of the presence of trees. On average, one of North Kansas City's trees provides an annual benefit of $109.01 per tree and $73.97 per capita.

The assessment found that aesthetics and other tangible and intangible benefits trees provide were the greatest value to the community. Approximately half of the total annual benefits were due to increases in property value. In addition to increasing property values, trees also play a major role in stormwater management. The city's street trees alone intercepted over 672,373 gallons of rainfall, which equates to a savings of $142,703 in stormwater management costs. Stormwater management comprises 44% of the annual benefits public trees provide. Energy conservation and reductions in CO_2 are important but account for lesser amounts of work performed by community trees. Energy reductions accounted for 16% of the annual benefits, while CO_2 reductions accounted for 5% and air quality accounted for 6% of the annual benefits.

Figure 8 summarizes the annual benefits and results for the street tree population. Table 2 presents results for individual tree species from the i-Tree Streets analysis.

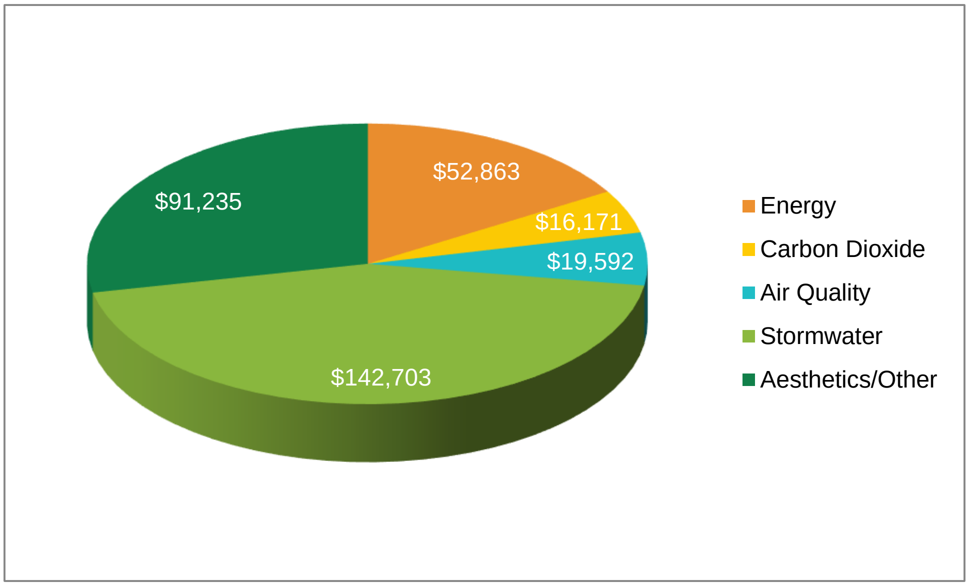


Figure 8. Breakdown of total annual benefits provided to North Kansas City.

Table 2. Benefit Data for Common Public Trees by Species

Most Common Trees Collected During Inventory		Number Trees on the ROW	Percent of Total Trees	Canopy Cover	Benefit Provide By Street Trees					Importance Value (IV)
					Aesthetic/ Other	Stormwater	Energy	Carbon Sequestered	Air Quality	
Common Name	Botanical Name		(%)	(ft^2)	Average/$/Tree					0–100 (higher IV = more important species)
thornless honeylocust	Gleditsia triacanthos inermis	566	19.1	670,581	71.54	53.19	23.49	7.59	8.41	22
red maple	Acer rubrum	347	11.7	223,544	23.69	28.68	14.58	4.19	5.47	9
green ash	Fraxinus pennsylvanica	295	10.0	428,862	32.01	88.41	27.51	8.59	10.85	15
sugar maple	Acer saccharum	290	9.8	269,748	23.79	47.65	19.69	5.31	6.72	10
callery pear	Pyrus calleryana	137	4.6	70,369	15.59	22.47	13.02	3.60	4.66	3
silver maple	Acer saccharinum	124	4.2	241,617	58.09	128.56	31.55	13.69	12.75	8
Siberian elm	Ulmus pumila	98	3.3	200,968	25.99	111.46	33.92	9.24	14.68	6
eastern redbud	Cercis canadensis	92	3.1	21,453	2.73	5.91	5.48	1.36	2.05	1
common baldcypress	Taxodium distichum	78	2.6	20,165	9.91	13.40	5.53	1.71	1.99	1
London planetree	Platanus x acerifolia	74	2.5	100,293	30.09	81.40	26.23	8.01	10.27	4
Norway maple	Acer platanoides	56	1.9	11,975	8.24	8.32	5.36	1.59	1.86	1
apple	Malus species	50	1.7	11,685	2.86	5.73	5.50	1.39	2.02	1
Austrian pine	Pinus nigra	38	1.3	17,059	12.93	42.31	11.07	2.13	2.71	1
Chinese elm	Ulmus parvifolia	36	1.2	18,790	13.82	23.62	12.06	2.68	4.16	1
eastern white pine	Pinus strobus	35	1.2	16,965	19.96	54.97	11.79	2.54	2.04	1
plum	Prunus species	34	1.1	4,704	1.60	3.03	3.19	0.80	1.12	0
scotch pine	Pinus sylvestris	31	1.0	13,732	17.29	47.79	10.86	2.31	1.98	1
eastern red cedar	Juniperus virginiana	30	1.0	1,314	4.98	3.25	1.03	0.19	0.16	0
hybrid elm,	Ulmus x	30	1.0	4,223	5.15	5.07	3.32	0.86	1.09	0
other street trees	~56 species of varying genera	518	18.0	174,826	12.22	28.38	10.35	2.49	3.73	14
ROW Total	~40 genera and ~56 species on the ROW	2,959	100.5	1,122,456	30.83	48.23	17.87	5.47	6.62	100

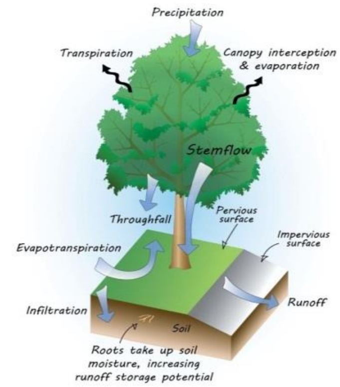
Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits of street trees was $91,235. The average benefit per tree equaled $30.83 per year.

Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. The inventoried trees in North Kansas City intercept 5,265,794 gallons of rainfall annually (Table 3). On average, the estimated annual savings for the city in stormwater runoff management is $142,703.

Of all species inventoried, thornless honeylocust contributed most of the annual stormwater benefits. The population of thornless honeylocust (19% of public trees) intercepted approximately 1.1 million gallons of rainfall. On a per-tree basis, large trees with leafy canopies provided the most value.



- *Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere.*
- *Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil.*
- *Trees help slow down and temporarily store runoff and reduce pollutants by absorbing nutrients and other pollutants from soils and water through their roots.*
- *Trees transform pollutants into less harmful substances.*

Air Quality Improvements

The inventoried tree population removes 1,373 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) on an annual basis through deposition. The population also avoids 9,375 pounds annually. The i-Tree Streets calculation takes into account the biogenic volatile organic compounds (BVOC's) that are released from trees. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. The net total value of these benefits is estimated to be $19,592.

Using the annual per-tree values in Table 2, *Ulmus pumila* (Siberian elm), *Acer saccharinum* (silver maple), *Fraxinus pennsylvanica* (green ash), and *Platanus* × *acerifolia (*London planetree) had the most adverse impact on air quality based on their annual per-tree average values, which ranged from $14.68 to $10.27.

Table 3. Stormwater Benefits Provided by Public Trees

Most Common Trees Collected During Inventory		Number of Trees on the ROW	Percent of Total Trees	Total Rainfall Interception
Common Name	Botanical Name		(%)	(gal.)
thornless honeylocust	Gleditsia triacanthos inermis	566	19	1,110,914
red maple	Acer rubrum	347	12	367,257
green ash	Fraxinus pennsylvanica	295	10	962,417
sugar maple	Acer saccharum	290	10	509,890
callery pear	Pyrus calleryana	137	5	113,595
silver maple	Acer saccharinum	124	4	588,234
Siberian elm	Ulmus pumila	98	3	403,082
eastern redbud	Cercis canadensis	92	3	20,059
common baldcypress	Taxodium distichum	78	3	38,565
London planetree	Platanus × acerifolia	74	3	222,272
Norway maple	Acer platanoides	56	2	17,194
apple	Malus species	50	2	10,572
Austrian pine	Pinus nigra	38	1	59,327
Chinese elm	Ulmus parvifolia	36	1	31,377
eastern white pine	Pinus strobus	35	1	70,991
plum	Prunus species	34	1	3,801
scotch pine	Pinus sylvestris	31	1	54,663
eastern red cedar	Juniperus virginiana	30	1	3,594
hybrid elm	Ulmus x	30	1	5,616
other street trees	~56 species of varying genera	518	18	672,373
ROW Total	~40 genera and ~56 species on the ROW	2,959	100	5,265,794
	Species on the ROW			

Carbon Storage and Carbon Sequestration

Trees store some of the carbon dioxide (CO_2) they absorb. This prevents CO_2 from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. These trees also sequester some of the CO_2 during growth (Nowak et al. 2013).

The i-Tree Streets calculation takes into account the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The net carbon benefit is approximately $16,171 per year.

The city's street and park trees store 16,862,191 pounds of carbon (measured in CO_2 equivalents). This amount reflects the amount of carbon they have amassed during their lifetimes. Through sequestration and avoidance, 2,156,152 pounds of CO_2 are removed each year. Silver maple provided the most carbon benefits, with each tree storing an average of $128.63 and annually sequestering $13.69 worth of carbon.

Energy Benefits

Gleditsia triacanthos inermis (thornless honeylocust)	Celtis occidentalis (common hackberry)	Cercis canadensis (eastern redbud)	Fraxinus pennsylvanica (green ash)
19% of public trees	**< 1% of** public trees	3% of public trees	**10% of** public trees
143 MWh ElectriXYZ	4 MWh ElectriXYZ	5 MWh ElectriXYZ	**86 Wh ElectriXYZ**
18,707 thm Natural Gas	607 thm Natural Gas	**811 thm** Natural **Gas**	12,039 thm Natural Gas
$23.49 Average $/tree	$33.53 Average $/tree	**$5.48 Average $/**tree	**$27.51 Average $/tree**

Public trees conserve energy by shading structures and surfaces, which reduces electricity use for air conditioning in the summer. Trees divert wind in the winter to reduce natural gas use. Based on the inventoried trees, the annual electric and natural gas savings are equivalent to 565 MWh of electricity and 75,979 therms of natural gas, which accounts for an annual savings of $52,863 in energy consumption.

Thornless honeylocust contributed $23.49 per tree to the annual energy benefits of the urban forest. That it was the greatest contributor is mostly due to its dominance on the streets and in parks. Other tree species, specifically *Celtis occidentalis* (common hackberry), silver maple, and Siberian elm, contributed more to reduce energy usage on a per-tree basis. The annual value these trees provide exceeds $30 per tree, although they comprise only 0.4%, 4.2%, and 3.3% of the population, respectively. These large leafy canopies are valuable because they provide shade, which reduces energy usage. Smaller trees inventoried such as *Cercis canadensis* (eastern redbud), *Malus* spp. (flowering crabapple), and *Prunus* spp. (cherry spp.) were found to have smaller reductions in energy usage on a per-tree basis.

Importance Value (IV)

Understanding the importance of a tree species to the community is based on its presence on the street ROW and in city parks, but also its ability to provide environmental and economic benefits to the community. The IV calculated by the computer model takes into account the total number of trees of a species, its percentage in the population, and its total leaf area and canopy cover. The IV can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. If IV values are greater or less than the percentage of a species on the street ROW and parks, it indicates that the loss of that species may be more important or less important than its population percentage implies.

The i-Tree Streets assessment found that thornless honeylocust has the greatest IV in the street ROW and city park population at 22.3, even though it comprises only 19% of the street ROW and city parks. This indicates that the loss of the thornless honeylocust population would be more economically detrimental than its percentage of the population leads us to believe. The second highest IV was sugar maple (9.9), followed by red maple (8.7) and silver maple (7.9). Because they are large growing species, the size and canopy of broadleaf species by nature provide more environmental benefits to the community, which all factor into assigning IV. The IV for eastern redbud (1.4) is much less than its percentage of the population (3%), indicating that if eastern redbud was lost, its economic impact would not be as significant.

Benefit-Cost Ratio

According to the benefits presented in this section, trees provide excellent value—but are the collective benefits worth the costs of management? In other words, are trees a good investment for North Kansas City? To answer that question, we must compare the benefit public trees provide to the cost of their management.

Applying a benefit-cost ratio (BCR) is another useful way to evaluate the investment in public trees. A BCR is an indicator used to summarize the overall value compared to the costs of a given project. Specifically, in this analysis, BCR is the ratio of the cumulative benefits provided by the city’s public trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. When North Kansas City’s annual expenditures of $147,000 are considered, the net annual benefit (benefits minus costs) returned by public trees to the city is $175,564. North Kansas City receives $59.33 in benefits for every $1 spent on its municipal forestry program.

Discussion/Recommendations

The i-Tree Streets analysis found that public trees provide environmental and economic benefits to the community by virtue of their mere presence on the streets and in parks. The stormwater benefits provided by public trees were rated as having the greatest value to the community. The management of stormwater provided by trees is important to stimulate economic growth. In addition to managing stormwater, trees increase aesthetics and property values, provide shade and windbreaks to reduce energy usage, store and sequester CO_2, and improve air quality.

To increase the benefits the urban forest provides, the city should plant young, large-statured tree species that are low emitters of BVOCs wherever possible. Leafy, large-stature trees consistently create the most environmental and economic benefits. Appendix B contains a list of the top 10% of species i-Tree Species recommends for maximized environmental benefits.

SECTION 3: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold North Kansas City's comprehensive vision for preserving its urban forest. This five-year program is based on the tree inventory data; the program was designed to reduce risk through prioritized tree removal and pruning, and to improve tree health and structure through proactive pruning cycles. Tree planting to mitigate removals and increase canopy cover and public outreach are important parts of the program as well.

While implementing a tree care program is an ongoing process, tree work must always be prioritized to reduce public safety risks. Davey Resource Group recommends completing the work identified during the inventory based on the assigned risk rating; however, routinely monitoring the tree population is essential so that other Extreme or High Risk trees can be identified and systematically addressed. While regular pruning cycles and tree planting are important, priority work (especially for Extreme or High Risk trees) must sometimes take precedence to ensure that risk is expediently managed.

Priority and Proactive Maintenance

In this plan, the recommended tree maintenance work was divided into either priority or proactive maintenance. Priority maintenance includes tree removals and pruning of trees with an assessed risk rating of Moderate, High, and Extreme Risk. Proactive tree maintenance includes pruning of trees with an assessed risk of Low Risk and trees that are young. Tree planting, inspections, and community outreach are also considered proactive maintenance. Further explanation about priority and proactive maintenance can be found in Appendix E.

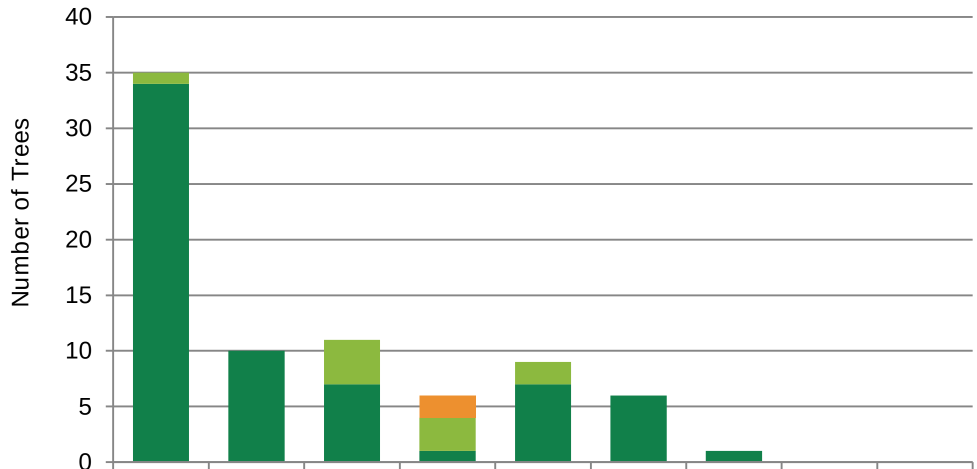
Extreme Risk	• Perform tree maintenance immediately to reduce hazards • Includes tree removal and pruning • Mostly high-use areas
High Risk	• Perform tree maintenance immediately to reduce hazards and improve tree health • Includes tree removal and pruning • Generally high-use areas
Moderate Risk	• Perform tree maintenance as soon as possible to improve tree health • Includes tree removal and pruning • May be high- or low-use areas
Low Risk	• Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees and stumps • Includes tree removals and pruning • Mostly low-use areas but may be high-use areas as well
Routine Pruning	• Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees
Training Prune	• Perform corrective pruning to young trees to increase structural integrity and develop a strong architecture of branches before serious problems develop

Tree and Stump Removal

Although tree removal is usually considered a last resort and may sometimes create a reaction from the community, there are circumstances in which removal is necessary. Trees fail from natural causes, such as diseases, insects, and weather conditions, and from physical injury due to vehicles, vandalism, and root disturbances. Davey Resource Group recommends that trees be removed when corrective pruning will not adequately eliminate the hazard or when correcting problems would be cost-prohibitive. Trees that cause obstructions or interfere with power lines or other infrastructure should be removed when their defects cannot be corrected through pruning or other maintenance practices. Diseased and nuisance trees also warrant removal.

Even though large short-term expenditures may be required, it is important to secure the funding needed to complete priority tree removals. Expedient removal reduces risk and promotes public safety.

Figure 9 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals identified during the inventory.



	1 –3	4 –6	7 –12	13 – 18	19 – 24	25 – 30	31 – 36	37 – 42	43
Extreme	0	0	0	0	0	0	0	0	0
High	0	0	0	2	0	0	0	0	0
Moderate	1	0	4	3	2	0	0	0	0
Low	34	10	7	1	7	6	1	0	0

Figure 9. Tree removals by risk rating and diameter size class.

Findings

The inventory identified 0 Extreme Risk trees, 2 High Risk trees, 10 Moderate Risk trees, and 66 Low Risk trees that are recommended for removal.

The diameter size class for High Risk trees was 13–18 inches diameter at breast height (DBH). These trees should be removed immediately based on their assigned risk. Extreme and High Risk removals can be performed concurrently.

All Moderate Risk trees were smaller than 24 inches DBH. These trees should be removed as soon as possible after all Extreme and High Risk removals have been completed.

Low Risk removals pose little threat; these trees are generally small, dead, invasive, or poorly formed trees that need to be removed. Eliminating these trees will reduce breeding site locations for insects and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species are also included in this category. All Low Risk trees should be removed when convenient and after all Extreme, High, and Moderate Risk removals have been completed.

The inventory identified 68 ash trees recommended for removal. These trees are percentages exclude from this maintenance analysis and schedule section. The management of ash trees is addressed in the EAB strategy section.

The inventory identified 101 stumps recommended for removal. Almost all of these stumps were larger than 11 inches in diameter. Stump removals should occur when convenient.

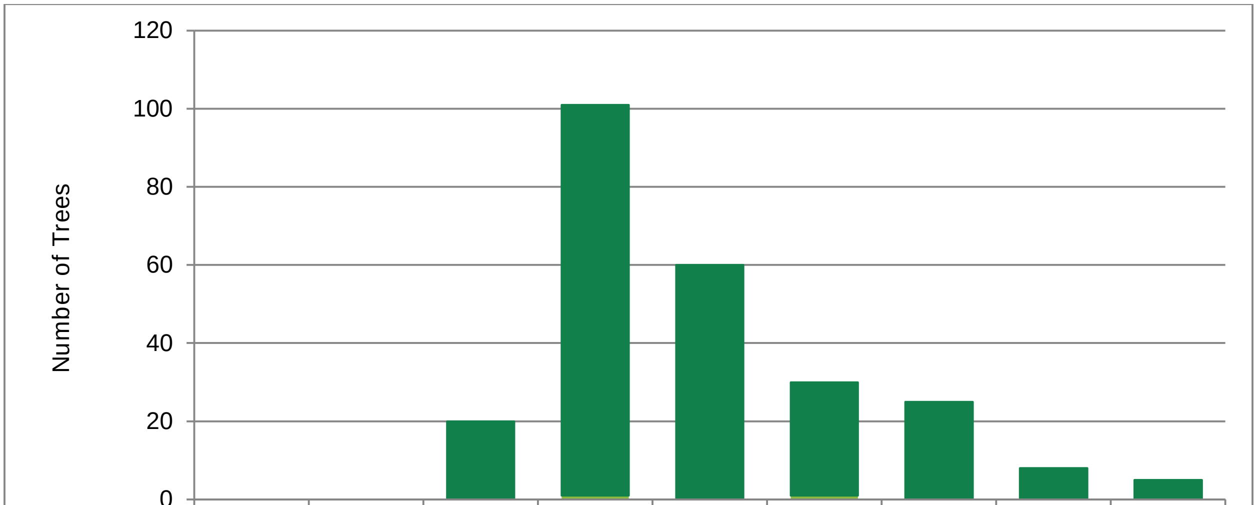
Discussion/Recommendations

Updating the tree inventory data can streamline work load management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using *TreeKeeper*® or similar computer software.

Tree Pruning

Extreme, High, and Moderate Risk pruning generally require cleaning the canopy of both small and large trees to remove defects such as dead and/or broken branches that may be present even when the rest of the tree is sound. In these cases, pruning the branch or branches can correct the problem and reduce risk associated with the tree.

Figure 10 presents the number of High and Moderate Risk trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.



	1 –3	4 –6"	7 – 12	13 –18	19 – 24	25 –30	31 – 36	37 – 42	43
Moderate	0	0	20	100	60	29	25	8	5
High	0	0	0	1	0	1	0	0	0

Diameter Size Class (inches)

Figure 10. High and Moderate Risk pruning by diameter size class.

Findings

The inventory identified 0 Extreme Risk trees, 2 High Risk trees, and 247 Moderate Risk trees recommended for pruning.

High Risk trees ranged in diameter size classes from 13–18 inches DBH to 25–30 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other Extreme and High Risk pruning.

Moderate Risk trees ranged in diameter size classes from 7–12 inches DBH to greater than 42 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other Extreme, High, and Moderate Risk pruning.

Low Risk trees recommended for pruning should be included in a proactive, routine pruning cycle after all of the higher risk trees are addressed.

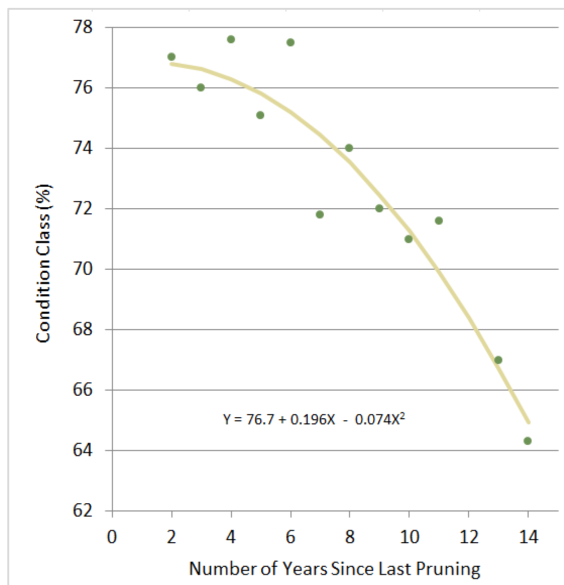


Figure 11. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

Pruning Cycles

The goals of pruning cycles are to visit, assess, and prune trees on a regular schedule to improve health and reduce risk. Davey Resource Group recommends that pruning cycles begin after all Extreme and High Risk trees are corrected through removal or pruning. However, due to the long-term benefits of pruning cycles, Davey Resource Group recommends that the cycles be implemented as soon as possible. To ensure that all trees receive the type of pruning they need to mature with better structure and lower associated risk, two pruning cycles are recommended: the young tree training cycle (YTT Cycle) and the routine pruning cycle (RP Cycle). The cycles differ in the type of pruning, the general age of the target tree, and length.

The recommended number of trees in the pruning cycles will need to be modified to reflect changes in the tree population as trees are planted, age, and die. Newly planted trees will enter the YTT Cycle once they become established. As young trees reach maturity, they will be shifted from the YTT Cycle into the RP Cycle. When a tree reaches the end of its useful life, it should be removed and eliminated from the RP Cycle.

For many communities, a proactive tree management program is considered unfeasible. An on-demand response to urgent situations is the norm. Research has shown that a proactive program that includes a routine pruning cycle will improve the overall health of a tree population (Miller and Sylvester 1981). Proactive tree maintenance has many advantages over on-demand maintenance, the most significant of which is reduced risk. In a proactive program, trees are regularly assessed and pruned, which helps detect and eliminate most defects before they escalate to a hazardous situation with an unacceptable level of risk. Other advantages of a proactive program include increased environmental and economic benefits from trees, more predictable budgets and projectable workloads, and reduced long-term tree maintenance costs.

Why Prune Trees on a Cycle?

Miller and Sylvester (1981) examined the frequency of pruning for 40,000 street and boulevard trees in Milwaukee, Wisconsin. They documented a decline in tree health as the length of the pruning cycle increased. When pruning was not completed for more than 10 years, the average tree condition was rated 10% lower than when trees had been pruned within the last several years. Miller and Sylvester suggested that a pruning cycle of five years is optimal for urban trees.

Young Tree Training Cycle

Trees included in the YTT Cycle are generally less than 8 inches DBH. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing risk and creating potential liability.

YTT pruning is performed to improve tree form or structure; the recommended length of a YTT Cycle is three years because young trees tend to grow at faster rates (on average) than more mature trees.

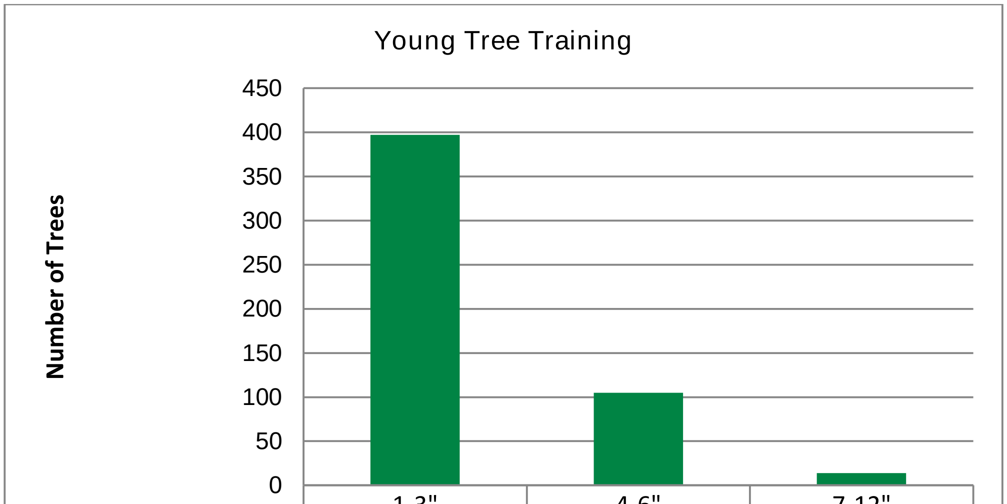
The YTT Cycle differs from the RP Cycle in that these trees generally can be pruned from the ground with a pole pruner or pruning shear. The objective is to increase structural integrity by pruning for one dominant leader. YTT Pruning is species-specific, since many trees such as *Betula nigra* (river birch) may naturally have more than one leader. For such trees, YTT pruning is performed to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

Recommendations

Davey Resource Group recommends that North Kansas City implement a three-year YTT Cycle as soon as possible. The YTT Cycle will include existing young trees. During the inventory, 516 trees smaller than 12 inches DBH were inventoried and recommended for young tree training. The benefit of beginning the YTT Cycle is substantial. Davey Resource Group recommends that an average of 172 trees be structurally pruned each year over three years, beginning in Year One of the management program.

If trees are planted, they will need to enter the YTT Cycle after establishment, typically a few years after planting.

In future years, the number of trees in the YTT Cycle will be based on tree planting efforts and growth rates of young trees. The city should strive to prune approximately one-third of its young trees each year.



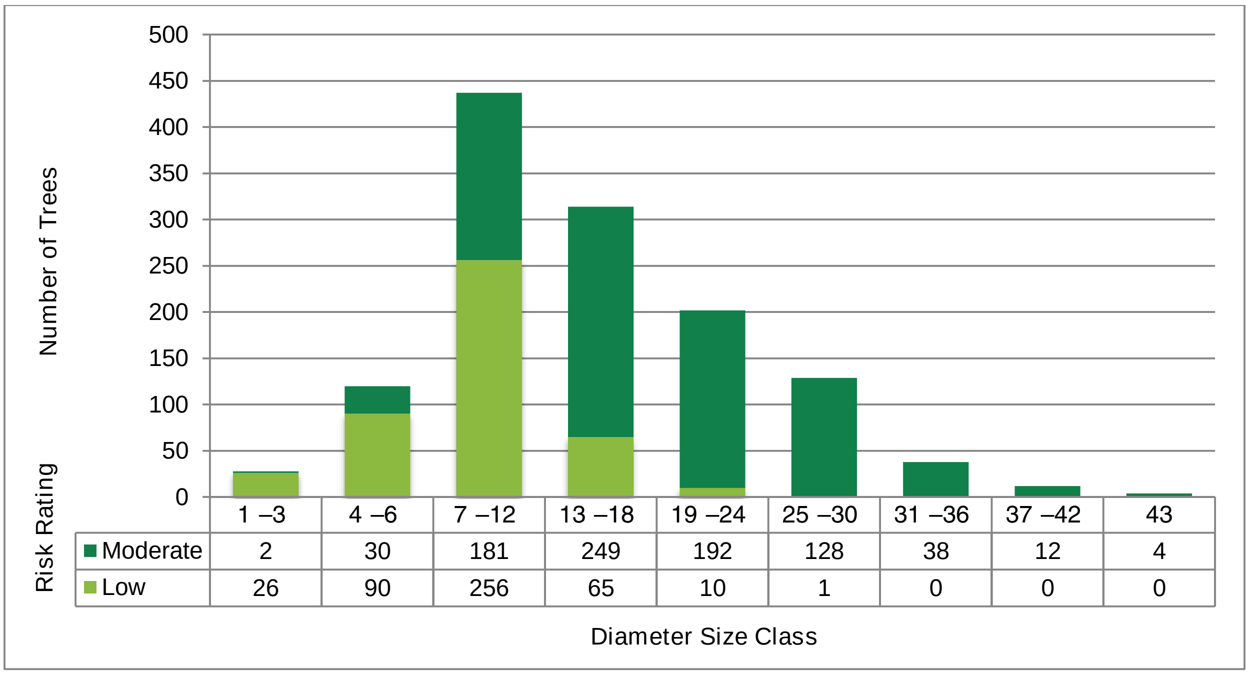
	1-3"	4-6"	7-12"
Young Tree Training	397	105	14

Figure 12. Trees recommended for the YTT Cycle by diameter size class.

Routine Pruning Cycle

The RP Cycle includes established, maturing, and mature trees (mostly greater than 8 inches DBH) that need cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance, minimize instances of elevated risk, and provide the basis for a more defensible risk management program. Included in this cycle are Low Risk trees that require pruning and pose some risk but have a smaller size of defect and/or less potential for target impact. The defects found within these trees can usually be remediated during the RP Cycle.

The length of the RP Cycle is based on the size of the tree population and what was assumed to be a reasonable number of trees for a program to prune per year. Generally, the RP Cycle recommended for a tree population is five years but may extend to seven years if the population is large.



Risk Rating	1 –3	4 –6	7 –12	13 –18	19 –24	25 –30	31 –36	37 –42	43
Moderate	2	30	181	249	192	128	38	12	4
Low	26	90	256	65	10	1	0	0	0

Figure 13. Trees recommended for the RP Cycle by diameter size class.

Recommendations

Davey Resource Group recommends that the city establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The 2016 tree inventory identified approximately 1,794 trees that should be pruned over a five-year RP Cycle. An average of 359 trees should be pruned each year over the course of the cycle. Davey Resource Group recommends that the RP Cycle begin in Year Two of this five-year plan, after all High and Moderate Risk trees are pruned.

The inventory found that most trees (68%) on the street ROW and in parks needed routine pruning. Figure 13 shows that a variety of tree sizes will require pruning; however, most of the trees that require routine pruning were smaller than 24 inches DBH.

Maintenance Schedule

Utilizing data from the 2017 City of North Kansas City tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. Davey Resource Group made budget projections using industry knowledge and public bid tabulations. Actual costs were not specified by North Kansas City. A complete table of estimated costs for North Kansas City's five-year tree management program is presented on the following page.

The schedule provides a framework for completing the inventory maintenance recommendations over the next five years. Following this schedule can shift tree care activities from an on-demand system to a more proactive tree care program.

To implement the maintenance schedule, the city's tree maintenance budget should average $89,902. Annual budget funds are needed to ensure that extreme, high, and moderate risk trees are remediated and that crucial young tree training and routine pruning cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

If routing efficiencies and/or contract specifications allow for the completion of more tree work, or if the schedule requires modification to meet budgetary or other needs, then the schedule should be modified accordingly. Unforeseen situations such as severe weather events may arise and change the maintenance needs of trees. Should conditions or maintenance needs change, budgets and equipment will need to be adjusted to meet the new demands.

Table 4. Estimated Costs for Five-Year Urban Forestry Management Program

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Priority Removals	1-3"	$28	1	$28	0	$0	0	$0	0	$0	0	$0	$28
	4-6"	$58	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$138	4	$550	0	$0	0	$0	0	$0	0	$0	$550
	13-18"	$314	5	$1,568	0	$0	0	$0	0	$0	0	$0	$1,568
	19-24"	$605	2	$1,210	0	$0	0	$0	0	$0	0	$0	$1,210
	25-30"	$825	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$1,045	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$1,485	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,035	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**12**	**$3,355**	0	$0	0	$0	0	$0	0	$0	**$3,355**
Low Risk Removals	1-3"	$28	0	$0	34	$935	0	$0	0	$0	0	$0	$935
	4-6"	$58	0	$0	10	$575	0	$0	0	$0	0	$0	$575
	7-12"	$138	0	$0	7	$963	0	$0	0	$0	0	$0	$963
	13-18"	$314	0	$0	1	$314	0	$0	0	$0	0	$0	$314
	19-24"	$605	0	$0	7	$4,235	0	$0	0	$0	0	$0	$4,235
	25-30"	$825	6	$4,950	0	$0	0	$0	0	$0	0	$0	$4,950
	31-36"	$1,045	1	$1,045	0	$0	0	$0	0	$0	0	$0	$1,045
	37-42"	$1,485	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,035	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**7**	**$5,995**	**59**	**$7,021**	0	$0	0	$0	0	$0	**$13,016**
Stump Removals	1-3"	$18	1	$18	34	$595	0	$0	0	$0	0	$0	$613
	4-6"	$28	4	$110	10	$275	0	$0	0	$0	0	$0	$385
	7-12"	$44	23	$1,012	7	$308	0	$0	0	$0	0	$0	$1,320
	13-18"	$72	34	$2,431	1	$72	0	$0	0	$0	0	$0	$2,503
	19-24"	$94	27	$2,525	7	$655	0	$0	0	$0	0	$0	$3,179
	25-30"	$110	16	$1,760	0	$0	0	$0	0	$0	0	$0	$1,760
	31-36"	$138	6	$825	0	$0	0	$0	0	$0	0	$0	$825
	37-42"	$160	5	$798	0	$0	0	$0	0	$0	0	$0	$798
	43"+	$182	4	$726	0	$0	0	$0	0	$0	0	$0	$726
Activity Total(s)			**120**	**$10,204**	**59**	**$1,904**	0	$0	0	$0	0	$0	**$12,108**
Priority Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	20	$1,500	0	$0	0	$0	0	$0	0	$0	$1,500
	13-18"	$120	101	$12,120	0	$0	0	$0	0	$0	0	$0	$12,120
	19-24"	$170	60	$10,200	0	$0	0	$0	0	$0	0	$0	$10,200
	25-30"	$225	30	$6,750	0	$0	0	$0	0	$0	0	$0	$6,750
	31-36"	$305	25	$7,625	0	$0	0	$0	0	$0	0	$0	$7,625
	37-42"	$380	8	$3,040	0	$0	0	$0	0	$0	0	$0	$3,040
	43"+	$590	5	$2,950	0	$0	0	$0	0	$0	0	$0	$2,950
Activity Total(s)			**249**	**$44,185**	0	$0	0	$0	0	$0	0	$0	**$44,185**
Routine Pruning (5-year cycle)	1-3"	$20	0	$0	18	$360	18	$360	18	$360	18	$360	$1,440
	4-6"	$30	0	$0	30	$900	30	$900	30	$900	30	$900	$3,600
	7-12"	$75	0	$0	82	$6,150	82	$6,150	82	$6,150	82	$6,150	$24,600
	13-18"	$120	0	$0	119	$14,280	119	$14,280	119	$14,280	119	$14,280	$57,120
	19-24"	$170	0	$0	67	$11,390	67	$11,390	67	$11,390	67	$11,390	$45,560
	25-30"	$225	0	$0	24	$5,400	24	$5,400	24	$5,400	24	$5,400	$21,600
	31-36"	$305	0	$0	11	$3,355	11	$3,355	11	$3,355	11	$3,355	$13,420
	37-42"	$380	0	$0	6	$2,280	6	$2,280	6	$2,280	6	$2,280	$9,120
	43"+	$590	0	$0	2	$1,180	2	$1,180	2	$1,180	2	$1,180	$4,720
Activity Total(s)			0	$0	**359**	**$45,295**	**359**	**$45,295**	**359**	**$45,295**	**359**	**$45,295**	**$181,180**
Young Tree Training Pruning (3-year cycle)	1-3"	$20	132	$2,640	132	$2,640	132	$2,640	178	$3,560	178	$3,560	$15,040
	4-6"	$29	35	$1,015	35	$1,015	35	$1,015	35	$1,015	35	$1,015	$5,075
	7-12"	$30	5	$150	5	$150	5	$150	5	$150	5	$150	$750
Activity Total(s)			**172**	**$3,805**	**172**	**$3,805**	**172**	**$3,805**	**218**	**$4,725**	**218**	**$4,725**	**$20,865**
Replacement Tree Planting	Purchasing	$170	46	$7,820	46	$7,820	46	$7,820	46	$7,820	46	$7,820	$39,100
	Planting	$110	46	$5,060	46	$5,060	46	$5,060	46	$5,060	46	$5,060	$25,300
Activity Total(s)			**92**	**$12,880**	**92**	**$12,880**	**92**	**$12,880**	**92**	**$12,880**	**92**	**$12,880**	**$64,400**
Replacement Young Tree Maintenance	Mulching	$100	46	$4,600	92	$9,200	138	$13,800	138	$13,800	138	$13,800	$55,200
	Watering	$100	46	$4,600	92	$9,200	138	$13,800	138	$13,800	138	$13,800	$55,200
Activity Total(s)			**92**	**$9,200**	**184**	**$18,400**	**276**	**$27,600**	**276**	**$27,600**	**276**	**$27,600**	**$110,400**
Activity Grand Total			**652**		**741**		**623**		**669**		**669**		
Cost Grand Total				**$89,624**		**$89,305**		**$89,580**		**$90,500**		**$90,500**	**$449,509**

Community Outreach

The data collected and analyzed to develop this plan contribute significant information about the tree population and can be utilized to guide the proactive management of that resource. These data can also be utilized to promote the value of the urban forest and the tree management program in the following ways:

- Tree inventory data can be used to justify necessary priority and proactive tree maintenance activities as well as tree planting and preservation initiatives.
- Species data can be used to guide tree species selection for planting projects with the goals of improving species diversity and limiting the introduction of invasive pests and diseases.
- Information in this plan can be used to advise citizens about threats to urban trees (such as granulate ambrosia beetle, emerald ash borer, and gypsy moth).

There are various avenues for outreach. Maps can be created and posted on websites, in parks, or in business areas. Public service announcements can be developed. Articles can be written and programs about trees and the benefits they provide can be developed. Arbor Day and Earth Day celebrations can become community traditions. Signs can be hung from trees to highlight the contributions trees make to the community. Contests can even be created to increase awareness of the importance of trees. Trees provide oxygen we need to breathe, shade to cool our neighborhoods, and canopies to stand under when it rains.

North Kansas City's data are instrumental in helping to provide tangible and meaningful outreach about the urban forest.

Inspections

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care.

Trees along the street ROW should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. Use appropriate computer management software such as *TreeKeeper®* to update inventory data and work records. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. North Kansas City has a large population of trees, such as maple, ash, and pine, that are susceptible to pests and diseases.

Inventory and Plan Updates

Davey Resource Group recommends that the inventory and management plan be updated using an appropriate computer software program so that the city can sustain its program and accurately project future program and budget needs:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.

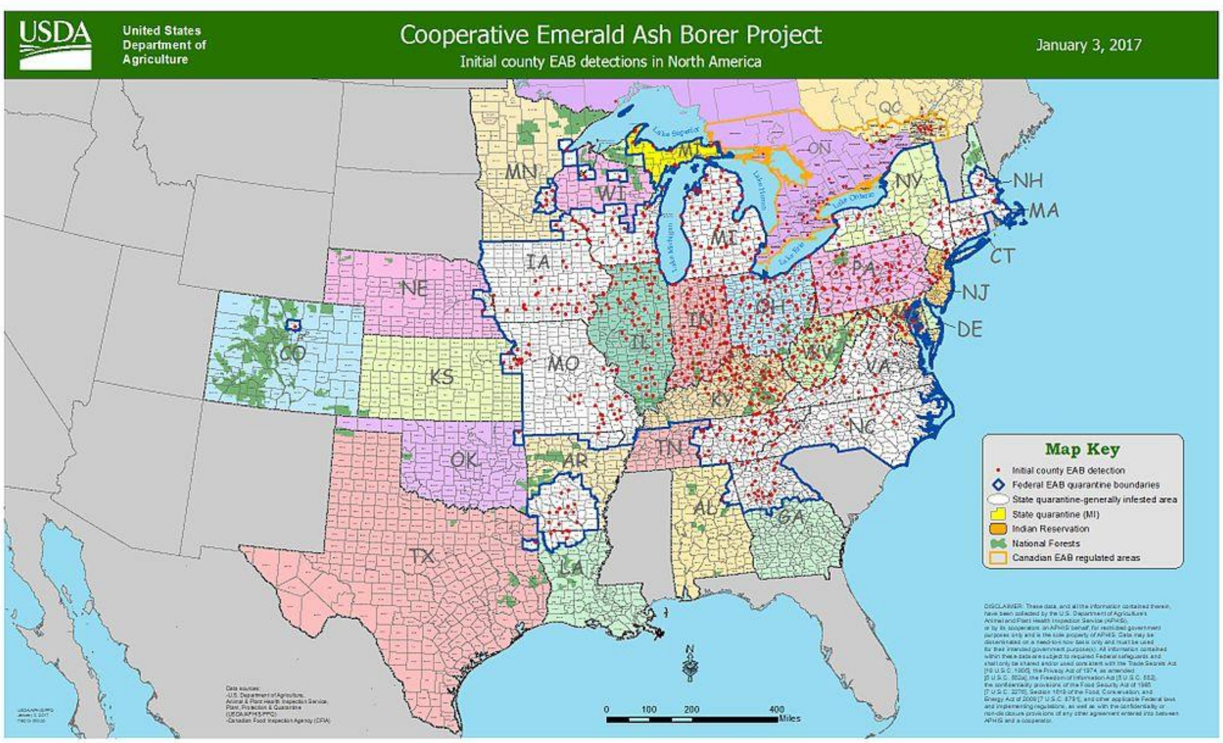
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help city staff stay apprised of changing conditions. Update the tree maintenance schedule and the budget as needed so that identified tree work may be efficiently performed. Schedule and prioritize work based on risk.
- If the recommended work cannot be completed as suggested in this plan, modify maintenance schedules and budgets accordingly.
- Update the inventory database using *TreeKeeper*® as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields in five years, or a portion of the population (1/5), every year over the course of five years.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

SECTION 4: EMERALD ASH BORER STRATEGY

Throughout the United States, urban and community forests are under increased pressure from exotic and invasive insects and diseases. Exotic pests that arrive from overseas typically have no natural predators and become invasive when our native trees and shrubs do not have appropriate defense mechanisms to fight them off. Mortality from these pests can range from two weeks with oak wilt (OW, *Ceratocystis fagacearum*), to seven years with emerald ash borer (EAB, *Agrilus planipennis*) or more.

An integral part of tree management is being aware of invasive insects and diseases in the area and how to best manage them. Depending on the tree diversity within North Kansas City's urban forest, an invasive insect or disease has the potential to negatively impact the tree population.

This chapter provides the different management strategies for dealing with EAB. Included are sections on how to effectively monitor EAB, increase public education, handle ash debris, reforestation, work with stakeholders, and utilize ash wood. Appendix F contains additional EAB reference materials.



Map 1. EAB detections throughout North America as of January 2014.
Map courtesy of USDA.

Emerald Ash Borer

Emerald ash borer is a small insect native to Asia. In North America, the borer is an invasive species highly destructive to ash trees in its introduced range. The potential damage of EAB rivals that of chestnut blight and Dutch elm disease. Chestnut blight is a fungus that was introduced in North America around 1900 and virtually wiped out most of the mature American chestnut population by 1940. It is believed that chestnut blight was imported by chestnut lumber or through imported chestnut trees. Dutch elm disease is a fungus spread sexually by the elm bark beetle. It was first reported in the United States in 1928 and was believed to have been introduced by imported timber. Since its discovery in the United States, it has killed millions of elm trees. EAB is thought to have been introduced into the United States and Canada in the 1990s but was not positively identified in North America until 2002 in Canton, Michigan. It has now been confirmed in 14 states and has killed at least 50 to 100 million ash trees so far and threatens another 7.5 billion ash trees throughout North America. Missouri's EAB infestation was discovered July 2008 in the campground at the Wappapello Lake U.S. Army Corps of Engineers (USACE) Greenville Recreational Area in Wayne County. The insect has since been found in Reynolds and Madison counties in southeast Missouri and in Platte County near Kansas City. EAB is a serious pest that threatens the health of all ash tree species in the state. With an estimated 3% ash trees at risk in Missouri woods—and another 14% to 30% in cities and towns—the state is committed to early detection and thoughtful management of this pest (http://extension.missouri.edu/emeraldashborer/response.aspx). In the U.S., EAB has been known to attack all native ash trees, including white, green, blue, and black ash.

EAB has been identified in Missouri and poses a serious threat to the health and condition of North Kansas City.

Photograph 2. EAB adults grow to 5/8 inch in length (Photograph courtesy of www.wisconsin.gov).

Photograph 3. EAB larvae (Photograph courtesy of www.emeraldashborer.info).

Identification

The adult beetle is elongate, metallic green, and 3⁄8- to 5⁄8-inch long. The adult beetle emerges from late May until early August, feeding on a small amount of foliage. The adult females then lay eggs on the trunk and branches of ash trees and, in about a week, the eggs hatch into larvae, which then bore into the tree. Larvae are creamy white in color and can grow up to an inch long and are found underneath the bark of the trees. The larvae tunnel and feed on the inner bark and phloem, creating winding galleries as they feed. This cuts off the flow of the water and nutrients to the tree, causing dieback and death.

Photograph 4. Larvae consume the cambium and phloem, effectively girdling the tree and eventually causing death within a few years.

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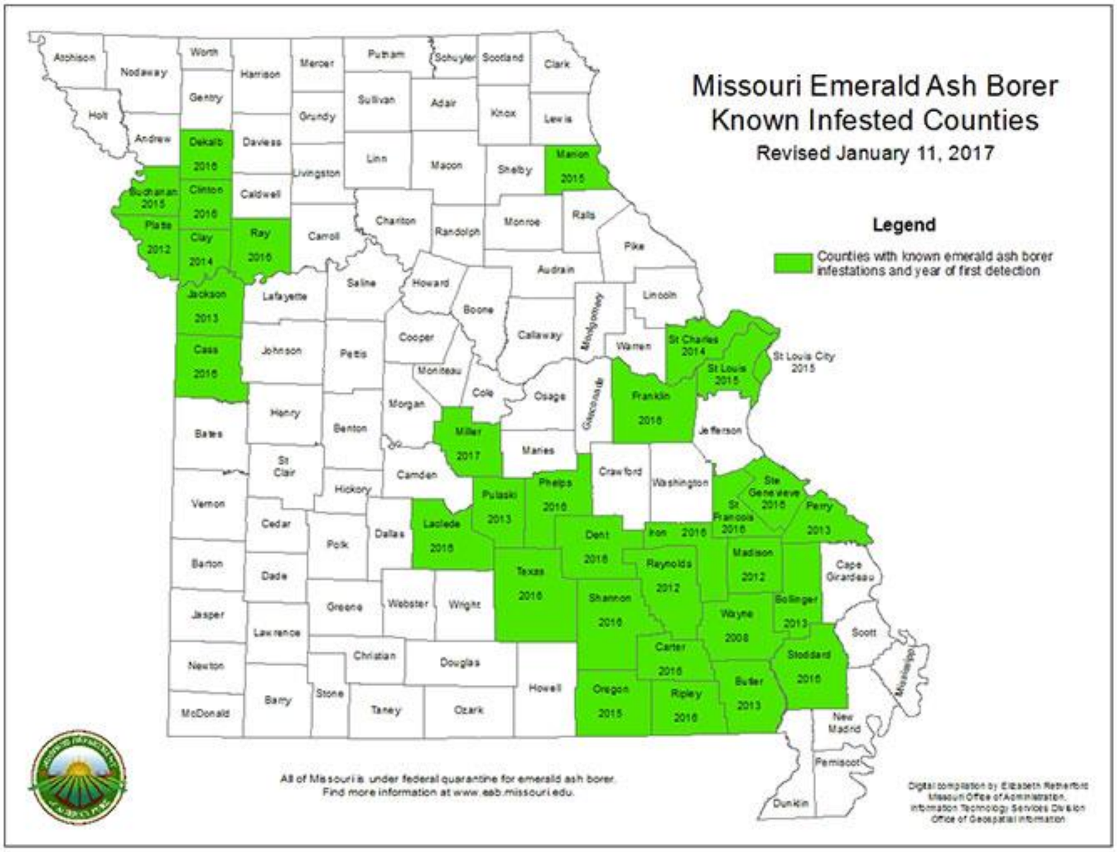
Photograph 5. This ash tree is declining from EAB infestation. The loss of water and nutrients from the intense larvae tunneling can cause the trees to lose between 30% and 50% of their canopies during the first year of infestation (Photo courtesy of http://labs.russell.wisc.edu/eab/signs-and-symptoms/).

EAB can be very difficult to detect. Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting. The entire canopy may die back, or symptoms may be restricted to certain branches. Declining trees may sprout epicormic shoots at the tree base or on branches. Woodpecker injury is often apparent on branches of infested trees, especially in late winter. Removal of bark reveals tissue callusing and frass-filled serpentine tunneling. The S-shaped larval feeding tunnels are about 1⁄4 inch in diameter. Tunneling may occur from upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole that is about 1/8 inch in diameter. The loss of water and nutrients from the intense larvae tunneling can cause trees to lose between 30% and 50% of their canopies during the first year of infestation. Trees often die within two years following infestation.

State and Federal Response

In Missouri, the Missouri Department of Agriculture (MDA) is the lead agency responsible for control of invasive pests. The federal agency USDA-APHIS assists with regulatory and control action of invasive pests. The MDA has declared EAB a public nuisance in Missouri, and enacted a quarantine restricting the movement of ash trees and non-coniferous firewood. In July 2008, it was reported that EAB had been found in the campground at the Wappapello Lake. In July 2008, further infestations were found in Wayne County. The insect has since been found in Reynolds and Madison Counties in southeast Missouri and in Platte County near Kansas City.



Map 2. Known Infested Counties in Missouri (Map courtesy of http://extension.missouri.edu/emeraldashborer/quarantines.aspx)

Federal agencies have been actively researching control measures, including biological controls, developing resistant species, and testing various insecticides. Since 2003, American scientists in conjunction with the Chinese Academy of Forestry have searched for natural enemies of EAB in the wild. This led to the discovery of several parasitoid wasps, namely *Oobius agrili*, a solitary, parthenogenic egg parasitoid; *Spathius agrili*, a gregarious larval ectoparasitoid, and *Tetrastichus planipennisi*, a gregarious larval endoparasitoid. These parasitoid wasps have been released into the Midwest region of the U.S. as a possible biological control of EAB. States that released parasitoid wasps include Indiana, Michigan, and Minnesota.

Ash Population

With the threat of EAB in North Kansas City, it is crucial that the city have an action plan. Some of the most important questions to answer include:

- How many ash trees do we have?
- Where are they located
- What actions should we take?

In order to answer these questions, North Kansas City needs to maintain an up-to-date inventory, know what resources are available, and understand the city’s priorities.

Based on the current public tree inventory, there are 322 ash trees distributed throughout the city. Most of the ash trees between 7 and 36 inches DBH were rated in Good condition. Table 5 illustrates the diameter class of each ash tree by condition class. Of the 322 ash trees inventoried, 13 are showing potential signs and symptoms of EAB.

Table 5. Tree Condition Versus Diameter Class Matrix

		Diameter Class (inches)									
Condition Class		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
	Excellent										0
	Very Good							1			1
	Good		1	21	36	83	79	23	2		245
	Fair		1	6	12	22	12	5	2		60
	Poor		1	3	5	5	1				15
	Critical										0
	Dead				1						1
	Total	0	3	30	54	110	92	29	4	0	322

Ash Tree Risk Reduction Pruning and Removals

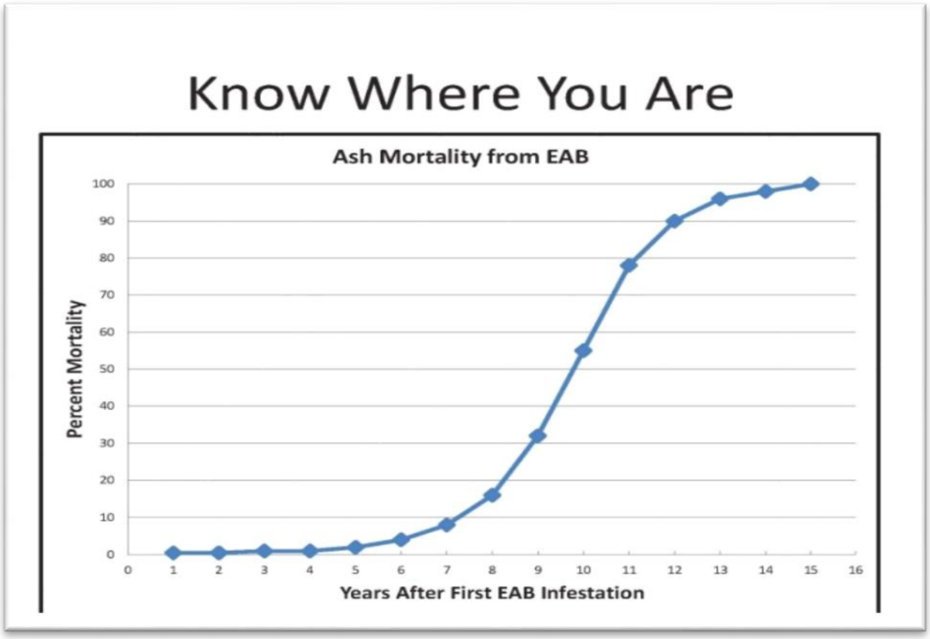
As the EAB infestation becomes more prominent in North Kansas City, the city is strongly encouraged to refocus budgeted funds and personnel to concentrate more closely on the ash tree population. Davey Resource Group recommends that North Kansas City perform both treatment and safety-related activities on ash trees. This activity will end up saving the city money and increasing productivity. However, it is only recommended due to EAB and the eventual removal of infested ash trees.

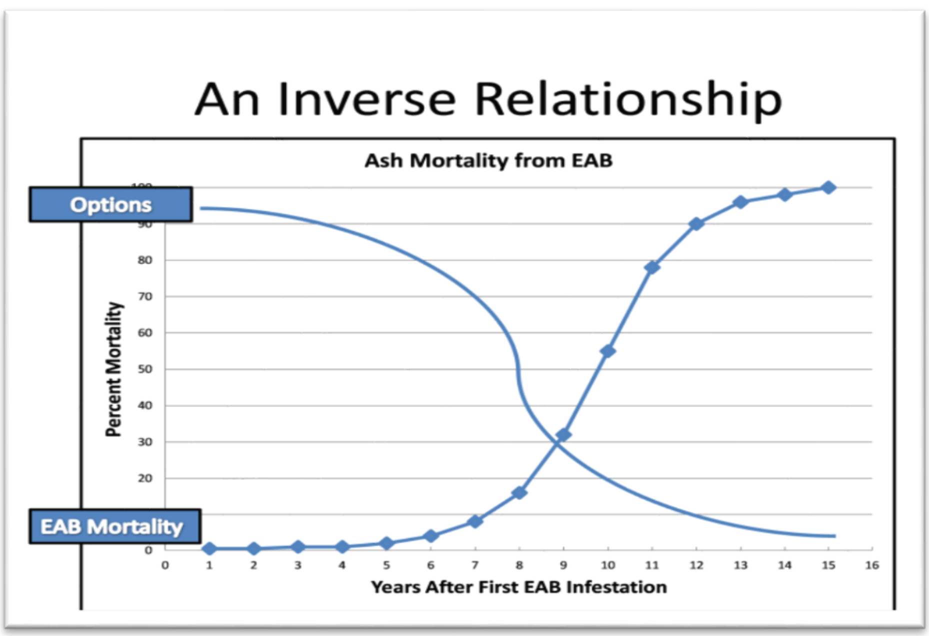
Davey Resource Group also recommends that North Kansas City proactively remove ash trees during road reconstruction projects and other public works associated activities. By proactively removing ash trees during construction, the cost and impacts should be lower.

In the event that North Kansas City decides to proactively remove ash trees, Davey Resource Group recommends that North Kansas City remove all ash trees less than 7 inches and trees that are rated as Dead, Poor, or Critical condition first. These trees are providing little benefit to the community, and the cost for removals should not be significant.

EAB Management Options

North Kansas City should explore different options for managing EAB. With the city striving to be proactive in EAB management before an infestation occurs, North Kansas City has provided itself with multiple management strategies. The graphs below present a unique tool for a city when deciding on what management options are available for varying levels of EAB infestations. North Kansas City can currently be placed at Year 3 on both graphs for years after first EAB infestation. At this position, the city has ample time to prepare as well as select a management option. When infestation occurs, as depicted in the graph, the city's options for management decrease.





Source: Emerald Ash University (www.emeraldashborer.info)

EAB Management

Current Management Strategy

North Kansas City's management strategy involves a combination of removals and treatments. City employees and contractors will complete the maintenance work. Many stakeholders of the North Kansas City urban forestry program have a thorough understanding of the implication of EAB.

EAB Management Options

EAB management strategies include do nothing, remove and replace all ash, treat all ash, or a combination of the strategies. Current strategies for managing EAB and costs associated with these strategies are as follows.

EAB Strategy 1: Do Nothing

This means letting EAB run its course and having no strategy for dealing with EAB. This strategy includes not removing and not treating any ash trees. This strategy is economical in the beginning of an infestation because it costs the city no money, but it would become a severe public safety issue within a few years. Davey Resource Group does not recommend this management strategy.

Photograph 6. This is an example of a do nothing strategy. These ash trees became infested with EAB and eventually died. They have now become a public safety issue.

EAB Strategy 2: Remove and Replace All Ash

Remove and replace all 322 ash trees by 2018. This strategy would benefit public safety from the EAB infestation but would have an impact on the city's budget. In order to achieve this strategy and remove all of the ash trees by 2018, the city would most likely have to contract work out. Removing mature ash trees that are in Good and Fair condition would take away all of the valuable benefits that these trees provide to the city. This strategy ultimately benefits the city by increasing public safety but will require a lot of upfront cost. It will be very important to replace all of these ash trees once they have been removed.

The total approximate cost for this strategy would be $292,470; $200,515 would be the approximate cost to remove all ash trees, $21,115 would be the approximate cost to remove all stumps, and $70,840 would be the approximate cost to replace all ash trees. Refer to Table 6.

Table 6. Cost to Remove and Replace All Ash

Management Strategy	Management Action	# of Trees	Cost
Remove and Replace All Ash Trees	Removal All	322	$200,515
	Replace All	322	$70,840
	Stump Removal	322	$21,115
	Total		$292,470

EAB Strategy 3: Treat all Ash

Treating all of the ash trees in North Kansas City could reduce the annual mortality rate, stabilize removals, and would be less expensive than removing and replacing all ash trees. Treating all ash would enable these trees to keep providing North Kansas City with the monetary benefits that they provide. On the other hand, treating all ash trees is not an ideal practice because some of these ash trees will eventually become infested with EAB and some of these ash trees are less desirable to retain.

If North Kansas City wanted to annually treat all of its 254 ash trees that are not recommended for removal, it would cost approximately $103,320 over a six-year period. This means that it would cost the city approximately $34,440 annually to treat all of North Kansas City's 254 ash trees. The 68 ash trees recommended for removal would cost approximately $39,085, approximately $4,145 to remove all stumps, and approximately $14,960 to replace all removals. After a six-year treatment period and removing the recommended 68 trees, this would cost the city an estimated $103,320. Refer to Table 7.

Table 7. Cost to Treat All Ash

Management Strategy	Management Action	# of Trees	Cost
Treat All Ash Trees	Treat all Ash Trees for Six Years	254	$103,320
	Ash Trees Recommended for Removal	68	$39,085
	Stump Removal	68	$4,145
	Replacement	68	$14,960
	Total	390	$161,510

EAB Strategy 4: Combination of Removals and Treatment

This strategy is intended to give the city options for a combination of removing and treating ash trees to stabilize annual removals, annual budgets, and prolong the life of ash trees in Good and Fair condition. Table 8 is an EAB matrix table that is intended to organize trees that should be considered for removal and trees that should be considered for treatment. The 68 ash trees recommended for removal are excluded from Table 8 and included in Table 9. This EAB matrix table sheds light on why certain ash trees should be considered for removal and treatment.

Table 8. EAB Matrix Table

		Diameter Class (inches)									
Condition Class		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
	Excellent										0
	Very Good							1			1
	Good		1	21	36	83	78	22	2		243
	Fair		1		3	3	3				10
	Poor										0
	Critical										0
	Dead										0
	Total	0	2	21	39	86	81	23	2	0	254

Based on these numbers, Davey Resource Group makes the following recommendations:

2 Trees to Be Removed

- Trees in the Poor, Critical, and Dead condition class are recommended for removal. These trees are recommended for removal because they are more susceptible to EAB infestation. If these trees are not removed, potential public safety issues could arise in the future. All trees in Poor and Critical condition and Dead trees were recommended for removal and replacement upon assessment.
- There are 2 trees less than 7 inches DBH recommended for removal and replacement upon analysis. These trees don't provide as many benefits to the community compared to mature ash trees. It would be in the best interest of the city to remove these trees and replace them with a more diversified mix of trees.

9 Candidate Trees for Chemical Treatment (Low-Moderate Probability of Treatment)

- The intent here is to defer removal of a large block of trees within the matrix of Fair condition class between 7 inches to 43+ inches DBH. These 9 trees are considered to be low-moderate priority for chemical treatment. Eventually, a lot of these trees will become infested with EAB and, therefore, have to be removed in a timely manner. However, if these trees are treated, then this could stabilize annual budgets and removals each year. Treating these trees could be economically beneficial and reduce the chance for a public safety issue in the near future.

243 Candidate Trees for Chemical Treatment (High Probability of Treatment)

- Candidates for chemical treatment will exhibit Fair condition or better, no more than 30% dieback, and will be located in an appropriate site (i.e., not under overhead utilities). Treating these 243 ash trees will help to keep these trees around for a long time. The city will profit from the monetary benefits these ash trees provide.

For maximum retention of public trees, Davey Resource Group recommends that North Kansas City treat all 252 ash trees that are low-moderate and high candidates for treatment, and that the rest of the ash trees be removed. Davey Resource Group also recommends that all 70 trees and stumps be removed and that replacement trees be planted immediately. Table 9 shows that the cost will be approximately $162,030; this option means that many beautiful, shady trees will be saved. After six years, treatment costs will be about $100,000 every two years, depending on ash tree mortality.

Table 9. Costs Associated with Combination Treatment and Removal EAB Strategy

Activity	Diameter	Cost/Tree	# of Trees	Total Cost
Removal	1-3"	$25	0	$0
	4-6"	$105	3	$315
	7-12"	$220	9	$1,980
	13-18"	$355	15	$5,325
	19-24"	$525	24	$12,600
	25-30"	$845	11	$9,295
	31-36"	$1,140	6	$6,840
	37-42"	$1,470	2	$2,940
	43"+	$1,850	0	$0
Activity Total(s)			70	$39,295
Treatment (over six years)	1-3"	$9	0	$0
	4-6"	$30	0	$0
	7-12"	$57	21	$3,591
	13-18"	$93	39	$10,881
	19-24"	$129	86	$33,282
	25-30"	$165	81	$40,095
	31-36"	$201	23	$13,869
	37-42"	$237	2	$1,422
	43"+	$276	0	$0
Activity Total(s)			252	$103,140
Stump Removal	1-3"	$25	0	$0
	4-6"	$25	3	$75
	7-12"	$25	9	$225
	13-18"	$40	15	$600
	19-24"	$60	24	$1,440
	25-30"	$85	11	$935
	31-36"	$110	6	$660
	37-42"	$130	2	$260
	43"+	$160	0	$0
Activity Total(s)			70	$4,195
Replacement		$220	70	$15,400
Activity Total(s)			70	$15.400
Option Totals			462	$162,030

Private Trees

In addition to ash trees located on public property, EAB will impact trees located on private property. The number of private ash trees is unknown but could be equal or more than the ash trees located on public property. During the inventory, it was evident to the inventory arborists that there is an abundance of ash trees located on private properties. The cost to remove ash trees will be higher on private property because of the greater inaccessibility to these areas. It is crucial that the city promote public education about EAB so that it can reduce the potential of city involvement with regulating tree removals on private properties. The public education section will explain more on how to minimize anxiety from private homeowners and give examples on how to go about informing the public about managing their ash trees.

Photograph 7. Hangers will help make private homeowners aware of the management options available for EAB.

Dying and infested ash trees on private property will pose a threat to human and public safety. In the event that city officials have to get involved with private property owners about a potential infested ash tree, North Kansas City should consider utilizing the current North Kansas City tree and landscape ordinance. North Kansas City should consider amending the ordinance so that EAB is acknowledged as a public nuisance.

Public Education

It is crucial for city property owners to be well informed about EAB. Their assistance and cooperation will be vital in helping detect EAB, managing ash trees on private property, and the reforestation process that will come from the removal of ash trees. The city should inform the public that EAB has been discovered in Clay County. If the public is well informed, then they are more likely to accept what is happening and cooperate with the city's requests. The following are examples of how the city should go about informing the public:

- New releases
- City newsletter articles
- Radio programs
- Post information about EAB on the City of North Kansas City website

Photograph 8. Posting information about EAB on ash trees around the city could promote private homeowners to become more proactive in managing their ash trees.

It is vital for North Kansas City to educate the public on how to detect EAB, provide information about treatment options, and relay the importance of reforestation. If the public is advised on how to detect EAB, it can make proactive choices about managing infested ash trees. This could help put city officials at ease by not having as many private trees become a public safety issue. Property owners may want to keep their ash trees because of the benefits the trees provide.

The city should provide information about treatment options so that their trees can last for years to come. It will be important for the city to inform the public about reforestation, the important benefits trees provide to neighborhoods, and how trees increase real estate value. This can help fund and promote neighborhood tree plantings. The following are examples of ways the city can inform the public about these issues:

- Display information packets at public buildings
- Postcard mailings to ash tree owners
- Door hangers explaining maintenance options
- Presentations to community groups
- Post information about EAB on the city's website
- Tie ribbons around ash trees and place tags on the trees with information about EAB

Reforestation

As the ash tree population is being reduced in North Kansas City, the city will need to come up with a plan to replant where ash trees have been removed. The city could potentially lose 11% of its tree population due to EAB. It will be vital for a prompt reforestation in North Kansas City because of the numerous benefits that ash trees provide the community. Some of the benefits that these ash trees provide to the city include, but are not limited to, removing pollutants from the air, helping improve summer temperatures, reducing storm water runoff, and providing social and psychological benefits.

If the city is to replace all the ash trees, it will cost approximately $292,470. This would be a huge financial burden on the city, but it will be important that these trees be replaced. The cost of replanting ash trees could be spread out over multiple years by establishing a goal that a certain amount of trees need to be planted each year. If the city was to plant 32 trees a year, then North Kansas City could replace all of the ash trees within 10 years. This cost could be reduced if the city comes up with a plan to work with volunteers and private property owners. This could include giving private property owners the option of paying for the tree and getting to pick the tree they want from a list of 10 species. North Kansas City should also explore grants for reforestation. Organizing volunteer groups to participate in planting trees could help decrease the cost for planting trees.

It is important to consider diversification when replacing ash trees. Without diversification, a community is much more vulnerable to catastrophic losses that impact budgets and community appearance. Davey Resource Group recommends that no one species represents 10% and that no one genus comprises more than 15% of the total public tree population. Since EAB has hit local communities, local nurseries may have a shortage of trees. North Kansas City might want to consider nurseries in other regions for trees.

CONCLUSIONS

Every hour of every day, public trees in North Kansas City are supporting and improving the quality of life. The city's trees provide an annual benefit of $322,564. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Managing trees in urban areas is often complicated. Navigating the recommendations of experts, the needs of residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge. The city should continue to prepare and implement an EAB Management Plan as soon as possible.

The city must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of the city's trees, North Kansas City is well positioned to thrive. If the management program is successfully implemented, the health and safety of North Kansas City's trees and citizens will be maintained for years to come.

GLOSSARY

aboveground utilities (data field): Shows the presence or absence of overhead utilities at the tree site.

address number (data field): The address number was recorded based on the visual observation by the Davey Resource Group arborist at the time of the inventory of the actual address number posted on a building at the inventoried site. In instances where there was no posted address number on a building or sites were located by vacant lots with no GIS parcel addressing data available, the address number assigned was matched as closely as possible to opposite or adjacent addresses by the arborist(s) and an "X" was added to the number in the database to indicate that the address number was assigned.

Aesthetic/Other Report: The i-Tree Streets Aesthetic/Other Report presents the tangible and intangible benefits of trees reflected by increases in property values in dollars ($).

Air Quality Report: The i-Tree Streets Air Quality Report quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], coarse particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces and reduced emissions from power plants (NO_2, PM_{10}, Volatile Oxygen Compounds [VOCs], SO_2) due to reduced electricity use measured in pounds (lbs.). Also reported are the potential negative effects of trees on air quality due to Biogenic Volatile Organic Compounds (BVOC) emissions.

American National Standards Institute (ANSI): ANSI is a private, nonprofit organization that facilitates the standardization work of its members in the United States. ANSI's goals are to promote and facilitate voluntary consensus standards and conformity assessment systems, and to maintain their integrity.

ANSI A300**:** Tree care performance parameters established by ANSI that can be used to develop specifications for tree maintenance.

arboriculture: The art, science, technology, and business of commercial, public, and utility tree care.

Benefit-Cost Ratio (BCR): The i-Tree Streets (BCR) is the ratio of the cumulative benefits provided by the landscape trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms.

biogenic volatile organic compounds (BVOC): Gases emitted from trees, like pine trees, which create the distinct smell of a pine forest. When exposed to sunlight in the air, BVOCs react to form tropospheric ozone, a harmful gas that pollutes the air and damages vegetation.

block side (data field): Address information for a site that includes the *on street*. The *on street* is the street on which the site is actually located.

canopy: Branches and foliage that make up a tree's crown.

canopy cover: As seen from above, it is the area of land surface that is covered by tree canopy.

Carbon Dioxide Report: The i-Tree Streets Carbon Dioxide Report presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use in pounds. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.

community forest: see **urban forest**.

condition (data field): The general condition of each tree rated during the inventory according to the following categories adapted from the International Society of Arboriculture's rating system: Excellent (100%), Very Good (90%), Good (80%), Fair (60%), Poor, (40%), Critical (20%), Dead (0%).

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

diameter: See **tree size**.

diameter at breast height (DBH): See **tree size**.

Energy Report: The i-Tree Streets Energy Report presents the contribution of the urban forest toward conserving energy in terms of reduced natural gas use in winter measured in therms (th) and reduced electricity use for air conditioning in summer measured in megawatt-hours (MWh).

Extreme Risk tree: Applies in situations where tree failure is imminent, there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area in order to prevent injury.

failure: In terms of tree management, failure is the breakage of stem or branches, or loss of mechanical support of the tree's root system.

further inspection (data field): Notes that a specific tree may require an annual inspection for several years to make certain of its maintenance needs. A healthy tree obviously impacted by recent construction serves as a prime example. This tree will need annual evaluations to assess the impact of construction on its root system. Another example would be a tree with a defect requiring additional equipment for investigation.

genus: A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature, the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.

geographic information system (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a piece of an organization's overall information system framework. GIS links location to information (such as people to addresses, buildings to parcels, or streets within a network) and layers that information to provide a better understanding of how it all interrelates.

global positioning system (GPS): GPS is a system of earth-orbiting satellites that make it possible for people with ground receivers to pinpoint their geographic location.

High Risk tree: The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.

importance value (IV): A calculation in i-Tree Streets displayed in table form for all species that make up more than 1% of the population. The i-Tree Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population, but have an IV of 25% because of its great size, indicating that the loss of those trees due to pests or disease would be more significant than their numbers suggest.

invasive, exotic tree: A tree species that is out of its original biological community. Its introduction into an area causes or is likely to cause economic or environmental harm, or harm to human health. An invasive, exotic tree has the ability to thrive and spread aggressively outside its natural range. An invasive species that colonizes a new area may gain an ecological edge since the insects, diseases, and foraging animals that naturally keep its growth in check in its native range are not present in its new habitat.

inventory: See **tree inventory**.

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase.

i-Tree Tools: State-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide.

location (data fields): A collection of data fields collected during the inventory to aid in finding trees, including address number, street name, side, and block side.

Low Risk tree: The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.

Management Costs: Used in i-Tree Streets, they are the expenditures associated with street tree management presented in total dollars, dollars per tree, and dollars per capita.

mapping coordinate (data field): Helps to locate a tree; X and Y coordinates were generated for each tree using GPS.

Moderate Risk tree: The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely;" or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.

monoculture: A population dominated by one single species or very few species.

Net Annual Benefits: Specific data field for i-Tree Streets. Citywide benefits and costs are calculated according to category and summed. Net benefits are calculated as benefits minus costs.

Nitrogen Dioxide (NO_2): Nitrogen dioxide is a compound typically created during the combustion processes and is a major contributor to smog formation and acid deposition.

None (risk rating): Equal to zero. It is used only for planting sites and stumps.

notes (data field): Describes additional pertinent information.

ordinance: See **tree ordinance**.

overhead utilities (data field): The presence of overhead utility lines above a tree or planting site.

Ozone (O_3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms. It is a product of the photochemical process involving the Sun's energy. Ozone exists in the upper layer of the atmosphere as well as at the Earth's surface. Ozone at the Earth's surface can cause numerous adverse human health effects. It is a major component of smog.

Particulate Matter (PM_{10}): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

Pollard (Secondary Maintenance Need): Pruning method in which tree branches are initially headed and then reduced on a regular basis without disturbing the callus knob.

Primary Maintenance Need (data field): The type of tree work needed to reduce immediate risk.

pruning: The selective removal of plant parts to meet specific goals and objectives.

Removal (Primary Maintenance Need): Data field collected during the inventory identifying the need to remove a tree. Trees designated for removal have defects that cannot be cost-effectively or practically treated. Most of the trees in this category have a large percentage of dead crown.

right-of-way (ROW): See **street right-of-way**.

risk: Combination of the probability of an event occurring and its consequence.

risk assessment (data fields): The risk assessment is a point-based assessment of each tree by an arborist using a protocol based on the U.S. Forest Service Community Tree Risk Rating System. In the field, the probability of tree or tree part failure is assigned 1–4 points (identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions), the size of the defective tree part is assigned 1–3 points (rates the size of the part most likely to fail), the probability of target impact by the tree or tree part is assigned 1–3 points (rates the use and occupancy of the area that would be struck by the defective part), and other risk factors are assigned 0–2 points (used if professional judgment suggests the need to increase the risk rating). The data from the risk assessment is used to calculate the risk rating that is ultimately assigned to the tree.

risk rating: Level 2 qualitative risk assessment will be performed on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, published by International Society of Arboriculture (2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory. The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.

side value (data field): Each site is assigned a side value to aid in locating the site. Side values include: *front*, *side to*, *side away*, *median* (includes islands), and *rear* based on the site's location in relation to the lot's street frontage. The *front* side is the side that faces the address street. *Side to* is the name of the street the arborist is walking towards as data are being collected. The *side from* is the name of the street the arborist is walking away from while collecting data. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

species: Fundamental category of taxonomic classification, ranking below a genus or subgenus, and consisting of related organisms capable of interbreeding.

stem: A woody structure bearing buds and foliage, and giving rise to other stems.

stems (data field): Identifies the number of stems or trunks splitting less than 1 foot above ground level.

Stored Carbon Report: While the i-Tree Streets Carbon Dioxide Report quantifies annual CO_2 reductions, the i-Tree Streets Stored Carbon Report tallies all of the Carbon (C) stored in the urban forest over the life of the trees as a result of sequestration measured in pounds as the CO_2 equivalent.

Stormwater Report: A report generated by i-Tree Streets that presents the reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons (gals.).

street name (data field): The name of a street right-of-way or road identified using posted signage or parcel information.

street right-of-way (ROW): A strip of land generally owned by a public entity over which facilities, such as highways, railroads, or power lines, are built.

street tree: A street tree is defined as a tree within the right-of-way.

structural defect: A feature, condition, or deformity of a tree or tree part that indicates weak structure and contributes to the likelihood of failure.

Stump Removal (Primary Maintenance Need): Indicates a stump that should be removed.

Sulfur Dioxide (SO_2): A strong-smelling, colorless gas that is formed by the combustion of fossil fuels. Sulfur oxides contribute to the problem of acid rain.

Summary Report: A report generated by i-Tree Streets that presents the annual total of energy, stormwater, air quality, carbon dioxide, and aesthetic/other benefits. Values are reflected in dollars per tree or total dollars.

topping: Characterized by reducing tree size using internodal cuts without regard to tree health or structural integrity; this is not an acceptable pruning practice.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. Characteristically, it has one main stem, although many species may grow as multi-stemmed forms.

tree benefit: An economic, environmental, or social improvement that benefits the community and results mainly from the presence of a tree. The benefit received has real or intrinsic value associated with it.

Tree Clean (Primary Maintenance Need): Based on *ANSI A300 Standards*, these trees require selective removal of dead, dying, broken, and/or diseased wood to minimize potential risk.

tree inventory: Comprehensive database containing information or records about individual trees typically collected by an arborist.

tree ordinance: Tree ordinances are policy tools used by communities striving to attain a healthy, vigorous, and well-managed urban forest. Tree ordinances simply provide the authorization and standards for management activities.

tree size (data field): A tree's diameter measured to the nearest inch in 1-inch size classes at 4.5 feet above ground, also known as diameter at breast height (DBH) or diameter.

urban forest: All of the trees within a municipality or a community. This can include the trees along streets or rights-of-way, in parks and greenspaces, in forests, and on private property.

urban tree canopy (UTC) assessment: A study performed of land cover classes to gain an understanding of the tree canopy coverage, particularly as it relates to the amount of tree canopy that currently exists and the amount of tree canopy that could exist. Typically performed using aerial photographs, GIS data, or Lidar.

Volatile Organic Compounds (VOCs): Hydrocarbon compounds that exist in the ambient air and are by-products of energy used to heat and cool buildings. Volatile organic compounds contribute to the formation of smog and/or are toxic. Examples of VOCs are gasoline, alcohol, and solvents used in paints.

Young Tree Train (Primary Maintenance Need): Data field based on *ANSI A300* standards, this maintenance activity is characterized by pruning of young trees to correct or eliminate weak, interfering, or objectionable branches to improve structure. These trees can be up to 20 feet tall and can be worked with a pole pruner by a person standing on the ground.

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

Davey Resource Group collected tree inventory data using a system that utilizes a customized ArcPad program loaded onto pen-based field computers equipped with geographic information system (GIS) and global positioning system (GPS) receivers. The knowledge and professional judgment of Davey Resource Group's arborists ensure the high quality of inventory data.

Data fields are defined in the glossary of the management plan. At each site, the following data fields were collected:

- aboveground utilities
- block side
- condition
- further inspection
- location
- primary maintenance needs
- mapping coordinates
- notes
- risk assessment
- risk rating
- species
- stems
- tree size*

* measured in inches in diameter at 4.5 feet above ground (or diameter at breast height [DBH])

Maintenance needs are based on *ANSI A300 (Part 1)* (ANSI 2008). Risk assessment and risk rating are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011).

The data collected were provided in an ESRI® shapefile, Access™ database, and Microsoft Excel™ spreadsheet on a CD-ROM that accompanies this plan.

Site Location Methods

Equipment and Base Maps

Inventory arborists use CF-19 Panasonic Toughbook® unit(s) with built-in GPS receiver(s).

Base map layers were loaded onto these unit(s) to help locate sites during the inventory. Table 1 lists the base map layers, utilized along with source and format information for each layer.

Table 1. Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Clay County Missouri GIS/Mapping Department https://www.claycountymo.gov/Assessor/GIS-Mapping	2014-2015	NAD 1983 StatePlane Missouri, West; Feet
USGS Aerial Imagery https://earthexplorer.usgs.gov/	2014	NAD 1983 StatePlane Missouri, West; Feet

Street ROW Site Location

Individual street ROW sites (trees, stumps, or planting sites) were located using a methodology that identifies sites by *address number*, *street name*, *side*, or *block side*. This methodology was developed by Davey Resource Group to help ensure consistent assignment of location.

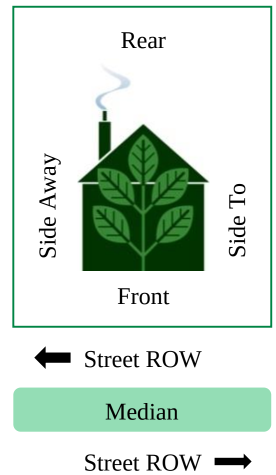


Figure 1. Side values for street ROW sites.

Address Number and Street Name

The *address number* was recorded based on visual observation by the arborist at the time of the inventory (the address number was posted on a building at the inventoried site). Where there was no posted address number on a building, or where the site was located by a vacant lot with no GIS parcel addressing data available, the arborist used his/her best judgment to assign an address number based on opposite or adjacent addresses. An “X” was then added to the number in the database to indicate that it was assigned (for example, “37X Choice Avenue”).

Sites in medians or islands were assigned an address number using the address on the right side of the street in the direction of collection closest to the site. Each segment was numbered with an assigned address that was interpolated from addresses facing that median/island. If there were multiple median/islands between cross streets, each segment was assigned its own address.

The *street name* assigned to a site was determined by street ROW parcel information and posted street name signage.

Side Value

Each site was assigned a *side value* and *site number*. Side values include: *front, side to, side away*, *median* (includes islands), or *rear* based on the site’s location in relation to the lot’s street frontage (Figure 1). The *front side* is the side that faces the address street. *Side to* is the name of the street the arborist walks towards as data are being collected. *Side from* is the name of the street the arborist walks away from while collecting data. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

Block Side

Block side information for a site includes the *on street*.

- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street).

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW sites.

Site Location Examples

Figure 2. The tree trimming crew in the truck traveling westbound on E. Mac Arthur Street is trying to locate an inventoried tree with the following location information:

Address/Street Name:	226 E. Mac Arthur Street
Side:	Side To
On Street:	Davis Street

The tree site circled in red signifies the crew's target site. Because the tree is located on the side of the lot, the on street is Davis Street, even though it is addressed as 226 East Mac Arthur Street.

Figure 3. Location information collected for inventoried trees at Corner Lots A and B.

<u>Corner Lot A</u>

Address/Street Name: 205 Hoover St.
Side: Side To
On Street: Taft St.

Address/Street Name: 205 Hoover St.
Side: Side To
On Street: Taft St.

Address/Street Name: 205 Hoover St.
Side: Side To
On Street: Taft St.

Address/Street Name: 205 Hoover St.
Side: Front
On Street: Hoover St.

<u>Corner Lot B</u>

Address/Street Name: 226 E Mac Arthur St.
Side: Side To
On Street: Davis St.

Address/Street Name: 226 E Mac Arthur St.
Side: Front
On Street: E Mac Arthur St.

Address/Street Name: 226 E Mac Arthur St.
Side: Front
On Street: E Mac Arthur St.

APPENDIX B
RECOMMENDED SPECIES FOR FUTURE PLANTING

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zone 6 on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer rubrum	red maple	Red Sunset®
Acer saccharum	sugar maple	'Legacy'
Aesculus flava*	yellow buckeye	
Betula alleghaniensis*	yellow birch	
Betula lenta*	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
Carya illinoensis*	pecan	
Carya lacinata*	shellbark hickory	
Carya ovata*	shagbark hickory	
Castanea mollissima*	Chinese chestnut	
Celtis laevigata	sugar hackberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
Diospyros virginiana*	common persimmon	
Fagus grandifolia*	American beech	
Fagus sylvatica*	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
Juglans nigra*	black walnut	
Larix decidua*	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
Liriodendron tulipifera*	tuliptree	'Fastigiatum'
Magnolia acuminata*	cucumbertree magnolia	(Numerous exist)
Magnolia macrophylla*	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
Platanus occidentalis*	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	

Large Trees: Greater than 45 Feet in Height at Maturity (Continued)

Scientific Name	Common Name	Cultivar
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus imbricaria	shingle oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	‘Splendens’
Quercus shumardii	Shumard oak	
Styphnolobium japonicum	Japanese pagodatree	‘Regent’
Taxodium distichum	common baldcypress	‘Shawnee Brave’
Tilia americana	American linden	‘Redmond’
Tilia cordata	littleleaf linden	‘Greenspire’
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	‘Sterling’
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	‘Green Vase’

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
Asimina triloba*	pawpaw	
Cladrastis kentukea	American yellowwood	‘Rosea’
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	‘Vanessa’
Phellodendron amurense	amur corktree	‘Macho’
Pistacia chinensis	Chinese pistache	
Prunus maackii	amur chokecherry	‘Amber Beauty’
Prunus sargentii	Sargent cherry	
Pterocarya fraxinifolia*	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
Sassafras albidum*	sassafras	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer cappadocicum	coliseum maple	'Aureum'
Acer ginnala	amur maple	Red Rhapsody™
Acer griseum	paperbark maple	
Acer nigrum	black maple	
Acer pensylvanicum*	striped maple	
Acer triflorum	three-flower maple	
Aesculus pavia*	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
Carpinus caroliniana*	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus kousa	Kousa dogwood	(Numerous exist)
Cornus mas	corneliancherry dogwood	'Spring Sun'
Corylus avellana	European filbert	'Contorta'
Cotinus coggygria*	common smoketree	'Flame'
Cotinus obovata*	American smoketree	
Crataegus phaenopyrum*	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
Franklinia alatamaha*	Franklinia	
Halesia tetraptera*	Carolina silverbell	'Arnold Pink'
Laburnum × watereri	goldenchain tree	
Maackia amurensis	amur maackia	
Magnolia × soulangiana*	saucer magnolia	'Alexandrina'
Magnolia stellata*	star magnolia	'Centennial'
Magnolia tripetala*	umbrella magnolia	
Magnolia virginiana*	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus subhirtella	Higan cherry	'Pendula'
Prunus virginiana	common chokecherry	'Schubert'
Staphylea trifolia*	American bladdernut	
Stewartia ovata	mountain stewartia	
Styrax japonicus*	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Note: * denotes species that are not recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Cedrus libani	cedar-of-Lebanon	
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× Cupressocyparis leylandii	Leyland cypress	
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Psedotsuga menziesii	Douglas-fir	
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	atlantic whitecedar	(Numerous exist)
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Pinus parviflora	Japanese white pine	
Thuja occidentalis	eastern arborvitae	(Numerous exist)

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Ilex × attenuata	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo mugo	mugo pine	

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on Davey Resource Group's experience. Tree availability will vary based on availability in the nursery trade.

Report

Top 10% of Species for Selected Functions

Location: North Kansas City, Clay, Missouri, United States of America
Hardiness: 6
Constraints:

- Minimum Height: None
- Maximum Height: None

Air Pollutant Removal (0-10 Importance):

- Overall: 10

Other Functions (0-10 Importance):

- Low VOC: 10
- UV Radiation Reduction: 10
- Carbon Storage: 10
- Building Energy Reduction: 10
- Wind Reduction: 10
- Streamflow Reduction: 10
- Air Temperature Reduction: 10
- Low Allergenicity: 10

Generated: 5/21/2017

S = Sensitive I = Intermediate S/I = Indeterminate

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
LIRIODENDRON TULIPIFERA	TULIP TREE	5 ~ 9		S			
ULMUS AMERICANA	AMERICAN ELM	3 ~ 9			I/S		Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth
TSUGA HETEROPHYLLA	WESTERN HEMLOCK	6 ~ 7			I		Southern Pine Beetle, Western Spruce Budworm
TSUGA MERTENSIANA	MOUNTAIN HEMLOCK	5 ~ 7					Fir Engraver, Southern Pine Beetle, Western Spruce Budworm
TSUGA CANADENSIS	EASTERN HEMLOCK	4 ~ 7		I			Hemlock Woolly Adelgid, Southern Pine Beetle
ULMUS GLABRA	WYCH ELM	4 ~ 7					Asian Longhorned Beetle, Dutch Elm Disease

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
LIRIODENDRON CHINENSE	CHINESE TULIP TREE	5 ~ 9**					
TILIA AMERICANA	AMERICAN BASSWOOD	4 ~ 9		I	I		Gypsy Moth, Winter Moth
TSUGA X JEFFREYI	JEFFREY HEMLOCK	5 ~ 7**					Southern Pine Beetle
MAGNOLIA ACUMINATA	CUCUMBER TREE	4 ~ 8					
BETULA ALLEGHANIENSIS	YELLOW BIRCH	3 ~ 7		I	S		Asian Longhorned Beetle, Large Aspen Tortrix, Winter Moth
LARIX KAEMPFERI	JAPANESE LARCH	4 ~ 6		I		S	
PICEA ABIES	NORWAY SPRUCE	3 ~ 7					Mountain Pine Beetle, Pine Shoot Beetle, Southern Pine Beetle, Spruce Beetle, Western Spruce Budworm
TSUGA CAROLINIANA	CAROLINA HEMLOCK	4 ~ 7					Hemlock Woolly Adelgid, Southern Pine Beetle
TILIA PLATYPHYLLOS	BIGLEAF LINDEN	4 ~ 6		I			Gypsy Moth
PICEA ASPERATA	CHINESE SPRUCE	6 ~ 7					Southern Pine Beetle, Spruce Beetle
CEDRUS LIBANI	CEDAR OF LEBANON	6 ~ 8					
SEQUOIADENDRON GIGANTEUM	GIANT SEQUOIA	6 ~ 8					
LARIX DECIDUA	EUROPEAN LARCH	3 ~ 6		I/S		S	Gypsy Moth, Pine Shoot Beetle

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
MAGNOLIA OFFICINALIS	NCN - MAGNOLIA OFFICINALIS	6 ~ 8					
ACER RUBRUM	RED MAPLE	4 ~ 10		I	I		Asian Longhorned Beetle, Winter Moth
PSEUDOTSUGA MACROCARPA	BIGCONE DOUGLAS FIR	4 ~ 6			S		Douglas-fir Black Stain Root Disease
FRAXINUS AMERICANA	WHITE ASH	4 ~ 9		S			Emerald Ash Borer, Winter Moth
PLATANUS OCCIDENTALIS	AMERICAN SYCAMORE	5 ~ 9		S			
AESCULUS HIPPOCASTANUM	HORSECHESTNUT	4 ~ 7					Asian Longhorned Beetle
FRAXINUS EXCELSIOR	EUROPEAN ASH	5 ~ 8					Emerald Ash Borer
PSEUDOTSUGA MENZIESII	DOUGLAS FIR	4 ~ 6			I/S		Douglas-Fir Beetle, Fir Engraver, Pine Shoot Beetle, Western Spruce Budworm, Douglas-fir Black Stain Root Disease
CELTIS OCCIDENTALIS	NORTHERN HACKBERRY	3 ~ 9					
PINUS PONDEROSA	PONDEROSA PINE	3 ~ 7		S	S/I		Mountain Pine Beetle, Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, Western Pine Beetle, Western Spruce Budworm, Pine Black Stain Root Disease
TILIA TOMENTOSA	SILVER LINDEN	5 ~ 7					Gypsy Moth
ACER X FREEMANII	FREEMAN MAPLE	4 ~ 8					Asian Longhorned Beetle

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
ZELKOVA SERRATA	JAPANESE ZELKOVA	5 ~ 8		S			
QUERCUS PETRAEA	DURMAST OAK	5 ~ 8					Gypsy Moth, Oak Wilt
TILIA CORDATA	LITTLELEAF LINDEN	4 ~ 7					Gypsy Moth
PLATANUS HYBRIDA	LONDON PLANETREE	5 ~ 8*					Asian Longhorned Beetle
ACER PLATANOIDES	NORWAY MAPLE	4 ~ 7		S		I	Asian Longhorned Beetle, Winter Moth
PINUS STROBUS	EASTERN WHITE PINE	4 ~ 7		I/S	S		Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, White Pine Blister Rust
PINUS MONTICOLA	WESTERN WHITE PINE	5 ~ 8			I		Mountain Pine Beetle, Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, Western Spruce Budworm, White Pine Blister Rust
ABIES CONCOLOR	WHITE FIR	4 ~ 7			I		Fir Engraver, Western Spruce Budworm, Balsam Woolly Adelgid
ABIES HOLOPHYLLA	MANCHURIAN FIR	3 ~ 7					Balsam Woolly Adelgid
FAGUS GRANDIFOLIA	AMERICAN BEECH	4 ~ 8					Beech Bark Disease
ABIES GRANDIS	GRAND FIR	6 ~ 8			I		Fir Engraver, Western Spruce Budworm, Balsam Woolly Adelgid
ACER PSEUDOPLATANUS	SYCAMORE MAPLE	5 ~ 7					Asian Longhorned Beetle
LARIX OCCIDENTALIS	WESTERN LARCH	2 ~ 6			S		Gypsy Moth, Western Spruce Budworm

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
LARIX LYALLII	SUBALPINE LARCH	3 ~ 6**					Gypsy Moth
LARIX SIBERICA	SIBERIAN LARCH	3 ~ 6**					
LARIX LEPTOLEPIS	JAPANESE LARCH	5 ~ 7*		I		S	Spruce Budworm
AESCULUS FLAVA	YELLOW BUCKEYE	4 ~ 8		S			Asian Longhorned Beetle
PINUS JEFFREYI	JEFFERY PINE	5 ~ 8		S			Jeffrey Pine Beetle, Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, Pine Black Stain Root Disease
METASEQUOIA GLYPTOSTROBOIDES	DAWN REDWOOD	5 ~ 8*					
JUGLANS NIGRA	BLACK WALNUT	4 ~ 9					Thousand Canker Disease
BETULA PAPYRIFERA	PAPER BIRCH	3 ~ 6			S		Asian Longhorned Beetle, Gypsy Moth, Large Aspen Tortrix, Winter Moth
PICEA KORAIENSIS	KOREAN SPRUCE	4 ~ 7**					Southern Pine Beetle, Spruce Beetle
CELTIS LAEVIGATA	SUGARBERRY	5 ~ 10					
ACER SACCHARINUM	SILVER MAPLE	3 ~ 9		I			Asian Longhorned Beetle, Winter Moth
ULMUS SEROTINA	SEPTEMBER ELM	5 ~ 8					Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth
FRAXINUS QUADRANGULATA	BLUE ASH	5 ~ 7					Emerald Ash Borer, Winter Moth

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
PRUNUS SEROTINA	BLACK CHERRY	4 ~ 9		S			Winter Moth
PINUS DENSIFLORA	JAPANESE RED PINE	4 ~ 7					Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle
FAGUS SYLVATICA	EUROPEAN BEECH	4 ~ 7					Beech Bark Disease
PICEA BICOLOR	ALCOCK SPRUCE	4 ~ 7**					Southern Pine Beetle, Spruce Beetle
PICEA RUBENS	RED SPRUCE	6 ~ 7					Southern Pine Beetle, Spruce Beetle
PICEA ABIES X ASPERATA	NORWAY X CHINESE SPRUCE	2 ~ 7					Southern Pine Beetle, Spruce Beetle
ACER SACCHARUM	SUGAR MAPLE	5 ~ 8					Asian Longhorned Beetle, Winter Moth
CORYLUS COLURNA	TURKISH HAZELNUT	5 ~ 7					
PINUS ECHINATA	SHORTLEAF PINE	6 ~ 8		I			Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle
AESCULUS GLABRA	OHIO BUCKEYE	4 ~ 7		I			Asian Longhorned Beetle
PINUS TABULAEFORMIS	CHINESE RED PINE	6 ~ 8					Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle
PICEA MONTIGENA	MONTIGENA SPRUCE	4 ~ 7**					Southern Pine Beetle, Spruce Beetle
GINKGO BILOBA	GINKGO	4 ~ 8					
PICEA SITCHENSIS	SITKA SPRUCE	6 ~ 7					Southern Pine Beetle, Spruce Beetle, Winter Moth
PICEA KOYAMAI	YATSUGATAKE-TOHI	4 ~ 7**					Southern Pine Beetle, Spruce Beetle

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
PINUS SYLVESTRIS	SCOTCH PINE	3 ~ 7		I			Mountain Pine Beetle, Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, Western Spruce Budworm
ULMUS PUMILA	SIBERIAN ELM	4 ~ 9	x				Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth
OSTRYA CARPINIFOLIA	HOP HORNBEAM	6 ~ 9					
PICEA X LUTZII	LUTZ'S SPRUCE	4 ~ 7**					Northern Spruce Engraver, Southern Pine Beetle, Spruce Beetle
BROUSSONETIA PAPYRIFERA	PAPER MULBERRY	6 ~ 11	x				
PINUS STROBIFORMIS	SOUTHWESTERN WHITE PINE	5 ~ 7					Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, White Pine Blister Rust
FRAXINUS PENNSYLVANICA	GREEN ASH	3 ~ 9		S	S		Asian Longhorned Beetle, Emerald Ash Borer, Winter Moth
PINUS RIGIDA	PITCH PINE	4 ~ 7		S/I			Fusiform Rust, Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle
PICEA GLEHNII	SAGHOLIA SPRUCE	4 ~ 7					Southern Pine Beetle, Spruce Beetle
PINUS RADIATA	MONTEREY PINE	3 ~ 11		S			Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle
TILIA EUCHLORA	CRIMEAN LINDEN	4 ~ 7*		I			Gypsy Moth

Hardiness zone derived from Horticopia database based on USDA Hardiness zones. For hardiness zones with decimal (e.g., 4.5) values were rounded down for maximum hardiness (e.g., 4) and up for minimum hardiness zone (e.g., 5)
* Some uncertainty to hardiness zone - hardiness zone estimates derived from Dirr (M.A. Dirr, 1975, Manual of Woody Landscape Plants. Stipes Publ. Co. Champaign IL. 1007 p.) and Sunset (1985, New Western Garden Book, Lane Publ. Co. Menlo Park, CA. 512 p.). As hardiness estimates or maps did not always exactly match USDA Hardiness zone ranges, some extrapolations were made to the closest hardiness zone.
** Moderate uncertainty to hardiness zone - hardiness zone estimate based on genera average of minimum and maximum hardiness zone based on Horticopia database and information from Dirr (1997) and Sunset (1985). Average value was rounded to nearest hardiness zone class (1 -11).
*** High uncertainty to hardiness zone - hardiness zone estimate based on family average of minimum and maximum hardiness zone based on Horticopia database and information from Dirr (1997) and Sunset (1985). Average value was rounded to nearest hardiness zone class (1 -11).
Sensitivity - "S" indicates sensitive to pollutant; "I" indicates intermediate rating between sensitive and tolerant to pollutant; and "S/I" indicates a mix of sensitive and intermediate ratings in the literature.

APPENDIX C
TREE PLANTING

Tree Planting

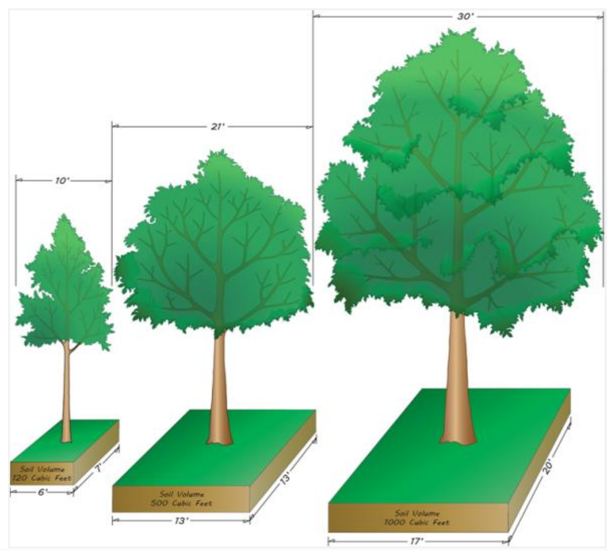
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the community.

When planting trees, it is important to be cognizant of the following:

- Consider the specific purpose of the tree planting.
- Assess the site and know its limitations (i.e., confined spaces, overhead wires, and/or soil type).
- Select the species or cultivar best suited for the site conditions.
- Examine trees before buying them, and buy for quality.

Inventoried Street ROW Planting Space

The goal of tree planting is to have a vigorous, healthy tree that lives to the limits of its natural longevity. That can be difficult to achieve in an urban growing environment because irrigation is limited and the soils are typically poor quality. However, proper planning, species selection, tree planting techniques, and follow-up tree maintenance will improve the chance of tree planting success.



Minimum recommended requirements for tree sites is based on tree size/dimensions. This illustration is based on the work of Casey Trees (2008).

Tree Species Selection

Selecting a limited number of species could simplify decision-making processes; however, careful deliberation and selection of a wide variety of species is more beneficial and can save money. Planting a variety of species can decrease the impact of species-specific pests and diseases by limiting the number of susceptible trees in a population. This reduces time and money spent to mitigate pest- or disease-related problems. A wide variety of tree species can help limit the impacts from physical events, as different tree species react differently to stress. Species diversity helps withstand drought, ice, flooding, strong storms, and wind.

North Kansas City is located in USDA Hardiness Zone 6a, which is identified as a climatic region with average annual minimum temperatures between −10°F and −5°F. Tree species selected for planting in North Kansas City should be appropriate for this zone.

Tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on site characteristics below ground (soil texture, soil structure, drainage, soil pH, nutrients, road salt, and root spacing). Matching a species to its favored soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well matched to their environmental site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall.

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Some grow tall, some grow wide, and some have extensive root systems. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating some shade may be a priority, but it is important to consider how a tree may impact existing utility lines as it grows taller, wider, and deeper. If the tree's canopy, at maturity, will reach overhead lines, it is best to choose another tree or a different location. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

A major consideration for street trees is the amount of litter dropped by mature trees. Trees such as *Acer saccharinum* (silver maple) have weak wood and typically drop many small branches during a growing season. Others, such as *Liquidambar styraciflua* (American sweetgum), drop high volumes of fruit. In certain species, such as *Ginkgo biloba* (ginkgo), female trees produce large odorous fruit; male ginkgo trees, however, do not produce fruit. Furthermore, a few species of trees, including *Crataegus* spp. (hawthorn) and *Gleditsia triacanthos* (honeylocust), may have substantial thorns. These species should be avoided in high-traffic areas.

Seasonal color should also be considered when planning tree plantings. Flowering varieties are particularly welcome in the spring, and deciduous trees that display bright colors in autumn can add a great deal of appeal to surrounding landscapes.

Tips for Planting Trees

To ensure a successful tree planting effort, the following measures should be taken:

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift trees by the trunk.
- If trees are stored prior to planting, keep the roots moist.
- Dig the planting hole according to the climate. Generally, the planting hole is two to three times wider and not quite as deep as the root ball. The root flair is at or just above ground level.

- Fill the hole with native soil unless it is undesirable, in which case soil amendments should be added as appropriate for local conditions. Gently tamp and add water during filling to reduce large air pockets and ensure a consistent medium of soil, oxygen, and water.
- Stake the tree as necessary to prevent it from shifting too much in the wind.
- Add a thin layer (1–2 inches) of mulch to help prevent weeds and keep the soil moist around the tree. Do not allow mulch to touch the trunk.

Newly Planted and Young Tree Maintenance

Caring for trees is just as important as planting them. Once a tree is planted, it must receive maintenance for several years.

Watering

Initially, watering is the key to survival; new trees typically require at least 60 days of watering to establish. Determine how often trees should be irrigated based on time of planting, drought status, species selection, and site condition.

Mulching

Mulch can be applied to the growspace around a newly planted tree (or even a more mature tree) to ensure that no weeds grow, that the tree is protected from mechanical damage, and that the growspace is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches, and the growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Lifelong Tree Care

After the tree is established, it will require routine tree care, which includes inspections, routine pruning, watering, plant health care, and integrated pest management as needed.

The city should employ qualified arborists to provide most of the routine tree care. An arborist can determine the type of pruning necessary to maintain or improve the health, appearance, and safety of trees. These techniques may include: eliminating branches that rub against each other; removing limbs that interfere with wires and buildings or that obstruct streets, sidewalks, or signage; removing dead, damaged, or weak limbs that pose a hazard or may lead to decay; removing diseased or insect-infested limbs; creating better structure to reduce wind resistance and minimize the potential for storm damage; and removing branches—or thinning—to increase light penetration.

An arborist can help decide whether a tree should be removed and, if so, to what extent removal is needed. Additionally, an arborist can perform—and provide advice on—tree maintenance when disasters such as storms or droughts occur. Storm-damaged trees can often be dangerous to remove or trim. An arborist can assist in advising or performing the job in a safe manner while reducing further risk of damage to property.

Plant Health Care, a preventive maintenance process that keeps trees in good health, helps a tree better defend itself against insects, disease, and site problems. Arborists can help determine proper plant health so that the city's tree population will remain healthy and provide benefits to the community for as long as possible.

Integrated Pest Management is a process that involves common sense and sound solutions for treating and controlling pests. These solutions incorporate basic steps: identifying the problem, understanding pest biology, monitoring trees, and determining action thresholds. The practice of Integrated Pest Management can vary depending on the site and based on each individual tree. A qualified arborist will be able to make sure that the city's trees are properly diagnosed and that a beneficial and realistic action plan is developed.

The arborist can also help with cabling or bracing for added support to branches with weak attachment, aeration to improve root growth, and installation of lightning protection systems.

Educating the community on basic tree care is a good way to promote the city's urban forestry program and encourage tree planting on private property. The city should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the city if they notice any changes in the trees, such as signs or symptoms of pests, early fall foliage, or new mechanical or vehicle damage.

APPENDIX D
INVASIVE PESTS AND DISEASES

In today's worldwide marketplace, the volume of international trade brings increased potential for pests and diseases to invade our country. Many of these pests and diseases have seriously harmed rural and urban landscapes and have caused billions of dollars in lost revenue and millions of dollars in clean-up costs. Keeping these pests and diseases out of the country is the number one priority of the United States Department of Agriculture's (USDA) Animal and Plant Inspection Service (APHIS).

Although some invasive species naturally enter the United States via wind, ocean currents, and other means, most invasive species enter the country with some help from human activities. Their introduction to the U.S. is a byproduct of cultivation, commerce, tourism, and travel. Many species enter the United States each year in baggage, cargo, contaminants of commodities, or mail.

Once they arrive, hungry pests grow and spread rapidly because controls, such as native predators, are lacking. Invasive pests disrupt the landscape by pushing out native species, reducing biological diversity, killing trees, altering wildfire intensity and frequency, and damaging crops. Some pests may even push species to extinction. The following sections include key pests and diseases that adversely affect trees in America at the time of this plan's development. This list is not comprehensive and may not include all threats.

It is critical to the management of community trees to routinely check APHIS, USDA Forest Service, and other websites for updates about invasive species and diseases in your area and in our country so that you can be prepared to combat their attack.

APHIS, Plant Health, Plant Pest Program Information
- www.aphis.usda.gov/plant_health/plant_pest_info

The University of Georgia, Center for Invasive Species and Ecosystem Health
- www.bugwood.org

USDA National Agricultural Library
- www.invasivespeciesinfo.gov/microbes

USDA Northeastern Areas Forest Service, Forest Health Protection
- www.na.fs.fed.us/fhp

Asian Longhorned Beetle

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an exotic pest that threatens a wide variety of hardwood trees in North America. The beetle was introduced in Chicago, New Jersey, and New York City, and is believed to have been introduced in the United States from wood pallets and other wood-packing material accompanying cargo shipments from Asia. ALB is a serious threat to America's hardwood tree species.

Adult Asian longhorned beetle

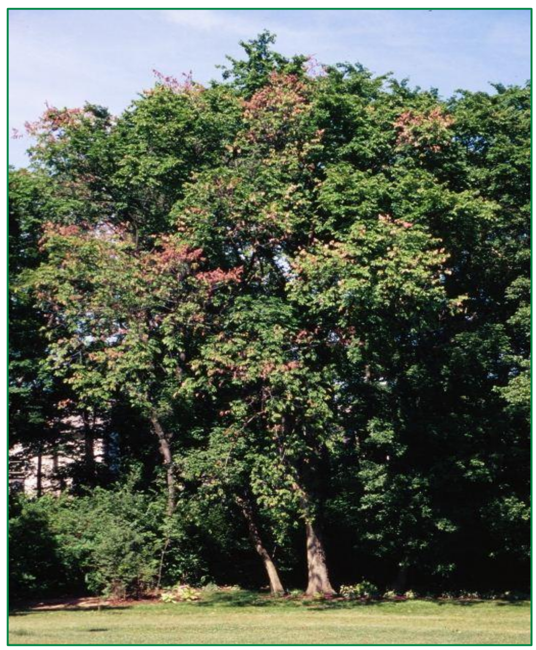
Photograph courtesy of New Bedford Guide 2011

Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods, including several maple species. Examples include: *Acer negundo* (box elder); *A. platanoides* (Norway maple); *A. rubrum* (red maple); *A. saccharinum* (silver maple); *A. saccharum* (sugar maple); *Aesculus glabra* (buckeye); *A. hippocastanum* (horsechestnut), *Betula* (birch), *Platanus* × *acerifolia* (London planetree), *Salix* (willow), and *Ulmus* (elm).

Dutch Elm Disease

Considered by many to be one of the most destructive, invasive diseases of shade trees in the United States, Dutch elm disease (DED) was first found in Ohio in 1930; by 1933, the disease was present in several East Coast cities. By 1959, it had killed thousands of elms. Today, DED covers about two-thirds of the eastern United States, including Illinois, and annually kills many of the remaining and newly planted elms. The disease is caused by a fungus that attacks the vascular system of elm trees blocking the flow of water and nutrients, resulting in rapid leaf yellowing, tree decline, and death.

There are two closely related fungi that are collectively referred to as DED. The most common is *Ophiostoma novo-ulmi*, which is thought to be responsible for most of the elm deaths since the 1970s. The fungus is transmitted to healthy elms by elm bark beetles. Two species carry the fungus: native elm bark beetle (*Hylurgopinus rufipes*) and European elm bark beetle (*Scolytus multistriatus).*



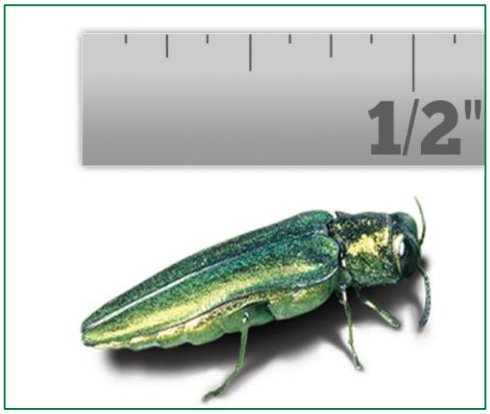
Branch death, or flagging, at multiple locations in the crown of a diseased elm

Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

The species most affected by DED is the *Ulmus americana* (American elm).

Emerald Ash Borer

Emerald ash borer *(EAB) (Agrilus planipennis*) is responsible for the death or decline of tens of millions of ash trees in 14 states in the American Midwest and Northeast. Native to Asia, EAB has been found in China, Japan, Korea, Mongolia, eastern Russia, and Taiwan. It likely arrived in the United States hidden in wood-packing materials commonly used to ship consumer goods, auto parts, and other products. The first official United States identification of EAB was in southeastern Michigan in 2002.



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

Adult beetles are slender and 1/2-inch long. Males are smaller than females. Color varies but adults are usually bronze or golden green overall with metallic, emerald-green wing covers. The top of the abdomen under the wings is metallic, purplish-red and can be seen when the wings are spread.

The EAB-preferred host tree species are in the genus *Fraxinus* (ash).

Gypsy Moth

The gypsy moth (GM) *(Lymantria dispar*) is native to Europe and first arrived in the United States in Massachusetts in 1869. This moth is a significant pest because its caterpillars have an appetite for more than 300 species of trees and shrubs. GM caterpillars defoliate trees, which makes the species vulnerable to diseases and other pests that can eventually kill the tree.

Close-up of male (darker brown) and female (whitish color) European gypsy moths

Photograph courtesy of APHIS (2011b)

Male GMs are brown with a darker brown pattern on their wings and have a 1/2-inch wingspan. Females are slightly larger with a 2-inch wingspan and are nearly white with dark, saw-toothed patterns on their wings. Although they have wings, the female GM cannot fly.

The GMs prefer approximately 150 primary hosts but feed on more than 300 species of trees and shrubs. Some trees are found in these common genera: *Betula* (birch), *Juniperus* (cedar), *Larix* (larch), *Populus* (aspen, cottonwood, poplar), *Quercus* (oak), and *Salix* (willow).

Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA, *Adelges tsugae*) was first described in western North America in 1924 and first reported in the eastern United States in 1951 near Richmond, Virginia.

Hemlock woolly adelgids on a branch

Photograph courtesy of USDA Forest Service (2011a)

In their native range, populations of HWA cause little damage to the hemlock trees, as they feed on natural enemies and possible tree resistance has evolved with this insect. In eastern North America and in the absence of natural control elements, HWA attacks both *Tsuga canadensis* (eastern or Canadian hemlock) and *T. caroliniana* (Carolina hemlock), often damaging and killing them within a few years of becoming infested.

The HWA is now established from northeastern Georgia to southeastern Maine and as far west as eastern Kentucky and Tennessee.

Oak Wilt

Oak wilt was first identified in 1944 and is caused by the fungus *Ceratocystis fagacearum*. While considered an invasive and aggressive disease, its status as an exotic pest is debated since the fungus has not been reported in any other part of the world. This disease affects the oak genus and is most devastating to those in the red oak subgenus, such as *Quercus coccinea* (scarlet oak), *Q. imbricaria* (shingle oak), *Q. palustris* (pin oak), *Q. phellos* (willow oak), and *Q. rubra* (red oak). It also attacks trees in the white oak subgenus, although it is not as prevalent and spreads at a much slower pace in these trees.

Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

Just as with DED, oak wilt disease is caused by a fungus that clogs the vascular system of oaks and results in decline and death of the tree. The fungus is carried from tree to tree by several borers common to oaks, but the disease is more commonly spread through root grafts. Oak species within the same subgenus (red or white) will form root colonies with grafted roots that allow the disease to move readily from one tree to another.

Pine Shoot Beetle

The pine shoot beetle (*Tomicus piniperda L.*), a native of Europe, is an introduced pest of *Pinus* (pine) in the United States. It was first discovered in the United States at a Christmas tree farm near Cleveland, Ohio in 1992. Following the first detection in Ohio, the beetle has been detected in parts of 19 states (Connecticut, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin).

Mined shoots on a Scotch pine

Photograph courtesy of USDA Forest Service (1993)

The beetle attacks new shoots of pine trees, stunting the growth of the trees. The pine shoot beetle may also attack stressed pine trees by breeding under the bark at the base of the trees. The beetles can cause severe decline in the health of the trees and, in some cases, kill the trees when high populations exist.

Adult pine shoot beetles range from 3 to 5 millimeters long, or about the size of a match head. They are brown or black and cylindrical. The legless larvae are about 5 millimeters long with a white body and brown head. Egg galleries are 10–25 centimeters long. From April to June, larvae feed and mature under the pine bark in separate feeding galleries that are 4–9 centimeters long. When mature, the larvae stop feeding, pupate, and then emerge as adults. From July through October, adults tunnel out through the bark and fly to new or 1-year-old pine shoots to begin maturation feeding. The beetles enter the shoot 15 centimeters or less from the shoot tip and move upwards by hollowing out the center of the shoot for a distance of 2.5–10 centimeters. Affected shoots droop, turn yellow, and eventually fall off during the summer and fall.

P. sylvestris (Scots pine) is preferred, but other pine species, including *P. banksiana* (jack pine), *P. nigra* (Austrian pine), *P. resinosa* (red pine), and *P. strobus* (eastern white pine), have been infested in the Great Lakes region.

Thousand Cankers Disease

A complex disease referred to as Thousand Cankers disease (TCD) was first observed in Colorado in 2008 and is now thought to have existed in Colorado as early as 2003. TCD is considered to be native to the United States and is attributed to numerous cankers developing in association with insect galleries.

TCD results from the combined activity of the *Geosmithia morbida* fungus and the walnut twig beetle (WTB, *Pityophthorus juglandis*). The WTB has expanded both its geographical and host range over the past two decades, and coupled with the *Geosmithia morbida* fungus, *Juglans* (walnut) mortality has manifested in Arizona, California, Colorado, Idaho, New Mexico, Oregon, Utah, and Washington. In July 2010, TCD was reported in Knoxville, Tennessee. The infestation is believed to be at least 10 years old and was previously attributed to drought stress. This is the first report east of the 100th meridian, raising concerns that large native populations of *J. nigra* (black walnut) in the eastern United States may suffer severe decline and mortality.

The tree species preferred as hosts for TCD are walnuts.

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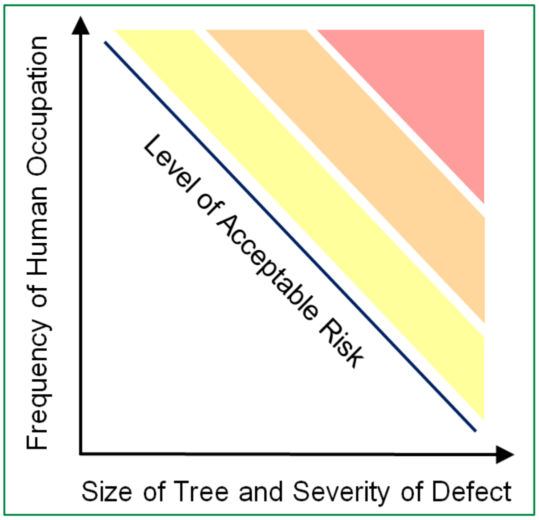
APPENDIX E
RISK ASSESSMENT/PRIORITY AND PROACTIVE MAINTENANCE

Risk Assessment



Every tree has an inherent risk of tree failure or defective tree part failure. During the inventory, Davey Resource Group performed a Level 2 qualitative risk assessment for each tree and assigned a risk rating based on the ANSI A300 (Part 9), and the companion publication *Best Management Practices: Tree Risk Assessment* (ISA 2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory. The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.

- **Likelihood of Failure**—Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.
  - Improbable—The tree or branch is not likely to fail during normal weather conditions and may not fail in many severe weather conditions within the specified time period.
  - Possible—Failure could occur but is unlikely during normal weather conditions within the specified time period.
  - Probable—Failure may be expected under normal weather conditions within the specified time period.
- **Likelihood of Impacting a Target**—The rate of occupancy of targets within the target zone and any factors that could affect the failed tree as it falls towards the target.
  - Very low—The chance of the failed tree or branch impacting the target is remote.
    - Rarely used sites
    - Examples include rarely used trails or trailheads
    - Instances where target areas provide protection
  - Low—It is not likely that the failed tree or branch will impact the target.
    - Occasional use area fully exposed to tree
    - Frequently used area partially exposed to tree
    - Constant use area that is well protected

- Medium—The failed tree or branch may or may not impact the target.
  - Frequently used areas that are partially exposed to the tree on one side
  - Constantly occupied area partially protected from the tree
- High—The failed tree or branch will most likely impact the target.
  - Fixed target is fully exposed to the tree or tree part

- **Categorizing Likelihood of Tree Failure Impacting a Target**—The likelihood for failure and the likelihood of impacting a target are combined in the matrix below to determine the likelihood of tree failure impacting a target.

Likelihood of Failure	Likelihood of Impacting Target			
	Very Low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very Likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

- **Consequence of Failure**—The consequences of tree failure are based on the categorization of target and potential harm that may occur. Consequences can vary depending upon size of defect, distance of fall for tree or limb, and any other factors that may protect a target from harm. Target values are subjective and should be assessed from the client's perspective.
  - Negligible—Consequences involve low value damage and do not involve personal injury.
    - Small branch striking a fence
    - Medium-sized branch striking a shrub bed
    - Large tree part striking structure and causing monetary damage
    - Disruption of power to landscape lights
  - Minor—Consequences involve low to moderate property damage, small disruptions to traffic or communication utility, or very minor injury.
    - Small branch striking a house roof from a high height
    - Medium-sized branch striking a deck from a moderate height
    - Large tree part striking a structure, causing moderate monetary damage
    - Short-term disruption of power at service drop to house
    - Temporary disruption of traffic on neighborhood street
  - Significant—Consequences involve property damage of moderate to high value, considerable disruption, or personal injury.
    - Medium-sized part striking a vehicle from a moderate or high height
    - Large tree part striking a structure resulting in high monetary damage
    - Disruption of distribution of primary or secondary voltage power lines, including individual services and street-lighting circuits
    - Disruption of traffic on a secondary street

- Severe—Consequences involve serious potential injury or death, damage to high-value property, or disruption of important activities.
  - Injury to a person that may result in hospitalization
  - Medium-sized part striking an occupied vehicle
  - Large tree part striking an occupied house
  - Serious disruption of high-voltage distribution and transmission power line disruption of arterial traffic or motorways

- **Risk Rating**—The overall risk rating of the tree will be determined based on combining the likelihood of tree failure impacting a target and the consequence of failure in the matrix below.

Likelihood of Failure	Consequences			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Trees have the potential to fail in more than one way and can affect multiple targets.

Tree risk assessors will identify the tree failure mode having the greatest risk, and report that as the tree risk rating. Generally, trees with the highest qualitative risk ratings should receive corrective treatment first. The following risk ratings will be assigned:

- None—Used for planting and stump sites only.
- Low—The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.
- Moderate—The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.
- High—The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.

- Extreme—The Extreme Risk category applies in situations where tree failure is imminent and there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area to avoid injury to people.

Trees with elevated (Extreme or High) risk levels are usually recommended for removal or pruning to eliminate the defects that warranted their risk rating. However, in some situations, risk may be reduced by adding support (cabling or bracing) or by moving the target away from the tree. Davey Resource Group recommends only removal or pruning to alleviate risk. But in special situations, such as a memorial tree or a tree in a historic area, Manchester may decide that cabling, bracing, or moving the target may be the best option for reducing risk.

Determination of acceptable risk ultimately lies with city managers. Since there are inherent risks associated with trees, the location of a tree is an important factor in the determination and acceptability of risk for any given tree. The level of risk associated with a tree increases as the frequency of human occupation increases in the vicinity of the tree. For example, a tree located next to a heavily traveled street will have a higher level of risk than a similar tree in an open field.

Priority Maintenance

Identifying and ranking the maintenance needs of a tree population enables tree work to be assigned priority based on observed risk. Once prioritized, tree work can be systematically addressed to eliminate the greatest risk and liability first (Stamen 2011).

Risk is a graduated scale that measures potential tree-related hazardous conditions. A tree is considered hazardous when its potential risks exceed an acceptable level. Managing trees for risk reduction provides many benefits, including:

- Lower frequency and severity of accidents, damage, and injury
- Less expenditure for claims and legal expenses
- Healthier, long-lived trees
- Fewer tree removals over time
- Lower tree maintenance costs over time

Regularly inspecting trees and establishing tree maintenance cycles generally reduce the risk of failure, as problems can be found and addressed before they escalate.

In this plan, all tree removals and Extreme and High Risk prunes are included in the priority maintenance program.

Proactive Maintenance

Proactive tree maintenance requires that trees are managed and maintained under the responsibility of an individual, department, or agency. Tree work is typically performed during a cycle. Individual tree health and form are routinely addressed during the cycle. When trees are planted, they are planted selectively and with purpose. Ultimately, proactive tree maintenance should reduce crisis situations in the urban forest, as every tree in the inventoried population is regularly visited, assessed, and maintained. Davey Resource Group recommends proactive tree maintenance that includes pruning cycles, inspections, and planned tree planting.

APPENDIX F
EMERALD ASH BORER INFORMATION

Extension Bulletin E-2942

New, May 2005

Ash Tree Identification

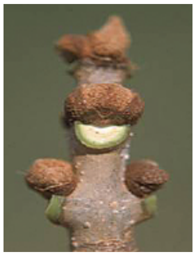
Ash species attacked by emerald ash borer include green (*Fraxinus pennsylvanica*), white (*F. americana*), black (*F. nigra*), and blue (*F. quadrangulata*), as well as horticultural cultivars of these species. Green and white ash are the most commonly found ash species in the Midwest with blue ash being rare.

While other woody plants, such as mountainash and pricklyash, have "ash" in their name, they are not true ash, or *Fraxinus* species. Only true ash are susceptible to attack by emerald ash borer.

To properly identify ash trees, use the following criteria:

Branch and Bud Arrangement

Branches and buds are directly across from each other and not staggered. When looking for opposite branching in trees, please consider that buds or limbs may die; hence not every single branch will have an opposite mate.



Diane Brown-Rytlewski

Leaves

Leaves are compound and composed of 5-11 leaflets. Leaflet margins may be smooth or toothed. The only other oppositely branched tree with compound leaves is boxelder (*Acer negundo*), which almost always has three to five leaflets. White ash (on left) and green ash (on right)

*Paul Wray, Iowa State University

Bark

On mature trees (left), the bark is tight with a distinct pattern of diamond-shaped ridges. On young trees (right), bark is relatively smooth.

*Paul Wray, Iowa State University

Seeds

When present on trees, seeds are dry, oar-shaped samaras. They usually occur in clusters and typically hang on the tree until late fall, early winter.

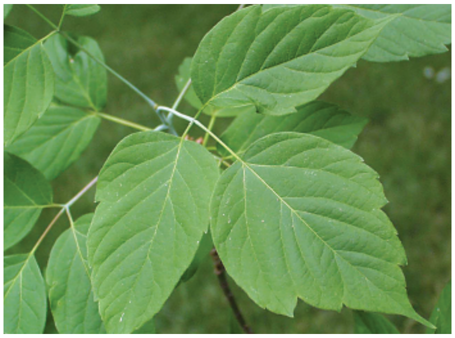
MICHIGAN STATE UNIVERSITY EXTENSION

Emerald Ash Borer

Tree Species Resembling Ash

Boxelder *(Acer negundo)*

Exhibits opposite branching and compound leaves. However, has 3 to 5 leaflets (instead of 5 to 11) and the samaras are always in pairs instead of single like the ash.



*Paul Wray, Iowa State University

*Bill Cook, Michigan State University

European Mountainash *(Sorbus aucuparia)*

Leaves are compound with alternate (staggered) branching. Tree bears clusters of creamy white flowers in May. Fruits are fleshy, red-orange berries.

Diane Brown-Rytlewski

*Boris Hrasovec, University of Zagreb

Shagbark Hickory *(Carya ovata)*

Leaves are compound with 5 to 7 leaflets, but the plant has an alternate branching habit. Fruit are hard-shelled nuts in a green husk.

*Paul Wray, Iowa State University

*Paul Wray, Iowa State University

Elm *(Ulmus species)*

Branching is alternate and the leaves are simple with an unequal leaf base.

*Paul Wray, Iowa State University

*Paul Wray, Iowa State University

*Paul Wray, Iowa State University

Black Walnut *(Juglans nigra)*

Leaves are compound with 9 to 15 leaflets, but the plant has an alternate branching habit. Fruit is a large dark brown nut inside a green husk.

*Paul Wray, Iowa State University

Authors: Kimberly Rebek and Mary Wilson

*www.forestryimages.org

MICHIGAN STATE UNIVERSITY EXTENSION

New - 5:05 - 6,250 - KMF/LB

Illinois Emerald Ash Borer Readiness Plan

Prepared by: Emerald Ash Borer Readiness Team (see attached)
Edited by: Edith Makra, Community Trees Advocate, The Morton Arboretum

The Emerald ash borer (EAB) is a significant threat to the urban and rural forests of Illinois. It was first identified in the spring of 2002 in Ontario and the Detroit area. It is estimated that it has already killed about 16 million ash trees in Michigan. In the two years since it was identified, infestations have broken out in several locations in Ohio, in Maryland, and most recently in Indiana. Thirteen counties in Michigan are quarantined and significant containment and clean-up operations are underway. The outbreaks in Indiana, Maryland and Ohio have required swift, aggressive and organized responses by regulatory and other government agencies and the cooperation of stakeholder groups.

The emerald ash borer, *Agrilus planipennis*, is a slender, elongated (3/4-inch), bright green beetle in the same genus as the bronze birch borer. It likely arrived in Michigan from China at least five years ago, probably traveling with ship cargo. Although chemical and biological controls are being researched and show promise, more aggressive containment and eradication efforts are necessary for new outbreaks outside the core zones and quarantined areas of Michigan.

The borer kills trees relatively quickly and affects white, green, black, pumpkin, and several horticultural varieties of ash whether healthy or stressed. The beetle deposits eggs on the surface or cracks of ash tree bark, which hatch to release larvae that feed on the tree's phloem and outer sapwood. Within several weeks, larval feeding creates S-shaped galleries in the tree's inner bark that wind back and forth, becoming progressively wider and girdling the trunk and branches as larvae grow. Adult beetles emerge headfirst, creating very small (3-4 mm) D-shaped exit holes that leave minimal evidence of infestation until the canopy begins to die back. Then the tree quickly declines in the second growing season and is usually dead by the third. The symptoms of emerald ash borer infestation resemble ash decline or damage from the native ash-lilac borer and the two-lined chestnut borer, making detection difficult.

The Morton Arboretum took the lead in organizing to minimize the risk of an EAB introduction into Illinois, to find it, and contain it quickly if it arrives. First, we conducted a survey of area municipalities to determine the scope of the ash population at risk. From a sample of municipal street tree inventories, we determined that about 19.2 % of public trees in the Chicago area are ash, usually white (*Fraxinus americana*) or green *(F. pennsylvanica.)* The US Forest Service did a sampling of public and private land in Cook and DuPage County in 1993 and determined that 19.4% of the overall urban and community forest is ash, essentially confirming the validity of the street tree sampling. Statewide, forests are 6% ash according to US Forest Service surveys.

The planning began in July of 2003 by assembling nearly 40 representatives from municipal, county, state, and federal governments, green industry professional associations, universities, and Chicago Wilderness (a coalition of public and private land management and educating organizations) to develop an Emerald ash borer 'readiness plan'. The group worked together to identify resources available from participating organizations and likewise, identify gaps. Existing EAB efforts and programs were compiled, including current regional efforts and work from other states that serve as useful models.

All members of the planning team brought useful and important knowledge and experience to the planning effort. The team itself creates a critical network for information sharing and dissemination. Educational outreach to the members and constituents represented on the planning team has already been effective in raising awareness and fostering cooperation and collaboration. The team's work has resulted in strengthening the ability of the state regulatory agency, putting more staff expertise in the field inspecting nursery stock and responding to possible sightings of EAB. The collaboration has also spawned and funded a survey of EAB in the Chicago area being done in the summer of 2004, and another statewide survey is in the works.

There is much work to be done to protect Illinois' ash trees from this aggressive pest. The following Plan lays out a comprehensive strategy to assess resources, minimize risk, identify an infestation promptly, and collaborate to contain an infestation. The network of the Readiness Planning Team already facilitates the administrative and technical readiness called for in the Plan. Public and professional education and awareness are critical to the overall success of the plan.

The Readiness Planning Team continues to collaborate and cooperate to implement the plan. Current priorities are public awareness to identify likely infestations and minimize the possible spread of EAB through firewood movement, and the regulation and inspection of the firewood industry in Illinois.

For information and inquiries, please contact Edith Makra, The Morton Arboretum, at 630-719-2425 or emakra@mortonarb.org.

Illinois Emerald Ash Borer Readiness Plan
June 12, 2006

1. GENERAL READINESS- to reduce risk, minimize impact, and respond more effectively to a possible infestation of the Emerald ash borer (EAB), *Agrilus planipennis,* and to work collaboratively towards overall health and sustainability of the forests, both urban and rural, throughout Illinois and northeast Indiana
(√ *indicates task completed,* →*indicates ongoing effort already begun)*

A. √ Establish a network of agencies and organizations that may be affected by the EAB into the **Emerald Ash Borer Readiness Team** (see attached list.) The team's goal is to collaborate in drafting a readiness plan; and to advise, advocate and lead in the implementation of the plan.

Subdivide into:

1. √Statutory Administrative Team – agencies that have, by law, been assigned the responsibility of managing an exotic infestation and have been granted the legal authority to act by the federal, state, or local government

- Illinois Department of Agriculture (IDA)
- USDA Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ)
- Affected local government(s) at site of infestation

2. √ Technical and Administrative Team – agencies and organizations that are vital to the design and rapid implementation of the readiness plan; and serve important roles in research related to Emerald ash borer; administration and coordination of policies, programs, and staff; and the education of stakeholders

- Illinois Department of Agriculture (IDA), Environmental Programs
- Illinois Department of Natural Resources (IDNR)
- USDA Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ)
- USDA Forest Service Urban and Community Forestry Program
- USDA Forest Service Forest Health Program
- USDA Forest Service, North Central Research Station
- University of Illinois
- Illinois Arborist Association
- Illinois Nurseryman's Association

3. √ **Education and Communication Team** – agencies that will collaborate to communicate accurate information, quickly and broadly in a manner that supports the prevention, identification and control of a possible infestation.

- APHIS PPQ
- USDA Forest Service, Public Affairs
- IDA, Environmental Programs
- Illinois Landscape Contractor's Association
- The Morton Arboretum
- Regional councils of governments (i.e., DuPage Mayor's and Manager's Association, Northwest Municipal Conference)
- Chicago Wilderness
- Illinois Department of Natural Resources (DNR)
- University of Illinois
- Municipalities
- Forest Preserve Districts
- Other Trade Groups and stakeholders

B. Administrative Readiness – to assure that current, relevant, and achievable policies are in place that allow the actions described in this plan to occur quickly and unencumbered:

1. √ Draft EAB Readiness Plan
   a) √ Distribute plan to readiness team
   b) Readiness Team members to distribute condensed plan to constituencies
   c) → Foster cooperation among agencies for implementation

2. Identify resources and needs
   a) √Evaluate staffing needs in regulatory agencies
   b) Monitor nursery field operations
   c) Determine firewood movement
   d) Identify sources of funding for readiness activities
   e) √ Assess human and technical resources

3. Take proactive steps to speed administrative processes
   a) √ analyze IDA procedures to identify streamlining opportunities
   b) √ analyze APHIS procedures to identify streamlining opportunities
   c) √ communicate EAB status to Illinois Emergency Management Agency (IEMA) liaison
   d) encourage communities to examine local administrative processes for streamlining opportunities

4. Educate the media and assure accuracy of information
    a) √Issue a press release on the final plan
    b) Coordinate Public Information Officers from statutory team
    c) √ Identify key sources of current information
    d) √ create a Core Communications Team for expedited communications clearance including representatives from:
        IDA
        Morton Arboretum
        Forest Service
5. Explore wood waste utilization opportunities to reclaim ash material to its highest possible use should a volume material suddenly become available

C. Technical Readiness – to assure that policy decisions, actions, and education initiatives are guided by the best and most current science

1. √ Review and distribute federal scientific guidelines to advise actions. (i.e., EAB biology and controls)
2. Reference national plan, when one is available
3. Operate under New Pest Response Guidelines or other relevant USDA technical guidelines
4. Advocate for continued research for greater understanding of EAB and management options
5. Participate in annual Forest Pest meeting in Annapolis, MD
6. Transfer technology as it becomes available

II. REDUCE RISK OF INFESTATION – to assure that all means of EAB introduction are known and blocked, whenever possible

A. Assess Risk_- to determine the size and scope of the ash resource and the severity of new and existing EAB infestations

1. →Analyze possible sources of EAB importation (i.e., ash logs, firewood and nursery stock from Michigan) and other affected areas
2. √ Assess the scope of the resource at risk (number of ash trees)
3. Analyze density of ash populations to determine high risk areas
4. →Track spread of EAB and distribute to Readiness Team

B. Reduce Risk

1. →Raise public awareness about risk from firewood importation
    b) install educational posters at State, and county campgrounds
    c) promote "EAB-free" firewood from reputable firewood dealers

2. →Convene a Firewood Committee to analyze the firewood market and find ways to reduce the risk of importation with representatives from:
   IDNR
   APHIS
   IDA
   Lake County Forest Preserve District
3. Survey or inspect firewood dealers
4. Recruit campground and firewood dealers associations to participate
5. →Contact municipal officials to request trace-back of records for firewood transport
6. Educate industries about risk of ash importation
   a) reach out to wood products manufacturers through IDNR's licensed timber buyers and the Illinois Wood Products Association
   b) →educate contractors and municipalities about the importance of knowing the source of ash trees and assure they are IDA inspected
   c) educate garden centers, firewood dealers about risk
   d) reach out to trucking associations to help track movement of ash

7. √Assure full and thorough analysis of ash nursery stock movement and effective inspection of current ash stock
   a) → advocate for strong state support of nursery inspection program
   b) √ track nursery stock importation in recent past
   a. √review trace-back program for nursery shipping records from Michigan with the assistance of ANLA (American Nursery and Landscape Association)

8. Assure planting selections contribute to a diverse and sustainable urban forest
   a) → educate municipalities and large property managers about diversity in planting
   b) →encourage tree inventories to analyze diversity and guide planting decisions

9. Seek legislative support to reduce risk
   a. assure Michigan's control efforts are well supported
   b. advocate for readiness funding
   c. advise federal legislators of the hardship of state required match of federal funds

III. IDENTIFY INFESTATION PROMPTLY – to minimize the spread and improve odds of containing an infestation

A. Survey urban ash populations - to quickly find or rule out the presence of EAB using USDA Forest Service Forest Health survey protocols
1. Continue the University of Illinois, The Morton Arboretum, and APHIS collaborative detection surveys
2. Enable municipal and commercial green industry professionals to participate in monitoring and reporting in a systematic way
3. Communicate survey results to stakeholders and the media

4. √ Convene Monitoring and Surveying Committee to survey and monitor ash populations to determine the presence of the Emerald ash borer including representatives from:
   APHIS
   The Morton Arboretum
   US Forest Service
   University of Illinois

B. →Educate the public and professionals to provide stakeholders with current and accurate information in a targeted manner to aid in rapid identification of symptoms of an infestation

1. → Offer training and outreach based on current information to landscapers, arborists, nurserymen and other green industry workers to assess ash health and accurately identify EAB
2. Educate general public about ash health and EAB
   a) √ Convene a Public Education Committee
      IDNR
      The Morton Arboretum
      DuPage County Forest Preserve District
      University of Illinois
   b) √develop simple educational materials for the general public
   c) → pursue opportunities for speaking, educating, and exhibiting educational displays including EAB identification material broadly
   d) distribute and promote newly developed *Project Learning Tree* activities on EAB and Asian Longhorned Beetle (ALB)
   e) Broadly distribute U of I public education materials
3. Recruit and enable volunteer scouting
   a) Promote awareness through the media with regular press releases and public appeals for help in scouting
   b) Prepare kits to support volunteer scouting by both individuals and groups

C. Coordinate state and national information to address professional and public inquiries from Illinois and foster cooperation and communication

1. Have Readiness Team members link to USFS, APHIS and Michigan State websites
2. Coordinate with http://www.emeraldashborer.info/to add Illinois information
3. Support full staffing of regulatory agencies so that vital information about Illinois forest health is readily available

D. →Guide public inquiries and possible sightings through the following process for the most effective use of resources and quickest response:

1. Contact University of Illinois Extension, The Morton Arboretum Plant Clinic, municipal forestry programs and other professional resources, or the expertise of a certified arborist to pre-screen inquiries, i.e., assure suspect tree is an ash, rule out similar but common insects, etc.

2. If other pests are ruled out and EAB is still suspected, contact IDA's statewide Pesticide Hotline 800-641-3934 or in the Chicago area use 312-74BEETL (312-742-3385)
3. An IDA or APHIS official shall dismiss or confirm the identification of the Emerald ash borer

E. **Guide *professional* (arborist, entomologist, pathologist, plant health care specialist) inquiries and possible sightings** through the following process:

1. If a suspected Emerald Ash Borer is found, contact:

   Illinois Department of Agriculture (847) 294-4343

   or

   USDA-APHIS-PPQ (847) 299-6939

   Officers from these agencies will collaborate to inspect the suspected ash tree(s) and identify the specimen.

2. Collected specimen will be sent or delivered to:

   APHIS Identifier
   USDA-APHIS
   P.O. Box 61192
   Terminal 5
   O'Hare International Airport
   Chicago, Illinois 66192

3. If collected specimen is initially confirmed to be Emerald Ash Borer by an APHIS Identifier, the specimen will then be sent to the National Systematic Entomology Laboratory to make final identification:

   Systematic Entomology Laboratory
   ATTN: Communication and Taxonomic Services Unit
   Bldg. 005, Rm 137
   BARK - West
   10300 Baltimore Avenue
   Beltsville, MD 20705

4. All cooperators are notified that a suspect Emerald Ash Borer is in the system for identification. However, **at this point, all information is not for public dissemination.**
5. The result, either positive or negative for EAB, is received from the Systematic Entomology Laboratory and all cooperators are notified.

IV. IN THE EVENT OF AN INFESTATION CONTAIN AND MANAGE THE EAB POPULATION – the Statutory Administrative Team will be established with the affected local government(s) and will implement coordinated efforts to contain the infestation according to New Pest Response Guidelines established by USDA under the leadership of IDA and APHIS

A. APHIS and the Illinois Department of Agriculture will take the lead in planning and implementing actions.

1. Begin collaborative response with affected county and city government(s)
    a) schedule an emergency meeting with cooperators
    b) discuss and determine a preliminary plan of action
    c) release verified, accurate information to the press
2. Initiate and conduct a thorough delimiting survey to determine the outer boundary of the infestation.
3. **Illinois Department of Agriculture places into effect an Emerald Ash Borer State Interior Quarantine** regulating all potential host material (ash wood and ash wood products) within the quarantined area as determined by the delimiting survey. This would include the "declaration of all plants and part thereof infested with the Emerald Ash Borer as a nuisance in the State of Illinois" as well as the establishment of a formal quarantine of the infested area (s).
4. Reference APHIS State Plant Health Director's Emergency Plant Health Management Plan based on incident command.
5. Regulatory and control activities will be initiated as necessary.
    a) Administer provisional quarantine established by IDA consistent with the Insect Pest and Plant Disease Act (505 ILCS 90) and associated regulation 8 IAC 240
    b) Remove trees up to ½ mile from infestation or necessary distance as determined by current protocol based on research
    c) Municipalities may act under their own local authorities when local ordinances are applicable and consistent with IDA quarantine requirements

B. Communicate and coordinate actions, information and response

1. Provide accurate information and updates to the media through EAB Core Communications Team.
2. Provide accurate information to affected residents
    a) have an informational door-hanger ready for customizing and distributing to affected area immediately after infestation is found
    b) host local resident meetings or visit affected residents to share information as soon as possible after finding an infestation
3. Communicate with public and industry professionals to foster cooperation to maximize effective response
4. Communicate eradication success stories

C. Dispose of Wood debris

1. Establish processing facilities in the quarantine zones to efficiently handle ash debris and reclaim useable products as best as possible
    a) market reclaimed wood products

D. Develop and implement a reforestation program authorized under applicable federal, state and local authorities using available resources.

Illinois Emerald Ash Borer Readiness Team

City of Chicago
Chicago Wilderness
Chicago Park District
Cook County Forest Preserve
DuPage Mayors & Mgrs. Assoc.
DuPage County Forest Preserve Dist.
Hinsdale Nursery
IL Arborist Association
IL Department. of Agriculture
IL Department of Natural Resources
IL Forestry Development Council
IL Landscape Contractors Assoc.
IL Natural History Survey
IL Nurseryman's Assoc.
IL Parks and Recreation Association
IL Wood Products Association
Indiana Dept of Natural Resources
Lake County Forest Preserve Dist
Michigan State University
The Morton Arboretum
Northwest Municipal Conference
Purdue University
University of Illinois
USDA Forest Service, Northeastern Area
USDA Forest Service, North Central Research Station
USDA Animal and Plant Health Inspection Service, APHIS, Plant Protection and Quarantine, PPQ
Wilson Nurseries
Village of Bolingbrook, for Northeast Municipal Foresters
Village of Oak Lawn, for Northeast Municipal Foresters

www.emeraldashborer.info

Insecticide Options for Protecting Ash Trees From Emerald Ash Borer

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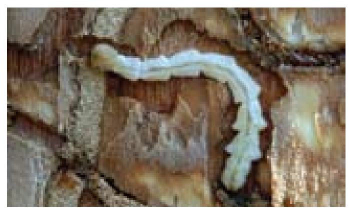
Emerald ash borer (*Agrilus planipennis* Fairmaire), an invasive insect native to Asia, has killed tens of millions of ash trees in urban, rural and forested settings. This beetle was first discovered in 2002 in southeast Michigan and Windsor, Ontario. As of May 2009, emerald ash borer (EAB) infestations were known to be present in 11 states and two Canadian provinces. Many homeowners, arborists and tree care professionals want to protect valuable ash trees from EAB. Scientists have learned much about this insect and methods to protect ash trees since 2002. This bulletin is designed to answer frequently asked questions and provide the most current information on insecticide options for controlling EAB.



EAB larvae damage the vascular system of the tree as they feed, which interferes with movement of systemic insecticides in the tree.

EAB adults must feed on foliage before they become reproductively mature.

Answers to Frequently Asked Questions

What options do I have for treating my ash trees?

If you elect to treat your ash trees, there are several insecticide options available and research has shown that treatments can be effective. Keep in mind, however, that controlling insects that feed under the bark with insecticides has always been difficult. This is especially true with EAB because our native North American ash trees have little natural resistance to this pest. In university trials, some insecticide treatments were effective in some sites, but the same treatments failed in other sites. Furthermore, in some studies conducted over multiple years, EAB densities continued to increase in individual trees despite annual treatment. Some arborists have combined treatments to increase the odds of success (e.g., combining a cover spray with a systemic treatment).

Healthy ash trees that have been protected with insecticides growing next to untreated ash trees killed by EAB.

THE OHIO STATE UNIVERSITY OARDC EXTENSION | MICHIGAN STATE UNIVERSITY | PURDUE UNIVERSITY | UW Extension Cooperative Extension | ILLINOIS

Our understanding of how EAB can be managed successfully with insecticides has increased substantially in recent years. The current state of this understanding is detailed in the bulletin. It is important to note that research on management of EAB remains a work in progress. Scientists from universities, government agencies and companies continue to conduct intensive studies to understand how and when insecticide treatments will be most effective.

I know my tree is already infested with EAB. Will insecticides still be effective?

If a tree has lost more than 50 percent of its canopy, it is probably too late to save the tree. Studies have shown that it is best to begin using insecticides while ash trees are still relatively healthy. This is because most of the insecticides used for EAB control act systemically — the insecticide must be transported within the tree. In other words, a tree must be healthy enough to carry a systemic insecticide up the trunk and into the branches and canopy. When EAB larvae feed, their galleries injure the phloem and xylem that make up the plant's circulatory system. This interferes with the ability of the tree to transport nutrients and water, as well as insecticides. As a tree becomes more and more infested, the injury becomes more severe. Large branches or even the trunk can be girdled by the larval galleries.

Studies have also shown that if the canopy of a tree is already declining when insecticide treatments are initiated, the condition of the tree may continue to deteriorate during the first year of treatment. In many cases, the tree canopy will begin to improve in the second year of treatment. This lag in the reversal of canopy decline probably reflects the time needed for the tree to repair its vascular system after the EAB infestation has been reduced.

My ash tree looks fine but my county is quarantined for EAB. Should I start treating my tree?

Scientists have learned that ash trees with low densities of EAB often have few or no external symptoms of infestation. Therefore, if your property is within a county that has been quarantined for EAB, your ash trees are probably at risk. Similarly, if your trees are outside a quarantined county but are still within 10-15 miles of a known EAB infestation, they may be at risk. If your ash trees are more than 15 miles beyond this range, it is probably too early to begin insecticide treatments. Treatment programs that begin too early are a waste of money. Remember, however, that new EAB infestations have been discovered every year since 2002 and existing EAB populations will build and spread over time. Stay up to date with current EAB quarantine maps and related information at **www.emeraldashborer.info**. You can use the links in this Web site to access specific information for individual states. When an EAB infestation is detected in a state or county for the first time, it will be added to these maps. Note, however, that once an area has been quarantined, EAB surveys generally stop, and further spread of EAB in that area will not be reflected on future maps.

I realize that I will have to protect my ash trees from EAB for several years. Is it worth it?

The economics of treating ash trees with insecticides for EAB protection are complicated. Factors that can be considered include the cost of the insecticide and expense of application, the size of the trees, the likelihood of success, and potential costs of removing and replacing the trees. Until recently, insecticide products had to be applied every year. A new product that is effective for two years or even longer (emamectin benzoate) has altered the economics of treating ash trees. As research progresses, costs and methods of treating trees will continue to change and it will be important to stay up to date on treatment options.

Benefits of treating trees can be more difficult to quantify than costs. Landscape trees typically increase property values, provide shade and cooling, and contribute to the quality of life in a neighborhood. Many people are sentimental about their trees. These intangible qualities are important and should be part of any decision to invest in an EAB management program.

It is also worth noting that the size of EAB populations in a specific area will change over time. Populations initially build very slowly, but later increase rapidly as more trees become infested. As EAB populations reach their peak, many trees will decline and die within one or two years. As untreated ash trees in the area succumb, however, the local EAB population will decrease substantially. Scientists do not yet have enough experience with EAB to know what will happen over time to trees that survive the initial wave of EAB. Ash seedlings and saplings are common in forests, woodlots, and right-of-ways, however, and it is unlikely that

EAB will ever completely disappear from an area. That means that ash trees may always be at some risk of being attacked by EAB, but it seems reasonable to expect that treatment costs could eventually decrease as pest pressure declines after the EAB wave has passed.

Insecticide Options for Controlling EAB

Insecticides that can effectively control EAB fall into four categories: (1) systemic insecticides that are applied as soil injections or drenches; (2) systemic insecticides applied as trunk injections; (3) systemic insecticides applied as lower trunk sprays; and (4) protective cover sprays that are applied to the trunk, main branches, and (depending on the label) foliage.

Insecticide formulations and application methods that have been evaluated for control of EAB are listed in Table 1. Some are marketed for use by homeowners while others are intended for use only by professional applicators. The "active ingredient" refers to the compound in the product that is actually toxic to the insect.

Formulations included in Table 1 have been evaluated in multiple field trials conducted by the authors. Inclusion of a product in Table 1 does not imply that it is endorsed by the authors or has been consistently effective for EAB control. Please see the following sections for specific information about results from these trials. Results of some tests have also been posted on **www.emeraldashborer.info**.

Strategies for the most effective use of these insecticide products are described below. It is important to note that pesticide labels and registrations change constantly and vary from state to state. It is the legal responsibility of the pesticide applicator to read, understand and follow all current label directions for the specific pesticide product being used.

Table 1. Insecticide options for professionals and homeowners for controlling EAB that have been tested in multiple university trials. Some products may not be labeled for use in all states. Some of the listed products failed to protect ash trees when they were applied at labeled rates. Inclusion of a product in this table does not imply that it is endorsed by the authors or has been consistently effective for EAB control. See text for details regarding effectiveness.

Insecticide Formulation	Active Ingredient	Application Method	Recommended Timing
		Professional Use Products	
Merit® (75WP, 75WSP, 2F)	Imidacloprid	Soil injection or drench	Mid-fall and/or mid- to late spring
Xytect™ (2F, 75WSP)	Imidacloprid	Soil injection or drench	Mid-fall and/or mid- to late spring
IMA-jet®	Imidacloprid	Trunk injection	Early May to mid-June
Imicide®	Imidacloprid	Trunk injection	Early May to mid-June
Pointer™	Imidacloprid	Trunk injection	Early May to mid-June
TREE-äge™	Emamectin benzoate	Trunk injection	Early May to mid-June
Inject-A-Cide B®	Bidrin®	Trunk injection	Early May to mid-June
Safari™ (20 SG)	Dinotefuran	Systemic bark spray	Early May to mid-June
Astro®	Permethrin	Preventive bark and foliage cover sprays	2 applications at 4-week intervals; first spray should occur when black locust is blooming (early May in southern Ohio to early June in mid-Michigan)
Onyx™	Bifenthrin		
Tempo®	Cyfluthrin		
Sevin® SL	Carbaryl		
		Homeowner Formulation	
Bayer Advanced™ Tree & Shrub Insect Control	Imidacloprid	Soil drench	Mid-fall or mid- to late spring

Using Insecticides to Control EAB

Soil-Applied Systemic Insecticides

Systemic insecticides applied to the soil are taken up by the roots and translocated throughout the tree. The most widely tested soil-applied systemic insecticide for control of EAB is imidacloprid, which is available under several brand names for use by professional applicators and homeowners (see Table 1). All imidacloprid formulations can be applied as a drench by mixing the product with water, then pouring the solution directly on the soil around the base of the trunk. Dinotefuran is also labeled for use as a soil treatment, but to date it has been tested only as a basal trunk spray (discussed below). Studies to test its effectiveness as a soil treatment are currently underway.

Imidacloprid soil applications should be made when the soil is moist but not saturated. Application to water-logged soil can result in poor uptake if the insecticide becomes excessively diluted and can also result in puddles of insecticide that could wash away, potentially contaminating surface waters and storm sewers. Insecticide uptake will also be limited when soil is excessively dry. Irrigating the soil surrounding the base of the tree before the insecticide application can improve uptake.

The application rates for the homeowner product (Bayer Advanced™ Tree & Shrub Insect Control) and professional formulations of imidacloprid are very similar. Homeowners apply the same amount of active ingredient that professionals apply. However, there are certain restrictions on the use of homeowner formulations that do not apply to professional formulations. Homeowner formulations of imidacloprid can be applied only as a drench. It is not legal to inject these products into the soil, although some companies have marketed devices to homeowners specifically for this purpose. Homeowners are also restricted to making only one application per year. Several generic products containing imidacloprid are available to homeowners, but the formulations vary and the effectiveness of these products has not yet been evaluated in university tests.

Soil drenches offer the advantage of requiring no special equipment for application other than a bucket or watering can. However, imidacloprid can bind to surface layers of organic matter, such as mulch or leaf litter, which can reduce uptake by the tree. Before applying soil drenches, it is important to remove, rake or pull away any mulch or dead leaves so the insecticide solution is poured directly on the mineral soil.

Imidacloprid formulations labeled for use by professionals can be applied as a soil drench or as soil injections. Soil injections require specialized equipment, but offer the advantage of placing the insecticide under mulch or turf and directly into the root zone. This also can help to prevent runoff on sloped surfaces. Injections should be made just deep enough to place the insecticide beneath the soil surface (2-4 inches). Soil injections should be made within 18 inches of the trunk where the density of fine roots is highest. As you move away from the tree, large radial roots diverge like spokes on a wheel and studies have shown that uptake is higher when the product is applied at the base of the trunk. There are no studies that show that applying fertilizer with imidacloprid enhances uptake or effectiveness of the insecticide.

Optimal timing for imidacloprid soil injections and drenches is mid-April to mid-May, depending on your region. Allow four to six weeks for uptake and distribution of the insecticide within the tree. In southern Ohio, for example, you would apply the product by mid-April; in southern Michigan, you should apply the product by early to mid-May. When treating larger trees (e.g., with trunks larger than 12 inches in diameter), treat on the earlier side of the recommended timing. Large trees will require more time for uptake and transportation of the insecticide than will small trees. Recent tests show that imidacloprid soil treatments can also be successful when applied in the fall.

Trunk-Injected Systemic Insecticides

Several systemic insecticide products can be injected directly into the trunk of the tree including formulations of imidacloprid and emamectin benzoate (see Table 1). An advantage of trunk injections is that they can be used on sites where soil treatments may not be practical or effective, including trees growing on excessively wet, compacted or restricted soil environments. However, trunk injections do wound the trunk, which may cause long-term damage, especially if treatments are applied annually.

Products applied as trunk injections are typically absorbed and transported within the tree more quickly than soil applications. Allow three to four weeks for most trunk-injected products to move through the tree. Optimal timing of trunk injections occurs after trees have leafed out in spring but before EAB eggs have hatched, or generally between mid-May and mid-June. Uptake of trunk-injected insecticides will be most efficient when trees are actively transpiring. Best results are usually obtained by injecting trees in the morning when soil is moist but not saturated. Uptake will be slowed by hot afternoon temperatures and dry soil conditions.

Noninvasive, Systemic Basal Trunk Sprays

Dinotefuran is labeled for application as a noninvasive, systemic bark spray for EAB control. It belongs to the same chemical class as imidacloprid (neonicotinoids) but is much more soluble. The formulated insecticide is sprayed on the lower five to six feet of the trunk using a common garden sprayer and low pressure. Research has shown that the insecticide penetrates the bark and moves systemically throughout the rest of the tree. Dinotefuran can be mixed with surfactants that may facilitate its movement into the tree, particularly on large trees with thick bark. However, in field trials, adding a surfactant did not consistently increase the amount of insecticide recovered from the leaves of treated trees.

The basal trunk spray offers the advantage of being quick and easy to apply and requires no special equipment other than a garden sprayer. This application technique does not wound the tree, and when applied correctly, the insecticide does not enter the soil.

Protective Cover Sprays

Insecticides can be sprayed on the trunk, branches and (depending on the label) foliage to kill adult EAB beetles as they feed on ash leaves, and newly hatched larvae as they chew through the bark. Thorough coverage is essential for best results. Products that have been evaluated as cover sprays for control of EAB include some specific formulations of permethrin, bifenthrin, cyfluthrin and carbaryl (see Table 1).

Protective cover sprays are designed to prevent EAB from entering the tree and will have no effect on larvae feeding under the bark. Cover sprays should be timed to occur when most adult beetles are feeding and beginning to lay eggs. Adult activity can be difficult to monitor because there are no effective pheromone traps for EAB. However, first emergence of EAB adults generally occurs between 450-550 degree days (starting date of January 1, base temperature of 50˚F), which corresponds closely with full bloom of black locust (*Robinia pseudoacacia*). For best results, consider two applications, one at 500 DD_{50} (as black locust approaches full bloom) and a second spray four weeks later.

How Effective Are Insecticides for Control of EAB?

Extensive testing of insecticides for control of EAB has been conducted by researchers at Michigan State University (MSU) and The Ohio State University (OSU). Results of some of the MSU trials are available at **www.emeraldashborer.info**.

Soil-Applied Systemic Insecticides

Efficacy of imidacloprid soil injections for controlling EAB has been inconsistent; in some trials EAB control was excellent, while others yielded poor results. Differences in application protocols and conditions of the trials have varied considerably, making it difficult to reach firm conclusions about sources of variation in efficacy. For example, an MSU study found that low-volume soil injections of imidacloprid applied to small trees averaging 4 inches in DBH (diameter of the trunk at breast height) using the Kioritz applicator (a hand-held device for making low-volume injections) provided good control at one site. However, control was poor at another site where the same application protocols were used to treat larger trees (13-inch DBH). Imidacloprid levels may have been too low in the larger trees to provide adequate control. Higher pest pressure at the second site also may have contributed to poor control in the large trees.

In the same trials, high-pressure soil injections of imidacloprid (applied in two concentric rings, with one at the base of the tree and the other halfway to the drip line of the canopy) provided excellent control at one site. At another site, however, soil injections applied using the same rate, timing and application method were completely ineffective, even though tree size and infestation pressure were very similar. It should be noted that recent studies have shown that imidacloprid soil injections made at the base of the trunk result in more effective uptake than applications made on grid or circular patterns under the canopy.

Imidacloprid soil drenches have also generated mixed results. In some studies conducted by MSU and OSU researchers, imidacloprid soil drenches have provided excellent control of EAB. However, in other studies, control has been inconsistent. Experience and research indicate that imidacloprid soil drenches are most effective on smaller trees and control of EAB on trees with a DBH that exceeds 15 inches is less consistent.

This inconsistency may be due to the fact that application rates for systemic insecticides are based on amount of product per inch of trunk diameter or circumference. As the DBH of a tree increases, the amount of vascular tissue, leaf area and biomass that must be protected by the insecticide increases exponentially. Consequently, for a particular application rate, the amount of insecticide applied as a function of tree size is proportionally decreased as trunk diameter increases. Hence, the DBH-based application rates that effectively protect relatively small trees can be too low to effectively protect large trees. Some systemic insecticide products address this issue by increasing the application rate for large trees.

In an OSU study with larger trees (15- to 22-inch DBH), Xytect™ (imidacloprid) soil drenches provided most consistent control of EAB when applied experimentally at twice the rate that was allowed at that time. Recently, the Xytect™ label was modified to allow the use of this higher rate, which we now recommend when treating trees larger than 15-inch DBH. Merit® imidacloprid formulations, however, are not labeled for application at this high rate. Therefore, when treating trees greater than 15-inch DBH with Merit® soil treatments, two applications are recommended, either in the fall and again in the spring, or twice in the spring, about four weeks apart (for example in late April and again in late May). This is not an option for Bayer Advanced™ Tree and Shrub Insect Control and other homeowner formulations of imidacloprid, which are limited by the label to one application per year. Homeowners wishing to protect trees larger than 15-inch DBH should consider having their trees professionally treated.

All treatment programs must comply with the limits specified on the label regarding the maximum amount of insecticide that can be applied per acre during a given year.

Trunk-Injected Systemic Insecticides

Emamectin benzoate

In several intensive studies conducted by MSU and OSU researchers, a single injection of emamectin benzoate in mid-May or early June provided excellent control of EAB for at least two years, even under high pest pressure. For example, in a highly-replicated study conducted on trees ranging in size from 5- to 20-inch DBH at three sites in Michigan, untreated trees had an average of 68 to 132 EAB larvae per m^2 of bark surface, which represents high pest pressure. In contrast, trees treated with emamectin benzoate had, on average, only 0.2 larvae per m^2, a reduction of > 99 percent. When additional trees were felled and debarked two years after the emamectin benzoate injection, there were still virtually no larvae in the treated trees, while adjacent, untreated trees at the same sites had hundreds of larvae.

In two OSU studies conducted in Toledo with street trees ranging in size from 15- to 25-inch DBH, a single application of emamectin benzoate also provided excellent control for two years. There was no sign of canopy decline in treated trees and very few emergence holes, while the canopies of adjacent, untreated trees exhibited severe decline and extremely high numbers of emergence holes.

One study suggests that a single injection of emamectin benzoate may even control EAB for three years. Additional studies to further evaluate the long-term effectiveness of emamectin benzoate are underway. To date, this is the only product that controls EAB for more than one year with a single application. In addition, in side-by-side comparisons with other systemic products (neonicotinoids), emamectin benzoate was more effective.

Imidacloprid

Trunk injections with imidacloprid products have provided varying degrees of EAB control in trials conducted at different sites in Ohio and Michigan. In an MSU study, larval density in trees treated with Imicide® injections were reduced by 60 percent to 96 percent, compared to untreated controls. There was no apparent relationship between efficacy and trunk diameter or infestation pressure. In another MSU trial, imidacloprid trunk injections made in late May were more effective than those made in mid-July, and IMA-jet® injections provided higher levels of control than did Imicide®, perhaps because the IMA-jet® label calls for a greater amount of active ingredient to be applied on large trees. In an OSU study in Toledo, IMA-jet® provided excellent control of EAB on 15- to 25-inch trees under high pest pressure when trees were injected annually. However, trees that were injected every other year were not consistently protected.

In a discouraging study conducted in Michigan, ash trees continued to decline from one year to the next despite being treated in both years with either imidacloprid (Imicide®, Pointer™) or Bidrin (Inject-A-Cide B®) trunk injections. Imicide®, Pointer™ and Inject-A-Cide B® trunk injections all suppressed EAB infestation levels in both years, with Imicide® generally providing best control under high pest pressure in both small (six-inch DBH) and larger (16-inch DBH) caliper trees. However, larval density increased in treated and untreated trees from one year to the next. Furthermore, canopy dieback increased by at least 67 percent in all treated trees (although this was substantially less than the amount of dieback observed in untreated trees). Although untreated trees were more severely impacted, these results indicate that even consecutive years of treatment with these trunk-injection treatments may only slow or delay ash decline when pest pressure is severe.

In three other side-by-side comparisons, Imicide® consistently provided higher levels of control than did Pointer™. In another MSU study, ACECAP® trunk implants (active ingredient is acephate) were not effective under high pest pressure.

Noninvasive Basal Trunk Sprays with Dinotefuran

Studies to date indicate that systemic basal trunk sprays with dinotefuran are about as effective as imidacloprid treatments. MSU and OSU studies have evaluated residues in leaves from trees treated with the basal trunk spray. Results show that the dinotefuran effectively moved into the trees and was translocated to the canopy at rates similar to those of other trunk-injected insecticides, and faster than other soil-applied neonicotinoid products.

As with imidacloprid treatments, control of EAB with dinotefuran has been variable in research trials. In an MSU study conducted in 2007 and 2008, dinotefuran trunk sprays reduced EAB larval density by approximately 30 percent to 60 percent compared to the heavily infested untreated trees. The treatment was effective for only one year and would have to be applied annually. In general, control is better and more consistent in smaller trees than in large trees, but more research is needed with larger trees. Studies to address the long-term effectiveness of annual dinotefuran applications for control of EAB are underway.

Protective Cover Sprays

MSU studies have shown that applications of Onyx™, Tempo® and Sevin® SL provided good control of EAB, especially when the insecticides were applied in late May and again in early July. Acephate sprays were less effective. BotaniGard® (*Beauvaria bassiana*) was also ineffective under high pest pressure. Astro® (permethrin) was not evaluated against EAB in these tests, but has been effective for controlling other species of wood borers and bark beetles.

In another MSU study, spraying Tempo® just on the foliage and upper branches or spraying the entire tree were more effective than simply spraying just the trunk and large branches. This suggests that some cover sprays may be especially effective for controlling EAB adults as they feed on leaves in the canopy. A single, well-timed spray was also found to provide good control of EAB, although two sprays may provide extra assurance given the long period of adult EAB activity.

It should be noted that spraying large trees is likely to result in a considerable amount of insecticide drift, even when conditions are ideal. Drift and potential effects of insecticides on non-target organisms should be considered when selecting options for EAB control.

Key Points and Summary Recommendations

- Insecticides can effectively protect ash trees from EAB.
- Unnecessary insecticide applications waste money. If EAB has not been detected within 10-15 miles, your trees are at low risk. Be aware of the status of EAB in your location. Current maps of known EAB populations can be found at **www.emeraldashborer.info**. Remember, however, that once a county is quarantined, maps for that county are no longer updated.
- Trees that are already infested and showing signs of canopy decline when treatments are initiated may continue to decline in the first year after treatment, and then begin to show improvement in the second year due to time lag associated with vascular healing. Trees exhibiting more than 50 percent canopy decline are unlikely to recover even if treated.
- Emamectin benzoate is the only product tested to date that controls EAB for more than one year with a single application. It also provided a higher level of control than other products in side-by-side studies.
- Soil drenches and injections are most effective when made at the base of the trunk. Imidacloprid applications made in the spring or the fall have been shown to be equally effective.
- Soil injections should be no more than 2-4 inches deep, to avoid placing the insecticide beneath feeder roots.
- To facilitate uptake, systemic trunk and soil insecticides should be applied when the soil is moist but not saturated or excessively dry.
- Research and experience suggest that effectiveness of insecticides has been less consistent on larger trees. Research has not been conducted on trees larger than 25-inch DBH. When treating very large trees under high pest pressure, it may be necessary to consider combining two treatment strategies.
- Xytect™ soil treatments are labeled for application at a higher maximum rate than other imidacloprid formulations, and we recommend that trees larger than 15-inch DBH be treated using the highest labeled rate. Merit® imidacloprid formulations are not labeled for use at this higher rate. When treating larger trees with Merit® soil treatments, best results will be obtained with two applications per year. Imidacloprid formulations for homeowners (Bayer Advanced™ Tree & Shrub Insect Control and other generic formulations) can be applied only once per year.
- Homeowners wishing to protect trees larger than 15-inch DBH should consider having their trees professionally treated.
- All treatment programs must comply with label restrictions on the amount of insecticide that can be applied per acre in a given year.

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BEFORE THE BUG COMES TO TOWN

Developing a State or Regional Readiness and Response Plan for Exotic Invasive Insects

PLAN DEVELOPMENT

An invasive pest can be a huge threat to the balance of the urban ecosystem. Managing an infestation – all the essential education, administration, information, communication, and regulation issues that need to be coordinated – is a staggering task for any agency. The main purpose for undertaking readiness planning *before* the bug comes to town is to learn as much as possible ahead of time, collaborate to share resources and information, and create a network to strengthen a coordinated response. **The primary goal is to protect the resource** to the extent possible.

1. BUILDING A TEAM - Bringing together stakeholders

A team approach is essential to tackle the imposing threat of an exotic species invasion. A strong and diverse team can be much more effective through collaboration, than any one organization can be alone. Members of the team should bring useful and important knowledge and experience to the planning effort. The team itself creates a critical network for information sharing and dissemination and supports and energizes individual member organizations in preparedness activities. A team working to plan for protection of the urban and community forest should include the following partners:

Regulatory agencies
- USDA APHIS-PPQ*
- State Department of Agriculture

Supporting agencies
- USDA* Forest Service – State and Private Forestry
- State Department of Natural Resources

Researchers
- Universities/Colleges
- USDA Forest Service – Research
- State Natural History Survey

Educators
- Arboreta and Botanic Gardens
- Non-profit organizations related to tree/forest issues

Resource managers
- Municipal Foresters Associations
- Local, County, Regional, and State Park Agencies
- Parks and Recreation Associations
- Forest Preserves
- Consulting Foresters Associations

Industry
- Arborist Associations
- Landscape Contractors Associations
- Nursery/Growers Associations
- Wood Products Associations
- Forestry Councils
- Golf Course Superintendent Associations

Municipalities
- Regional Councils of Governments
- Mayors & Managers Associations
- Individual Municipalities
- County and Township Agencies

Organizations/Agencies involved in outbreaks in other states

2. WHAT IS AT RISK? - Calculating consequences of infestation

In order to garner support, interest, and collaboration for readiness planning, it is important to determine the following:

- What is the extent of the resource at risk?
  (e.g. 6% of the forest cover is ash, 19% of all public trees are ash, and 35% of the public canopy cover is ash)
  - Research FIA* data for rural forests
  - State natural resources department
  - Survey of city foresters for urban forest data

- What consequences could arise from the infestation?
  (e.g. loss of canopy and resulting economic and environmental impacts such as increase in stormwater runoff; expenses associated with removal and replanting; visual/aesthetic impacts; property loss, hazardous conditions with dead standing trees; private homeowner assistance needs – be specific!)
  - Readiness planning team members can contribute from various perspectives
  - Research consequences of infestation in other states

3. WHAT IS ALREADY BEING DONE? – Coordinate with existing plans

APHIS* is directing all states to develop "Plant Resource Emergency Response Guidelines." These guidelines outline the legal authority, roles and responsibilities of various agencies and organizations, and a system for rapid response to an insect, disease, or weed that impacts plants. These general guidelines may be useful in developing a species-specific preparedness/response plan. For information about the status of your state's guidelines, contact your State Plant Health Director or State Plant Regulatory Official (visit the following websites for directories by state):

- State Plant Regulatory Officials
  http://nationalplantboard.org/member/index.html

- State Plant Health Directors
  http://ceris.purdue.edu/napis/names/sphdXstate.html

Look to management plans from other state. APHIS PPQ develops manuals and guidelines for all kinds of introduced pests. Review relevant manuals (e.g. New Pest Response Guidelines Asian Longhorned Beetle) to glean ideas for regional readiness.

- APHIS manuals for introduced pests
  http://www.aphis.usda.gov/ppq/manuals/online_manuals.html

Utilize the resources of the National Invasive Species Information Center, an interdepartmental coordinating council of federal agencies that compiles numerous model management and control plans into a Manager's Toolkit.

- Invasive Species Manager's Toolkit
  http://www.invasivespecies.gov/toolkit/main.shtml

4. WHAT HAVE YOU GOT? Identifying strengths, capacity, resources, and programs

- Determine who has authority and responsibility
- Inventory existing programs and efforts to educate, monitor and reduce risk

- Identify strengths
  (e.g. strong green industry professional networks to educate and disseminate information, previous ALB experience had success with public awareness and support)
- Find mechanisms to distribute information
- Locate expertise in team organizations
  (e.g. where are the entomologists, foresters, communications specialists, and lobbyists?)
- Look for sources of funds
  (e.g. US Forest Service Forest Health Program, APHIS, State Department of Agriculture, professional organizations, State Urban Forestry Grants, Councils of Governments, state and federal legislature)

Example: Illinois Authorities and Resources

Lead State Regulatory Agency

IL Dept. of Agriculture – enacts IL Pest and Disease Act
- identification of pest
- declaration of nuisance (allows regulation to begin)
- initiate delimiting survey
- establish interior quarantine
- has authority to enter property for control
- leads communication

Lead Federal Regulatory Agency

APHIS PPQ
- definitive identification of pest
- initiate delimiting survey
- coordinates with local governments
- oversees eradication
- administers emergency funds

Local government
- eradication
- communication
- cooperation

State Support Organizations

IL Dept. of Natural Resources
- monitoring
- technical assistance to communities

University of Illinois
- technical expertise
- professional education

Federal Support Organizations

US Forest Service
- regional monitoring and forest health support
- research
- reforestation resources
- wood utilization expertise

APHIS PPQ
- information
- outreach

5. WHERE ARE THE GAPS? - Identifying needs, shortages, and hindrances
- Are the public agencies adequately staffed and supported?
- Are all at-risk land managers engaged?
- What information do we need to know before we can plan?
- Are there any policies, attitudes or programs that would be obstacles to readiness?
  (e.g. Do state regulatory statutes allow for rapid response? Is there political support?)

6. WILL IT HAPPEN TO YOU? - Determining vulnerability
- What geographic area is at highest risk?

(e.g. most of the ash forests are in the Northeast part of the state--Windham, Olmsted, Orleans, and Lawrence Counties, most of the public ash trees are located in the highly populous areas of the Chicago metro)

- Where is the most probable source of an infestation?
  (e.g. human movement such as nursery stock, wood products and firewood transfer from out-of-state infested site)
- Where is the most probable port of entry into the state?
  (e.g. 1. urban areas with newly planted ash (from nursery stock),
  2. recreation areas like campgrounds from firewood transfer,
  3. Chicago due to its large population and proximity to Michigan and Indiana; because it is a major port for foreign shipments; there is a high concentration of industry and because there are multiple ports of entry via train, auto, and ship)

7. DRAFT A PLAN. - With consensus from major stakeholders draft a plan to guide planning and prioritize action.

8. MAINTAIN READINESS.

- Share evolving issues, actions, information and technology with team members.
- Collaborate with team member to act on key steps in the readiness plan.
  (e.g. Collaborate with land owners and universities to conduct a detection survey.)
- Inform stakeholders and constituents of plan and state of readiness.
- Communicate with the media about the plan and achievements to foster public cooperation and confidence.

PLAN COMPONENTS

This is an example of a plan developed in Illinois to prepare for the emerald ash borer (EAB):

1. **Readiness-** reduce risk, minimize impact, and respond more effectively to a possible infestation and work towards overall health and sustainability of the urban forest in Illinois and northeast Indiana
   A. Administrative Readiness
      1) Establish a network of agencies and organizations to be affected by EAB
         a. Statutory Administrative Team – lead regulatory agencies
         b. Technical and Administrative Team
         b. Education and Communication Team
      2) Finalize Develop an EAB Readiness Plan
      3) Identify resources and needs
      4) Take proactive steps to speed administrative processes i.e., shorten time required to establish quarantine
      5) Educate the media and assure accuracy of information
   B. Technical Readiness
      1) Review and distribute federal scientific guidelines to advise actions
      2) Advocate for continued research for greater understanding of EAB and management options
      3) Transfer technology

2. **Prevention infestation** – to assure that all means of introduction are known and blocked, whenever possible
   A. Assess Risk
      1) Identify possible sources of EAB importation (i.e., firewood and nursery stock from Michigan)
      2) Assess the scope of the resource at risk (number of ash trees)
      3) Track spread of EAB and distribute to Readiness Team
   B. Reduce Risk
      1) Advocate for appointment of vital vacant positions
      2) Raise public awareness about risk from firewood importation
      3) Track nursery stock, ash lumber and ash firewood importation in recent past
      4) Educate industries about risk of ash importation
      5) Assure plantings selections contribute to a diverse and sustainable urban forest
      6) Seek legislative support to reduce risk

3) **Identification** – minimize the spread and improve odds of containing an infestation
   A. Survey urban ash populations to quickly find, or rule out the presence of EAB
   B. Offer training and outreach to landscapers, arborists, nurserymen and other green industry workers to accurately identify EAB
   C. Educate general public about ash health and EAB
   D. Establish a hotline and a website
   E. Support full staffing of IDA Inspectors to respond quickly to possible sightings

4) **Response** - contain infestation and manage the EAB population
   A. Implement coordinated effort to contain the infestation
   B. Provide accurate information to the media through EAB Teams
   C. Communicate with public and industry professionals to foster cooperation to maximize effective response
   D. Reforest

*ACRONYMS

Federal Organizations:
APHIS – Animal and Plant Health Inspection Service
PPQ – Plant Protection and Quarantine (Under APHIS)
FEMA – Federal Emergency Management Agency
USDA – United States Department of Agriculture
FS – Forest Service

State Organizations:
DNR – State Department of Natural Resources
DA – State Department of Agriculture
EMA – State Emergency Management Agency
FHP – Forest Health Program

Other:
FIA – Forest Inventory and Analysis (program of the USDA Forest Service)
ALB – Asian longhorned beetle
EAB - emerald ash borer

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