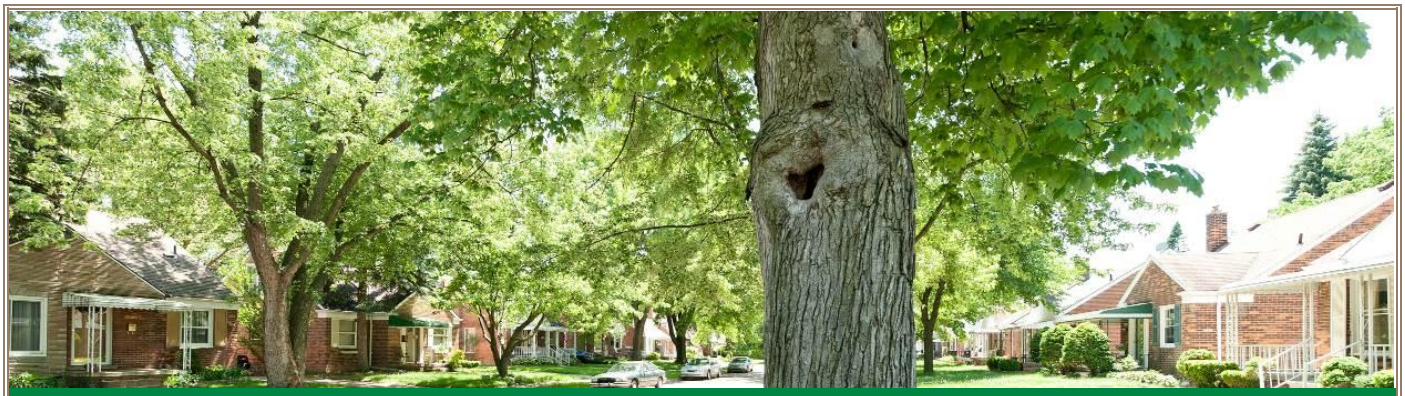

Tree Management Plan

City of Middletown, New York

July 2015

Prepared for:

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Acknowledgments

Middletown'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 value.

The city also recognizes the support of its Mayor, Joseph M. DeStefano.

Executive Summary

This plan was developed for the City of Middletown by Davey Resource Group with a focus on addressing short- 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 was utilized to develop this management plan.

State of the Existing Urban Forest

The June 2015 inventory included trees, stumps, and planting sites in specified parks and public properties, and along select street rights-of-way (ROW). Inventoried parks and areas included:

- Academy Avenue Park
- Birch Drive Park
- Chappelle Park
- City Hall property
- East Avenue Park
- Fancher-Davidge Park
- Fulton Street median
- Grove Street Park
- Linden Avenue Park
- Maple Hill Park
- Monhagen Lake (around the buildings)
- North Street Park
- North Street corridor
- Prospect Avenue Park
- The Rockland Psychiatric Center campus park
- Sproat Street Pool
- West Main Street Park
- Watts Memorial Park.

A total of 2,748 sites were recorded during the inventory: 2,498 individual trees, 118 stumps, and 132 planting sites. Analysis of the tree inventory data found:

- The overall condition of the inventoried tree population is rated Fair.
- *Quercus* (oak) comprises the largest percentage of the inventory (32%) and threatens biodiversity.
- Overall, the diameter size class distribution of the inventoried tree population showed a greater number of established and maturing trees than young trees.

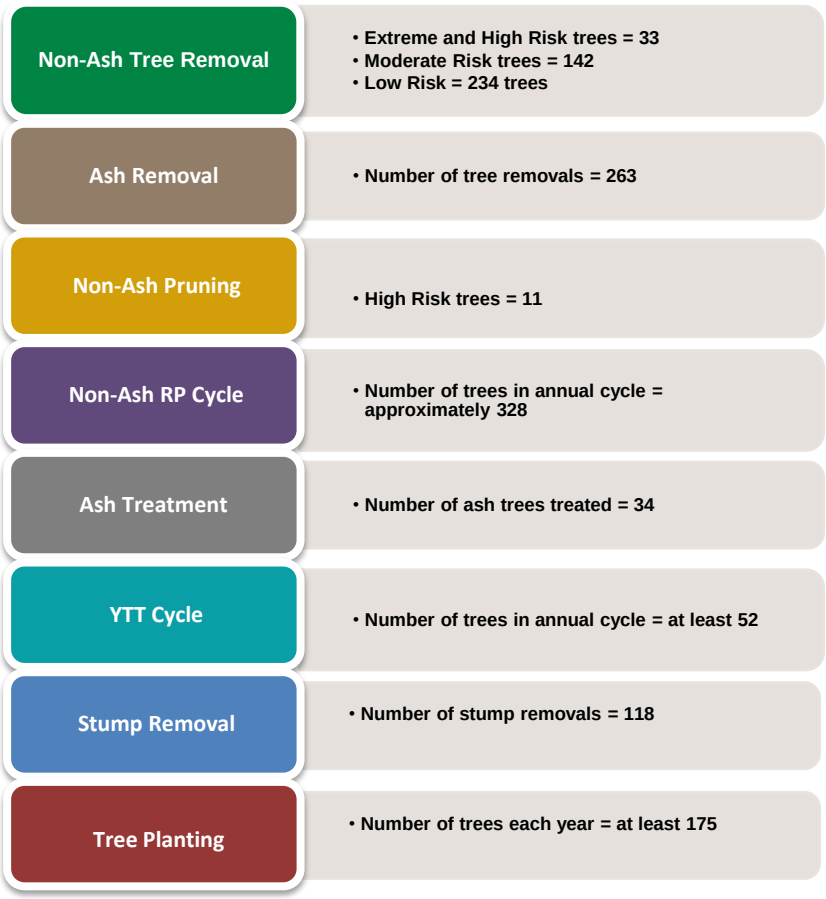
Quantifiable Benefits

- The appraised value of Middletown's inventoried tree population is $7,257,964.
- Trees provide approximately $329,000 in the following annual benefits:
  - *Aesthetic and other benefits*: valued at $164,243 per year.
  - *Stormwater peak flow reductions:* 12,280,611 gallons valued at $121,578 per year.
  - *Energy*: 328.3 megawatt-hours (MWh) and 11,105.7 Therms valued at $36,534 per year.
  - *Carbon sequestered and avoided*: 772 tons for a net value of $11,041 per year.
  - *Air quality*: valued at -$4,396 per year (see 'Air Quality Benefits' in Section 2 for more detail on the air quality net benefits).

See Appendix A for an overview of the methodology used in the inventory and assessment.

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 (16%), stump removal (5%), pruning (75%), and planting (4%). Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted a few Extreme and High Risk trees (2%) that need to be removed or pruned immediately to promote public safety. Low and Moderate Risk trees should be addressed after all elevated risk tree maintenance has been completed. Trees should be planted to mitigate removals and create canopy.



Middletown'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 52 young trees should be structurally pruned each year during the young tree training cycle, and approximately 328 trees should be cleaned during the routine pruning cycle each year.

Photograph 1. The City of Middletown recognizes that its urban forest is critical to ecosystem health and economic growth. Planning and action is required to promote and sustain a healthy urban forest.

Planting trees is necessary to maintain 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 175 trees of a variety of species each year to offset these losses and maintain canopy and maximum benefits.

Citywide tree planting should focus on creating canopy in areas that promote economic growth (such as business districts), in parking lots and near buildings with insufficient shade, and where there are gaps in the existing canopy. Trees of varied species should be planted; however, the planting of *Acer* (maple) and *Quercus* (oak) should be limited until the species distribution normalizes. Davey Resource Group provides a planting list that offers smart choices for species selection and diversity to build a resilient urban forest that will not be significantly affected by any single disease or invasive pest. Due to the species distribution and impending threats from EAB (*Agrilus planipennis*), all *Fraxinus* (ash) trees should be 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- and long-term public benefits, ensures that priority maintenance is expediently performed, and establishes proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $257,000 and $184,000 for the second year; this total will decrease to approximately $95,000 per year by Year Three of the program. High-priority removal and pruning is costly. Since most of this work is scheduled during the first two years of the program, the budget is higher for that year. After this high-priority work has been completed, the urban forestry program will mostly involve proactive work, which is generally less costly and more predictable. Budgets for later years are thus projected to be lower.

Over the long term, funding that supports proactive management of trees will reduce municipal tree care management costs and possibly reduce the costs to build, manage, and support some city infrastructure.

Middletown has many opportunities to improve its urban forest. Planned tree planting and a systematic approach to tree maintenance will transform an on-demand, priority-based operation into a cost-effective, proactive program. Investing in this tree management program will improve tree care efficiency, promote public safety, and increase the economic, environmental, and social benefits the community receives from its trees.

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Introduction

The City of Middletown is home to more than 28,000 full-time residents who enjoy the beauty and benefits of their urban forest. The city's forestry program manages trees on public property—in parks, public spaces, and along the street ROW.

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 a tree management plan) to set goals and measure progress. These tools can be utilized to establish tree care priorities, generate 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 June 2015, the City of Middletown 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 park trees. The following tasks were completed:

- Inventory of trees, stumps, and planting sites within the community parks and street ROW
- Analysis of tree inventory data
- Review of pest and disease threats
- Calculation of ecological, monetary, and other benefits
- Development of 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* presents information about 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 Middletown.
- *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 June 2015, Davey Resource Group arborists assessed and inventoried trees, stumps, and planting sites in parks and along select street rights-of-way. A total of 2,748 sites were collected during the inventory: 2,498 trees, 118 stumps, and 132 vacant planting sites. Of the 2,748 sites collected, 94% were collected in parks, and the remaining 6% were collected along the street ROW. Table 1 provides a detailed breakdown of the number and type of sites inventoried.

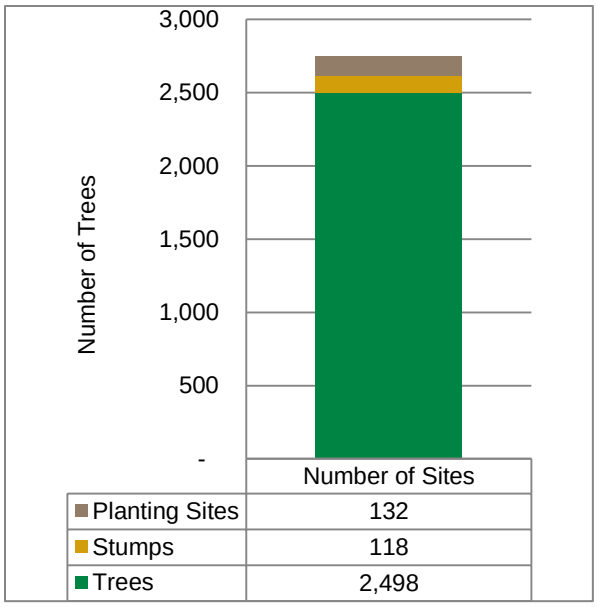


Figure 1. Total sites inventoried.

Data Collection Methods

Tree inventory data were collected using a system developed by Davey Resource Group 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, and the site location method is provided in Appendix A. At each site, the following data fields were collected:

- block side
- canopy spread
- condition
- further inspection
- IPED (integrated pest detection protocol)
- location
- mapping coordinate
- notes
- observations
- primary maintenance needs
- risk assessment
- risk rating
- secondary maintenance needs
- species
- stems
- tree size*

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

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

Project Area

The project areas include:

- Academy Avenue Park
- Birch Drive Park
- Chappelle Park
- City Hall property
- East Avenue Park
- Fancher-Davidge Park
- Fulton Street median
- Grove Street Park
- Linden Avenue Park
- Maple Hill Park
- Monhagen Lake (around the buildings)
- North Street Park
- North Street corridor
- Prospect Avenue Park
- The Rockland Psychiatric Center campus park
- Sproat Street Pool
- West Main Street Park
- Watts Memorial Park.

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 2. Davey Resource Group's arborists inventoried trees in city parks to collect information about trees that could be used to assess the state of urban forests.

- *Species diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. It 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, affects the valuation of tree-related benefits as well as the estimation of maintenance needs and costs, planting goals, and canopy continuity; the diameter size class distribution is used to indicate the relative age of a tree population.
- *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 ROW trees compared to the total number of potential street ROW trees (number of inventoried trees plus the number of potential planting spaces). Stocking level can help determine tree planting needs and budgets.

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 (DED, *Ophiostoma novo-ulmi*) throughout New England and the Midwest. Because of the introduction and spread of DED in the 1930s, combined with its prevalence today, massive numbers of *Ulmus americana* (American elm), a popular street tree in Midwestern cities and towns, have perished (Karnosky 1979). Many 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 concern for biodiversity. Emerald ash borer (EAB, *Agrilus planipennis*) and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are non-native insect pests that attack some of the most prevalent urban shade trees and some 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 Middletown's tree inventory data indicated that the population has relatively good diversity, with 50 genera and 90 species represented.

Figure 2 compares the percentages of the most common species identified during the inventory to the 10% Rule. *Quercus rubra* (northern red oak) and *Acer rubrum* (red maple) exceed the recommended 10% maximum for a single species in a population, comprising 17% and 12% of the inventoried tree population, respectively. *Fraxinus americana* (white ash) is approaching the 10% threshold.

	red oak	red maple	white ash	white oak	sugar maple
Middletown, NY	17%	12%	9%	6%	5%
10% Rule	10%	10%	10%	10%	10%

Figure 2. Five most abundant species of trees during the 2015 inventory.

Figure 3 compares the percentages of the most common genus identified during the inventory to the 20% Rule. *Acer* spp. (maple) and *Quercus* spp. (oak) both exceed the recommended 20% maximum for a single genus in a population, comprising 32% and 22% of the inventoried tree population, respectively.

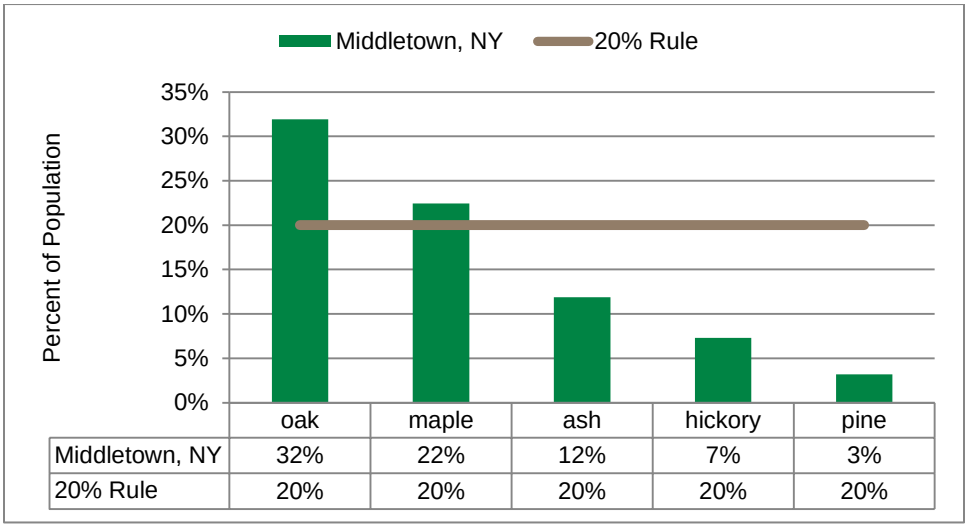


Figure 3. Five most abundant genera of trees during the 2015 inventory.

Discussion/Recommendations

Quercus rubra (northern red oak) dominates the parks. This is a biodiversity concern because its abundance in the landscape makes it a limiting species. Also, *Ceratocystis fagacearum* (oak wilt) is a target of oaks. Having a diverse population of trees will ensure that Middletown's urban forest is sustainable and resilient to future invasive pest infestations.

Considering the large quantity of oaks already present in the population, combined with its susceptibility to oak wilt, the planting of oaks should be limited to minimize the potential for loss should oak wilt threaten Middletown's urban tree population. Due to the presence of emerald ash borer (EAB), the planting of all ash should be discontinued. A more in-depth look at the EAB problem can be found in Section 4. 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 insight into maintenance practices and needs.

The inventoried trees were categorized into the following diameter size classes: young (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature trees (>24 inches DBH). These categories were chosen so that the population could be analyzed following 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 (<8 inches DBH), while a smaller fraction (approximately 10%) should be in the mature size class (>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.

Findings

Figure 4 compares Middletown's diameter size class distribution of the inventoried park and street tree population to the ideal proposed by Richards (1983). Middletown is more evenly distributed than the theoretical ideal. Challenges exist with having enough young trees to fill out the canopy of future generations. Young trees fall short of the ideal by nearly 20%, while larger diameter size classes far exceed the ideal.

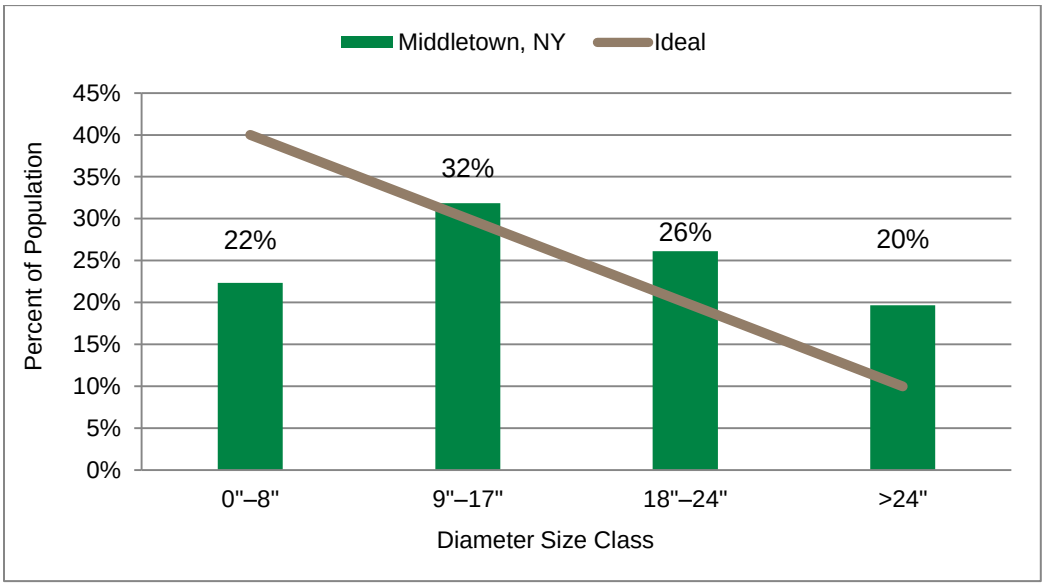


Figure 4. Comparison of diameter size class distribution for Middletown's inventoried trees to the ideal distribution.

Discussion/Recommendations

While having a high number of mature trees is often the goal, there must also be young trees planted to replace them. One of Middletown's objectives is to have an uneven-aged distribution of trees at the street, neighborhood, and management zone levels, as well as citywide. Davey Resource Group recommends that Middletown support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in the tree canopy and provide for gradual succession of older 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, replace trees lost to natural mortality (expected to be 1–3% per year), and minimize 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 finding the best places to create new canopy is critical.

General Health

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.

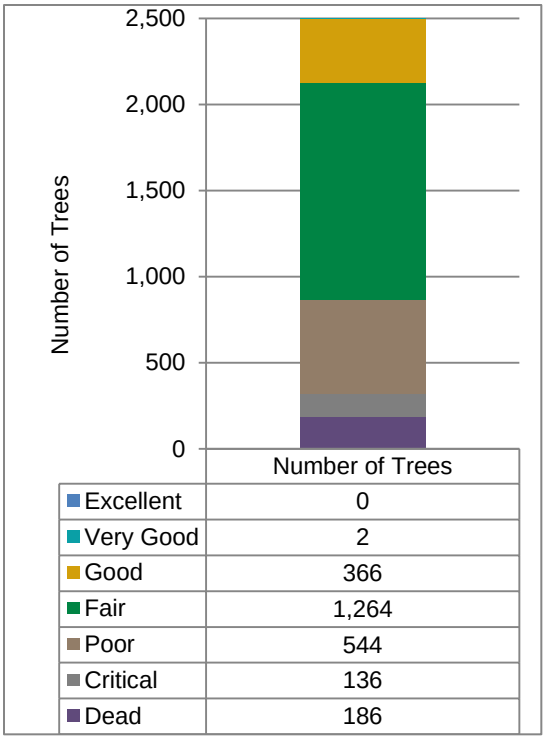


Figure 5. Condition of park trees during the 2015 inventory.

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 can provide some insight into the stability of the population. In this plan, relative age was based on DBH. 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 (>24 inches DBH).

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

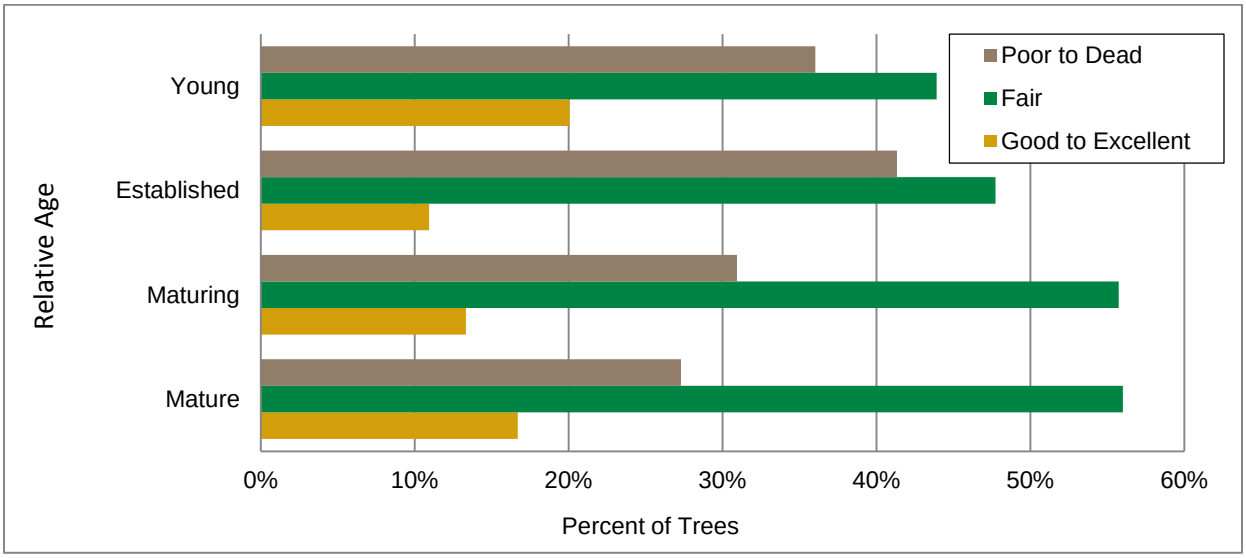


Figure 6. Tree condition by relative age during the 2015 inventory.

Findings

Most of the inventoried trees were recorded to be in Fair or Poor condition, 51% and 22%, respectively (Figure 5). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 6 illustrates that most of the young, established, maturing, and mature trees were rated to be in Fair condition.

Discussion/Recommendations

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

- The similar trend in tree condition across street ROW and park trees reveals that growing conditions and/or past management of trees were consistent.
- Remove Dead trees and trees in Critical condition. Because of their failed health, these trees most likely will not recover, even with increased care.
- Younger trees rated in Fair or Poor condition can benefit from improvements in structure. Over time, such improvements may enhance their health. Pruning should follow *ANSI A300 (Part 1)* (2008).
- Poor condition ratings assigned to 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. Follow guidelines developed by the ISA and those recommended by *ANSI A300 (Part 9)* (2011) to ensure that tree maintenance practices improve the general health of the urban forest.

Photograph 3. This ash located in Fancher-Davidge Park is poorly structured. Based on the location of the tree, size of defect, and potential for failure, this tree was recorded as High Risk.

Other Observations

Observations were recorded during the inventory to further describe a tree's health, structure, or location when more detail was needed.

Findings

'Grate or Guard' and 'Poor structure' were observed and recorded most often (1.3% and 1% of inventoried trees, respectively). Of these 65 trees, 6 were recommended for removal, and 2 were rated to be High Risk trees.

Table 1. Observations Recorded During the Street Tree Inventory

Observation	Number Inventoried	Percent
Grate or Guard	37	1.3%
Poor Structure	28	1.0%
Poor Location	6	0.2%
Memorial Tree	4	0.2%
None	2,673	97.3%
Total	2,748	100%

Discussion/Recommendations

Trees noted as having poor structure (28 trees) should be regularly inspected. Corrective action should be taken when warranted. If their condition worsens, removal may be required.

Staking should only be installed when necessary to keep trees from leaning (windy sites) or to prevent damage from pedestrians and/or vandals. Stakes should only be attached to trees with a loose, flexible material. Installed hardware that has been attached to any tree for more than one year and hardware that may no longer be needed for its intended purposes should be inspected and removed as appropriate.

Costs for treating deficient trees must be considered to determine whether removal and replacement is the more viable option.

Potential Threats from Pests

Insects and diseases pose serious threats to tree health. Awareness and early diagnosis are crucial to ensuring the health and continuity of the street trees. Appendix C provides information about some of the current potential threats to Middletown'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 New York (see Figure 7). It is important to note that the figure presents data exclusively from the inventory. Many more trees throughout Middletown, including those on public and private property, may be susceptible to these invasive pests.

Findings

Oak wilt (*Ceratocystis fagacearum*) and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street trees (33% and 25%, respectively). These pests were not detected in Middletown, but if they were, the city could see severe losses in its tree population.

EAB is present in Middletown: Davey staff found symptoms of infestation in ash throughout the city. There were 297 ash trees inventoried within the street ROW, but only 53 were confirmed to have damage caused by EAB. However, 228 of the inventoried ash trees showed symptoms of potential infestation. Private trees that were not part of this inventory also showed symptoms of infestation. The unknown amount of private trees that were not part of this inventory may be a future concern.

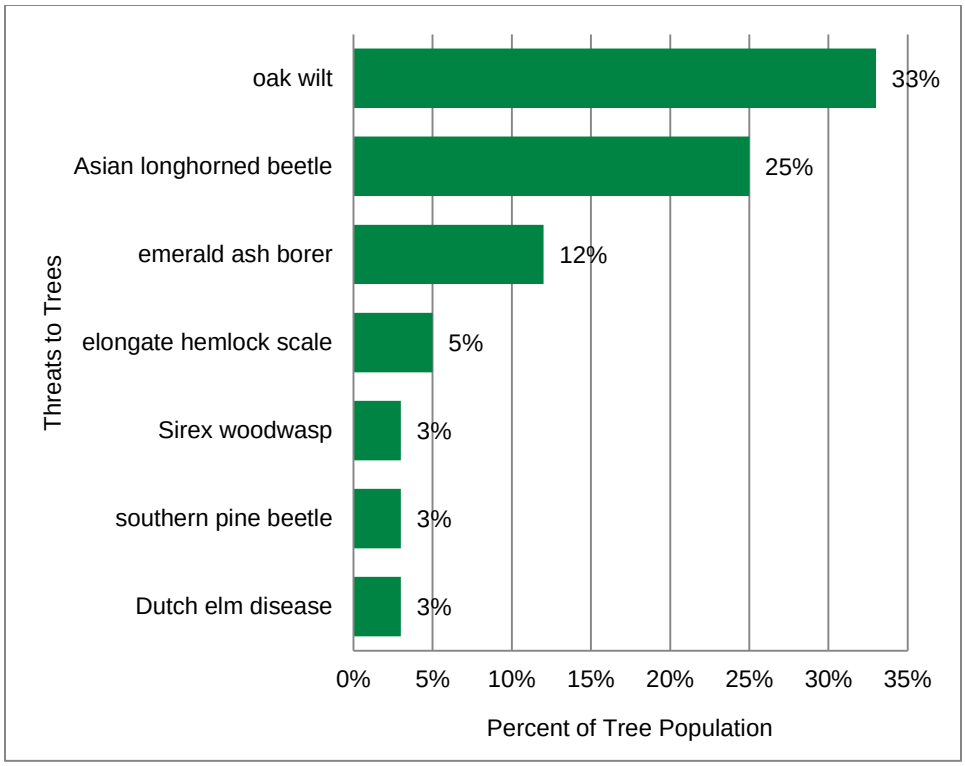


Figure 7. Potential impact of insect and disease threats noted during the 2015 inventory.

Discussion/Recommendations

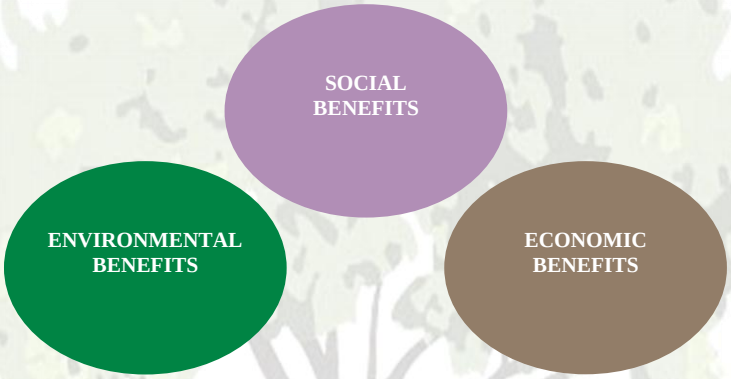
Middletown should be aware of the signs and symptoms of infestations and should be prepared to act if a significant threat is observed in their tree population or in a nearby community. An integrated pest management plan should be established. The plan should focus on identifying and monitoring threats, understanding the economic threshold when considering options such as removal or treatment, selecting the correct treatment, properly timing management strategies, recordkeeping, and evaluating results.

Section 2: Benefits of the Urban Forest

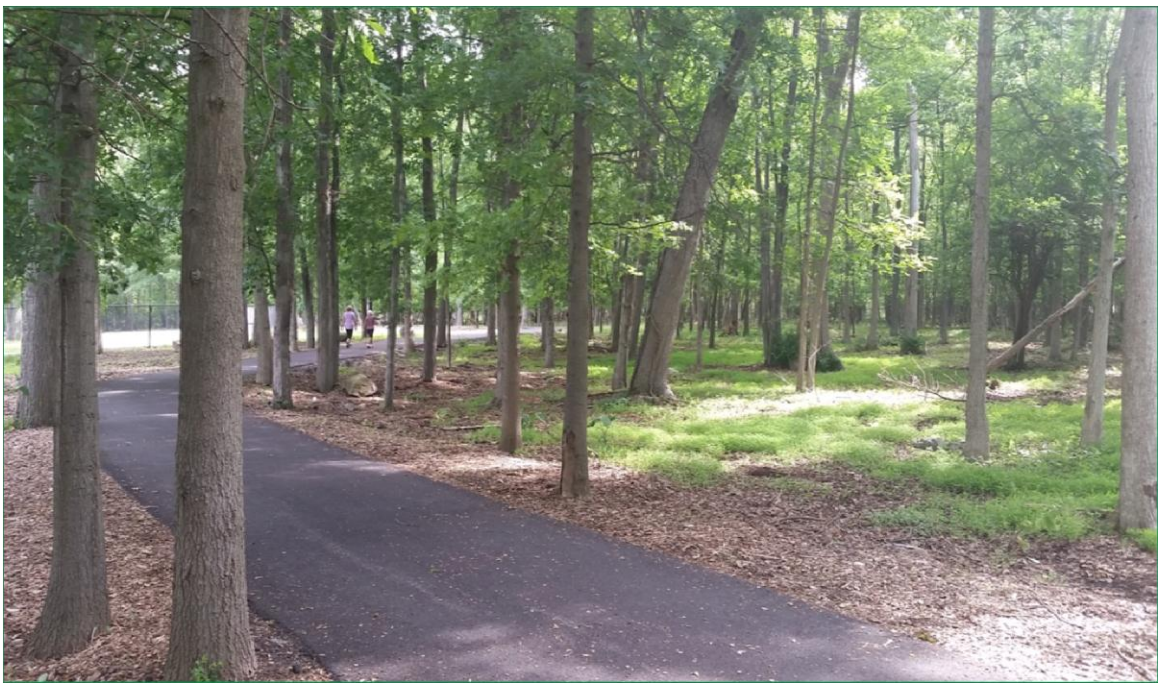
The urban forest plays an important role in supporting and improving the quality of life in urban areas. A tree's shade and beauty contributes to the community's quality of life and softens the often-hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide abundant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

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf, 1998b, Kuo and Sullivan 2001b).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- 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).

- 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. 100 mature tree crowns intercept 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.



- Trees increase residential property values by an average of 7% when present in a yard or neighborhood. Commercial property rental rates were 7% higher when trees were on the property (Wolf 2007).
- Trees moderate temperatures in the summer and winter, saving on heating and cooling expenses (North Carolina State Univ. 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 1998a, 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 1998a).
- The quality of landscaping along the routes leading to the business district had a positive influence on consumers' perceptions of the area (Wolf 2000).



Photograph 4. Trees provide a wealth of aesthetic value to the community. Additionally, the tangible services of trees provide quantifiable benefits that justify the time and money invested in planting and maintenance.

The trees growing along the public streets constitute a valuable community resource. They provide numerous tangible and intangible benefits such as air 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 Middletown's current tree inventory data are summarized in this report using the i-Tree's Streets application. The results of Middletown'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 street 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.
- **Carbon Stored:** Tallies all of the carbon dioxide (CO_2) stored in the urban forest over the life of its trees as a result of sequestration. Carbon stored is measured in tons.
- **Energy:** Presents the contribution of the urban forest toward conserving energy in terms of reduced natural gas use in the winter 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.

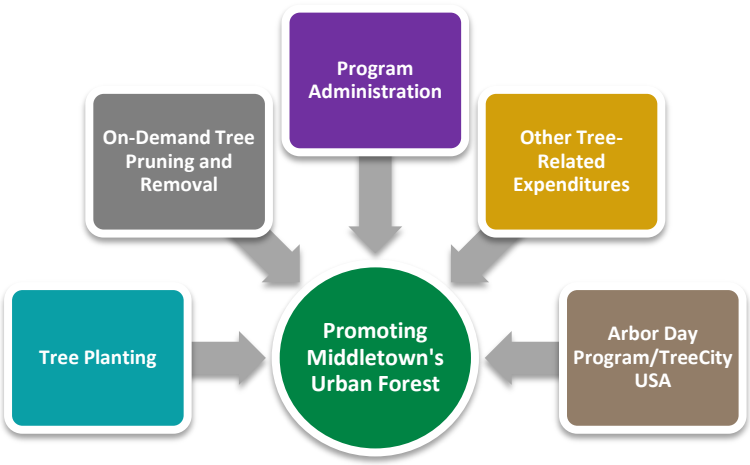
i-Tree Tools

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 Middletown'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 costs or local economic data are not available, i-Tree Streets uses default economic inputs from a reference city selected by the USDA FS for the climate zone in which your community is located. Any default value can be adjusted for local conditions.



Middletown's Inputs

Since specific local economic data for the city's urban forestry program were not available at the time of this plan, economic data from a Climate Zone 6b reference city (Queens, NY) were used to help calculate the benefits provided by Middletown's community.

Because unadjusted program economic defaults were used, the reporting function of the i-Tree Streets model will be limited to the estimation of tree benefits and the Net Annual Benefits, Cost for Public Trees, and benefit-cost ratio (BCR) will not be calculated.

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

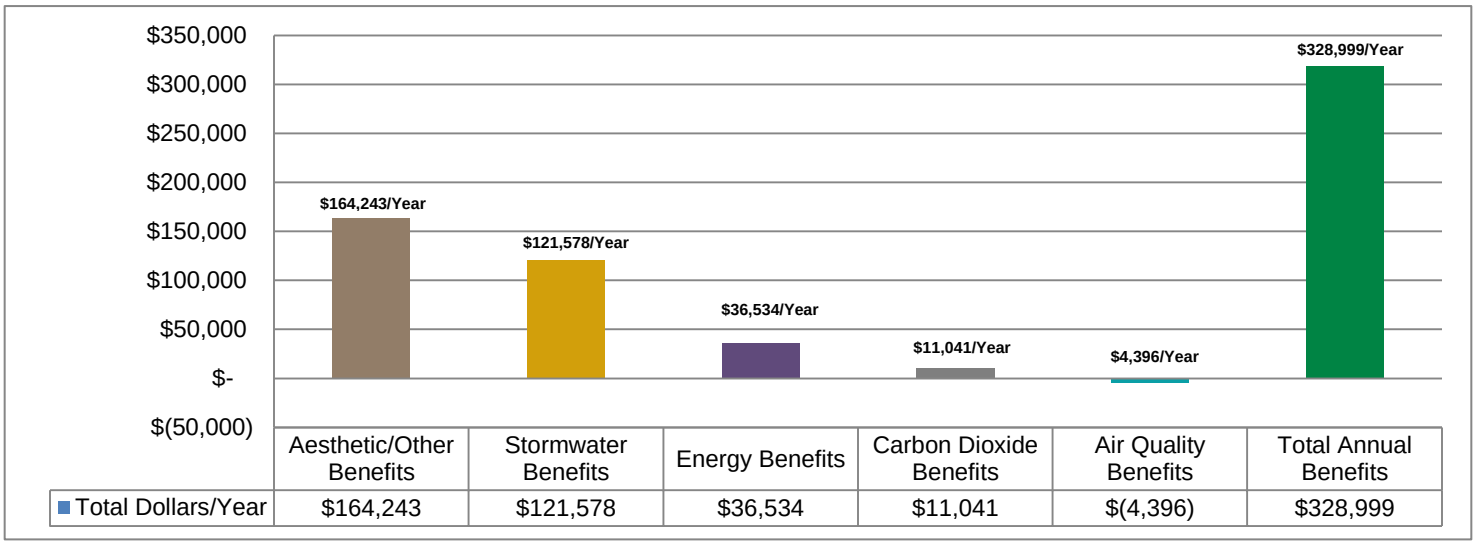
Table 2. Benefit Data for Common Trees by Species

Most Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Benefit Provide By Street Trees						Importance Value (IV)
				Aesthetic/ Other	Stormwater	Carbon Dioxide Stored	Energy	Carbon Sequestered	Air Quality	
Common Name	Botanical Name		(%)	Average/$/Tree						0–100 (higher IV = more important species)
oak, northern red	*Quercus rubra*	432	17.3	97.39	89.44	123.09	24.67	7.25	-1.37	26.60
maple, red	*Acer rubrum*	309	12.4	72.60	41.68	42.04	13.22	4.19	3.45	11.34
ash, white	*Fraxinus Americana*	222	8.9	49.30	23.79	24.73	8.44	2.70	-3.41	5.93
oak, white	*Quercus alba*	149	6	118.58	96.20	122.49	22.18	7.88	0.40	9.59
maple, sugar	*Acer saccharum*	131	5.2	59.49	58.98	69.46	19.86	4.13	4.96	6.21
oak, pin	*Quercus palustris*	114	4.6	76.90	62.07	77.52	17.05	5.15	-12.27	5.35
hickory, shagbark	*Carya ovata*	99	4	64.11	37.20	40.08	12.22	3.86	-5.97	3.35
maple, Norway	*Acer platanoides*	98	3.9	52.43	30.02	34.08	9.62	3.03	-4.99	2.94
oak, chestnut	*Quercus prinus*	81	3.2	91.78	81.43	103.37	21.46	6.45	-16.64	4.63
hickory, pignut	*Carya glabra*	80	3.2	77.51	52.45	59.06	15.83	4.97	-9.25	3.36
pine, eastern white	*Pinus strobus*	75	3	24.63	20.49	18.34	8.29	2.29	3.56	1.76
elm, American	*Ulmus Americana*	55	2.2	55.37	30.71	33.54	10.18	3.21	-4.89	1.67
pear, callery	*Pyrus calleryana*	52	2.1	19.64	11.40	12.70	6.50	1.83	2.82	1.08
ash, green	*Fraxinus pennsyvanica*	40	1.6	52.68	25.00	24.73	9.12	2.94	-3.40	1.10
crabapple	*Malus spp.*	37	1.5	5.43	3.99	4.98	3.97	1.20	1.44	0.63
other street trees	~43 genera of varying species	524	20.9	65.75	48.67	59.31	14.63	4.42	-1.76	14.46
Total		2,498	100	65.75	48.67	59.31	14.63	4.42	-1.76	100

Annual Benefits

The i-Tree Streets model estimated that the inventoried trees provide annual benefits equal to $328,999. Simply stated, this means that because of Middletown's trees, $328,999 was not spent to cool buildings, manage stormwater, and clean the air. In addition, community aesthetics were improved and property values increased merely because of the presence of trees. On average, one of Middletown's trees provides an annual benefit equal to $131.70.

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 net benefits were due to increases in property value because of the presence of trees. In addition to increasing property values, trees also play a major role in stormwater management. The city's inventoried trees alone intercepted over 12.2 million gallons of rainfall, which equates to a savings of $121,578 in stormwater management costs. Overall, stormwater management makes up 37% of the annual net benefits Middletown's inventoried 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 11% and CO_2 reductions for 3% of the total annual net benefits. The effect of the urban forest on air quality was negative due to the emission of natural BVOC from trees. This effect is discussed in detail in the Air Quality Benefit section.



	Aesthetic/Other Benefits	Stormwater Benefits	Energy Benefits	Carbon Dioxide Benefits	Air Quality Benefits	Total Annual Benefits
Total Dollars/Year	$164,243	$121,578	$36,534	$11,041	$(4,396)	$328,999

Figure 8. Breakdown of total annual benefits provided to the city.

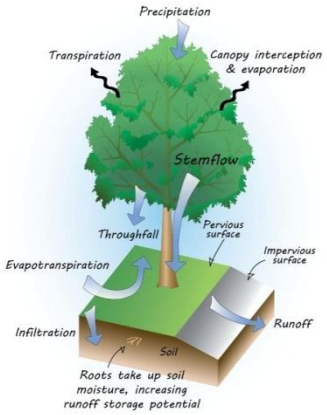
Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits because of the presence of street trees was $164,243. The average benefit per tree equaled $65.75 per year. The trees which made the biggest impact in the determination of aesthetic/other benefits were northern red oak, red maple, and white oak. Their values totaled 50% of the annual aesthetic/other benefit provided by the street tree population. Northern red oak and red maple were found in the greatest abundance (30% of population).

Stormwater Benefits

Rainfall interception by trees can help reduce the costs to manage stormwater runoff. The inventoried trees alone intercept 12,280,611 gallons of rainfall annually (Table 3). The estimated average savings for the city in the management of stormwater runoff because of street trees is $121,578 annually.

Looking at the inventoried population, northern red oak contributed most of the annual stormwater benefits. The population of northern red oak (17% of ROW) intercepted approximately 3.9 million gallons of rainfall. On a per tree basis, large trees with leafy canopies provided the most value. Red maple and white oak comprised 12.4% and 6% of the inventoried population, respectively, and combined to intercept approximately 2.7 million gallons of rainfall. These large-statured trees with big canopies created the greatest benefits.



- *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 taking up nutrients and other pollutants from soils and water through their roots.*
- *Trees transform pollutants into less harmful substances.*

Table 3. Stormwater Benefits Provided by Inventoried Trees

Most Common Trees Collected During Inventory		Number of Inventoried Trees	Percent of Total Trees	Total Rainfall Interception
Common Name	Botanical Name		(%)	(gal.)
oak, northern red	*Quercus rubra*	432	17.3	3,902,921
maple, red	*Acer rubrum*	309	12.4	1,300,835
ash, white	*Fraxinus Americana*	222	8.9	533,440
oak, white	*Quercus alba*	149	6	1,447,836
maple, sugar	*Acer saccharum*	131	5.2	780,449
oak, pin	*Quercus palustris*	114	4.6	714,790
hickory, shagbark	*Carya ovata*	99	4	372,038
maple, Norway	*Acer platanoides*	98	3.9	297,162
oak, chestnut	*Quercus prinus*	81	3.2	666,272
hickory, pignut	*Carya glabra*	80	3.2	423,865
pine, eastern white	*Pinus strobus*	75	3	155,221
elm, American	*Ulmus Americana*	55	2.2	170,596
pear, callery	*Pyrus calleryana*	52	2.1	59,898
ash, green	*Fraxinus pennsyvanica*	40	1.6	100,990
crabapple	*Malus spp.*	37	1.5	14,902
other street trees	~43 genera of varying species	524	20.9	1,339,396
Total		2,498	100	12,280,611

Stored Carbon and Annual Carbon Dioxide Benefits

Trees store some of the CO_2 they absorb, thereby preventing it from reaching the upper atmosphere where it can react with other compounds and form gases like ozone, which adversely affect air quality.

The i-Tree Streets analysis found that the city's inventoried trees store 9,876 tons of carbon (measured in CO_2 equivalents). This amount is equal to the amount of carbon they have amassed during their lifetimes. On an annual basis, 772 tons of CO_2 are removed each year through sequestration and avoidance. This amounts to a total benefit of $11,041 annually. White oak provided the most carbon benefits, with each tree storing an annual average of $122.49 and sequestering $7.88 worth of carbon.

Photograph 5. Trees improve quality of life and help enhance the character of a community. Trees filter air, water, and sunlight, moderate local climate, slow wind and stormwater, shade homes, and provide shelter to animals and recreational areas for people.

Energy Benefits

The inventoried trees conserve energy by shading structures and surfaces, which reduce 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 328.3MWh of electricity and 11,106thm of natural gas. When converted into dollars and cents using default economic data, this accounts for a savings of $36,534 in energy consumption each year.

Quercus rubra (northern red oak)	*Acer rubrum* (red maple)	*Fraxinus americana* (white ash)	*Quercus alba* (white oak)
17% of Population	12% of Population	9% of Population	6% of Population
99MWh Electricity	36MWh Electricity	16MWh Electricity	30MWh Electricity
2,995thm Natural Gas	1,279thm Natural Gas	626thm Natural Gas	966thm Natural Gas
$24.67 Average $/tree	$13.22 Average $/tree	$8.44 Average $/tree	$22.18 Average $/tree

Northern red oak contributed $24.67/tree to the annual energy benefits of the urban forest. Other tree species that provide values that exceed $20 per tree annually include white oak and chestnut oak. These large leafy canopies are valuable because they provide shade, which reduces energy usage. Smaller trees inventoried, such as crabapple, were found to have smaller reductions in energy usage on a per tree basis. Crabapple provides a value of only $3.97 per tree.

Air Quality Benefits

The inventoried tree population annually removes 1,446 lbs. of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) through deposition. The population also avoids 2,435 lbs. annually. However, the abundance of trees in the urban forest naturally emits high quantities of Biogenic Volatile Organic Compounds (BVOCs) as gases. A common example of a natural BVOC is the gas emitted from pine trees, which creates the distinct smell of a pine forest.

While trees do a great deal to absorb air pollutants, they also contribute negatively to air pollution. Trees emit various BVOCs such as isoprenes and monoterpenes, which can also contribute to formation of ozone, a harmful gas that pollutes the air and damages vegetation. These BVOC emissions are accounted for in the air quality net benefit. Due to high BVOC emitters in Middletown, the net air quality benefit is negative.

Middletown's trees emit -3,134 lbs. of BVOCs per year. With the addition of BVOCs emitted as gases, the inventoried trees end up removing 747 lbs. of air pollutants per year. Even though the trees removed or avoided more pollutants than they emitted, it was not enough to result in a positive economic value. Using the annual per tree values in Table 2, the individual tree species chestnut oak, pin oak, and horsechestnut had the greatest adverse impact on air quality based on their annual per tree average values, which ranged from -$12.27 to -$18.53. The trees that provided the most benefits based on the annual per tree average value were black tupelo and Norway spruce ($6.13 and $6.48, respectively).

Importance Value (IV)

Understanding the importance of a tree species to the community is based not only on its presence within the city but also its ability to provide environmental and economic benefits to the community. The IV calculated by the i-Tree Streets 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 in the city, 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 northern red oak has the greatest IV in the population at 26.6, even though it comprises only 17% of the population. This indicates that the loss of the northern red oak population would be more economically detrimental than its percentage of the population leads us to believe. The second highest IV was red maple (11.3), followed by white oak (9.6) and sugar maple (6.2).

Discussion/Recommendations

The i-Tree Streets analysis found that the inventoried trees provide environmental and economic benefits to the community by virtue of their mere presence on the streets. Currently, the aesthetic/other benefits provided by the inventoried trees were rated as having the greatest value to the community. The property value increase provided by trees is important to stimulate economic growth. In addition to increasing aesthetics and property values, trees manage stormwater through rainfall interception, provide shade and windbreaks to reduce energy usage, and store and sequester CO_2. Even though these environmental benefits were not found to be as great as the aesthetic/other benefits, they are noteworthy. Trees work to intercept rainfall and reduce runoff—in Middletown, as little as 890 trees absorb over 6.6 million gallons of rainfall. While air quality is impaired by the number of high-BVOCs emitting trees, this effect can be offset by smart tree-planting efforts.

i-Tree Streets analysis found that the northern red oak is the most influential tree in Middletown's inventoried tree population. If this species was lost to oak wilt or other threats, its loss would be felt more than the community may realize.

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-statured trees consistently created the most environmental and economic benefits. The following list of tree species is used for improving air quality (ICLEI 2006):

- *Betula nigra* (river birch)
- *Celtis laevigata* (sugar hackberry)
- *Fagus grandifolia* (American beech)
- *Metasequoia glyptostroboides*, (dawn redwood)
- *Tilia cordata* (littleleaf linden)
- *Tilia europea* (European linden)
- *Tilia tomentosa* (silver linden)
- *Ulmus americana* (American elm)
- *Ulmus procera* (English elm)

Section 3: Tree Management Program

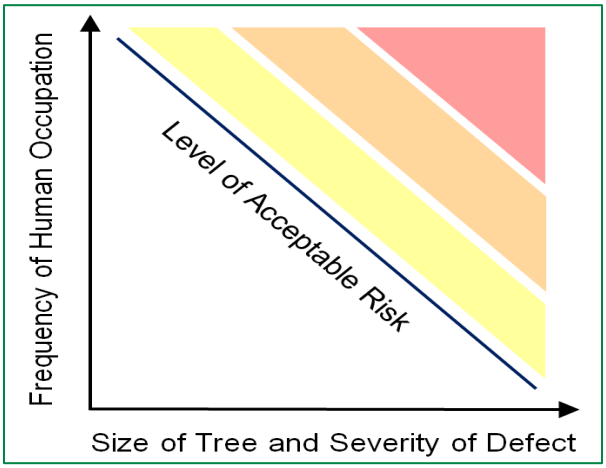
This tree management program was developed to uphold Middletown's vision for preserving its urban forest. This five-year program is based on the tree inventory data. The program was designed to reduce risk through prioritized tree removal and pruning, and to improve tree health and structure through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

Management recommendations for this section exclude all ash trees (297), which are addressed in the emerald ash borer action plan presented in *Section 4: Emerald Ash Borer Strategy*.

Implementing a tree care program is an ongoing process; however, 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, it is also essential to routinely monitor the tree population to identify other Extreme or High Risk trees so that they may be systematically addressed. Regular pruning cycles and tree planting is important, however priority work (especially for trees rated as Extreme or High Risk) must sometimes take precedence to ensure that risk is expediently managed.

How Risk Was Assessed During the Inventory

Every tree has an inherent risk of tree failure or defective tree part failure. During the inventory, Davey Resource Group performed a risk assessment for each tree and assigned a risk rating following protocol based on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, (International Society of Arboriculture 2011). The probability of failure, size of defective part, probability of target impact, and other risk factors were evaluated for each inventoried tree. Independent point values were assigned and summed to generate the risk rating.



- *Failure*: Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.
- *Target Impact*: Rates the use and occupancy of the area that would be struck by the defective part.
- *Consequences*: Rates the possible ramifications if the potential target were impacted by the defective part.
- *Other Risk Factors*: This category is used if professional judgment suggests the need to increase the risk rating. It is especially helpful when growth characteristics become a factor in risk rating. For example, some tree species have growth patterns that make them more vulnerable to certain defects such as weak branch unions and branching shedding.

Once risk rating is calculated, a level of risk is assigned to each tree. The assigned risk rating allows for effective prioritization of tree maintenance work.

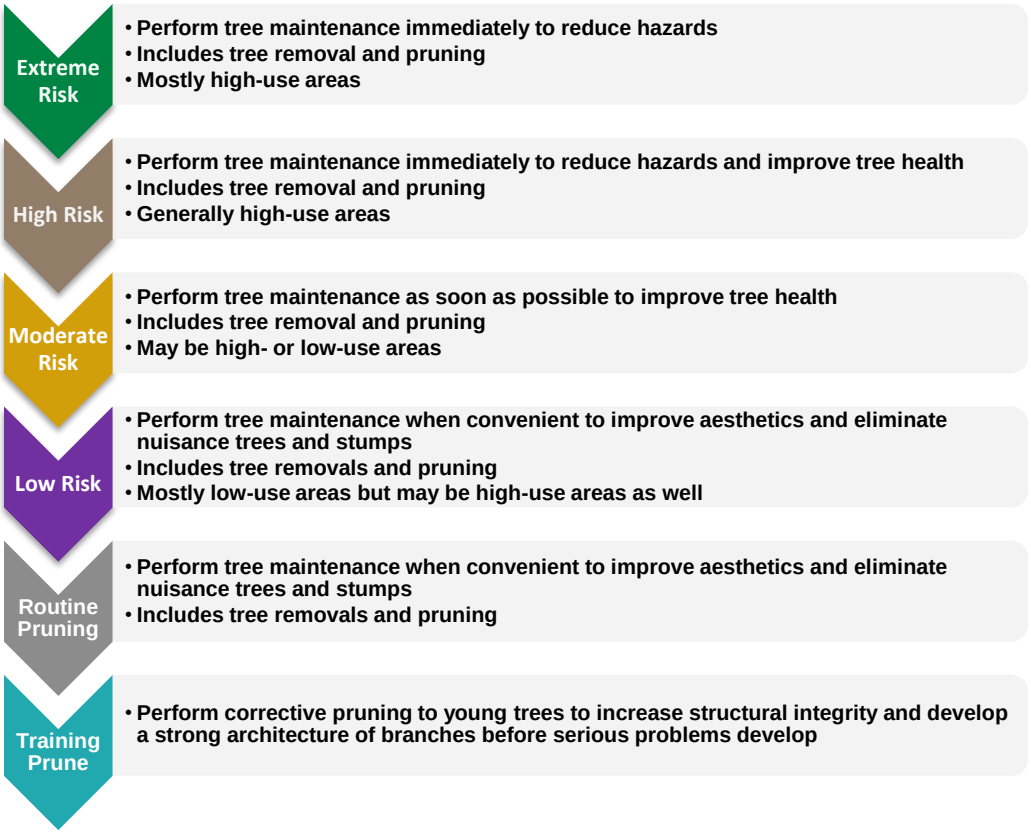
- *Extreme Risk*: Trees described as Extreme Risk have defects that cannot be cost-effectively or practically treated. Most of the trees in this category have multiple or significant defects in the trunk, crown, or critical root zone. Defective trees and/or tree parts are generally larger than 20 inches in diameter and are found in areas of frequent occupation, such as a congested street, a main thoroughfare, and/or near a school.
- *High Risk*: Trees designated as High Risk have defects that may or may not be cost-effectively or practically treated. Most of the trees in this category have multiple or significant defects that affect more than 40% of the trunk, crown, or critical root zone. Defective trees and/or tree parts are generally 4–20 inches in diameter and are found in areas of frequent occupation, such as a congested street, main thoroughfare, and/or near a school.
- *Moderate Risk*: Trees described as Moderate Risk have defects that may be cost-effectively or practically treated. Most of the trees in this category exhibit several moderate defects that affect less than 40% of a tree's trunk, crown, or critical root zone. These trees may be in high-, moderate-, or low-use areas.
- *Low Risk*: Trees designated as Low Risk have minor visible structural defects or wounds and are typically found in areas with moderate- to low-use areas.
- *None*: Used for planting sites and stumps.

Trees with elevated (Extreme or High) risk levels are usually recommended for removal or pruning. 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 minimize risk. In special situations, such as a significant or memorial tree, or a tree in a historic area, Middletown may decide that cabling, bracing, or moving the target may be the best options to reduce risk.

Determination of acceptable risk ultimately lies with the City of Middletown managers. Trees often have associated risks; 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.

Tree 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 Extreme and High Risk. Proactive tree maintenance includes pruning of young trees, along with Moderate or Low Risk trees. Tree planting, inspections, and community outreach are also considered proactive 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:

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

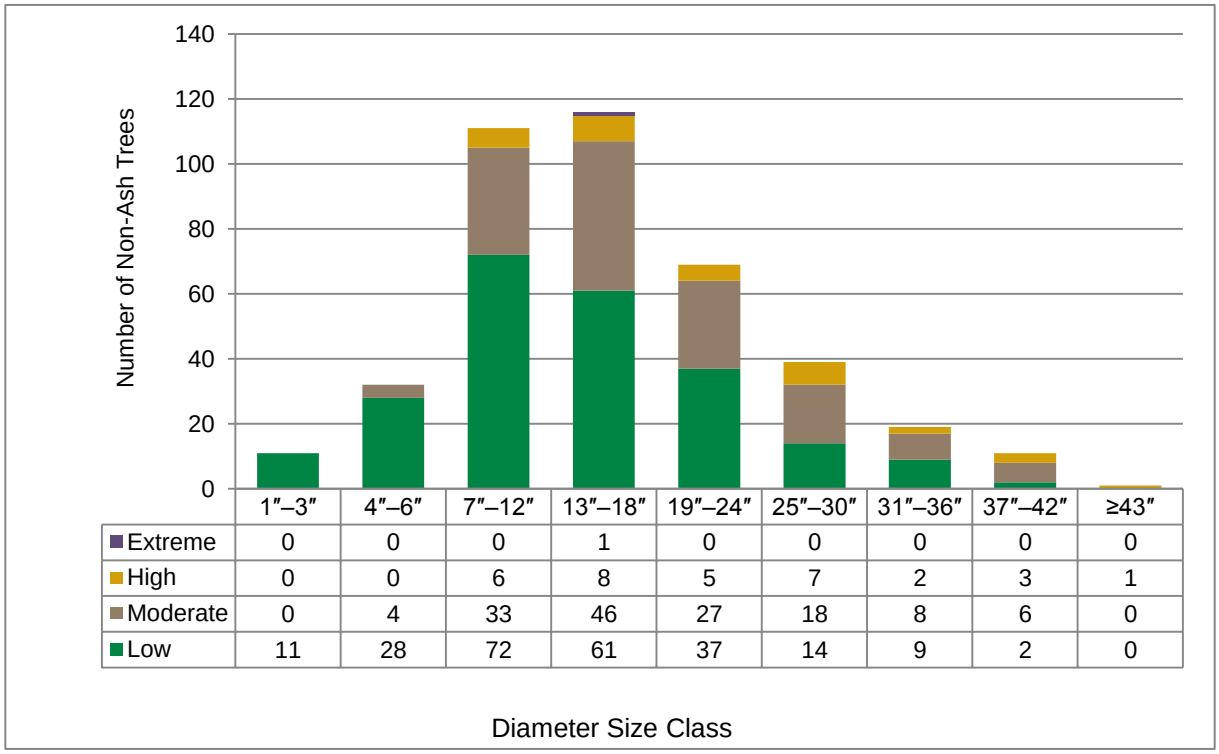
In this plan, all tree removals and Extreme and High Risk pruning are included in the priority maintenance program.

Removal

Although tree removal is usually considered a last resort and may sometimes create a reaction from the community, certain circumstances can only be resolved by removal. Trees fail from natural causes, such as diseases, insects, and weather conditions, and from physical injury due to vandalism, vehicles, 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 summary 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	1	0	0	0	0	0
High	0	0	6	8	5	7	2	3	1
Moderate	0	4	33	46	27	18	8	6	0
Low	11	28	72	61	37	14	9	2	0

Figure 9. Tree removals identified during the inventory by risk rating and diameter size class.

The following sections briefly summarize the recommended removals.

Extreme and High Risk

Extreme and High Risk removals have observable and sizeable defects with elevated probabilities of failure. The location of these trees in relation to their surroundings also increases their risk. The inventory identified 33 Extreme and High Risk trees recommended for removal. The diameter for these trees ranged between 7 inches DBH and 51 inches DBH. These trees should be immediately removed based on their assigned risk. Extreme removals can be performed concurrently with High Risk removals.

Moderate Risk

Tree removals in this category still pose some risk, but have a smaller size of defect and/or less potential for target impact. The inventory identified 142 Moderate Risk trees recommended for removal. Most Moderate Risk trees were smaller than 30 inches DBH. These trees should be removed as soon as possible, after all Extreme and High Risk removals and pruning have been completed.

Low Risk

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 diseases and insects and will enhance the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species are also included in this category.

The inventory identified 234 Low Risk trees recommended for removal. Most of these trees were smaller than 24 inches DBH. Most of these trees were dead, nearly dead, or in locations which made damage upon their failure unlikely. All Low Risk trees should be removed when convenient and after all Extreme, High, and Moderate Risk removals and pruning have been completed.

Ash Removals

The inventory identified 263 ash trees recommended for removal.

Stump Removal

The inventory identified 118 stumps recommended for removal. These stumps ranged in diameter from 6 inches to 80 inches.

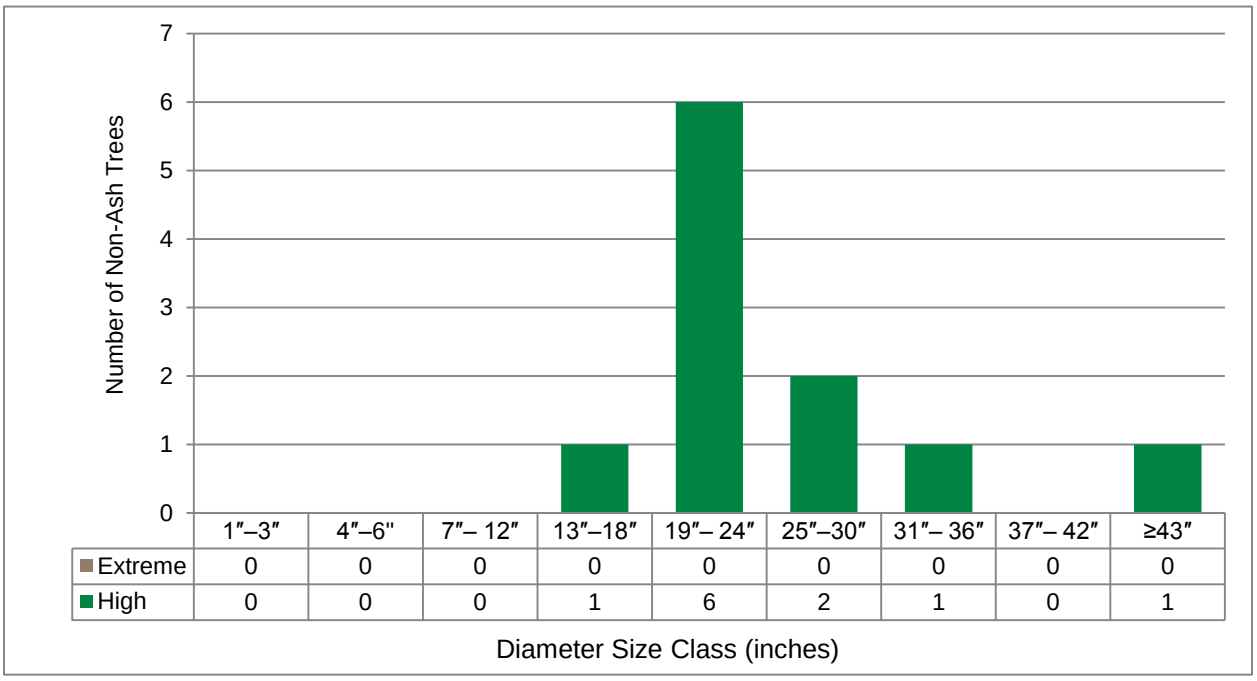
Discussion/Recommendations

Trees noted as having poor structure (28 trees) or having a Grate or Guard around them (37 trees) should be inspected on a regular basis. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety.

Extreme and High Risk Pruning

Extreme and High Risk pruning generally requires cleaning the canopy of both small and large trees to remove hazardous 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. This section accounts for only non-ash trees. Section 4 provides information on ash trees.

Figure 10 presents the number of trees recommended for pruning by size class. The sections that follow briefly summarize the recommendations.



	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	1	6	2	1	0	1

Figure 10. High Risk pruning by diameter size class.

High Risk trees recommended for pruning have observable and sizeable defects with elevated probabilities of failure. The location of these trees in relation to their surroundings also increases their risk. The inventory identified only 11 High Risk trees recommended for pruning. The diameter size classes for these trees ranged between 14 inches DBH and 43+ inches DBH. This pruning should be performed immediately according to assigned risk and may be done at the same time as other Extreme and High Risk removals and pruning.

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 managed population is regularly visited, assessed, and maintained. Davey Resource Group recommends proactive tree maintenance that includes pruning cycles, inspections, and planned tree planting.

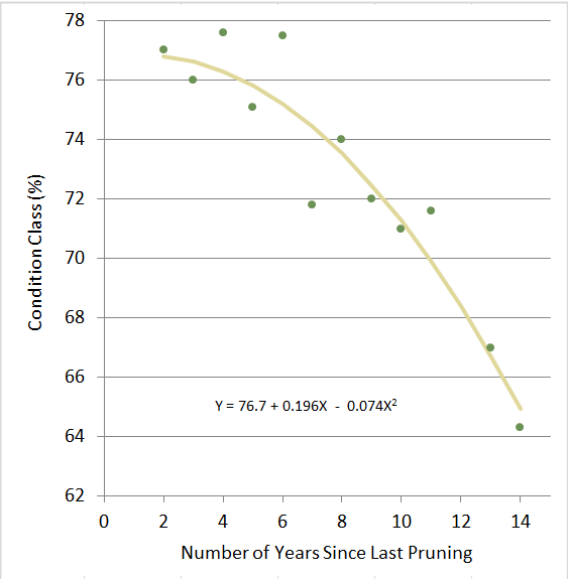


Figure 11. Relationship between average tree condition class and number of years since last pruning (adapted from Miller and Sylvester 1981).

Routine Pruning

The goals of pruning cycles are to visit, assess, and prune trees on a regular schedule to improve health and reduce risk. Typically, Davey Resource Group recommends that pruning cycles begin after all Severe and High Risk trees are corrected through priority removal or pruning. However, because of the long-term benefits of pruning cycles, Davey Resource Group recommends that they cycles be implemented in Year One, after all priority work is completed. To ensure that all trees receive the type of pruning they need to mature with better structure and fewer hazards, 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 generally means that most defects will be found and eliminated 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, 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.

YTT 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, which increases risk and creates 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. Of course, this is species-specific, since many trees such as *Betula nigra* (river birch) may naturally have more than one leader. For these and similar trees, YTT pruning is used to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

Discussion/Recommendations

Davey Resource Group recommends that Middletown implement a three-year YTT Cycle to begin after all Severe and High Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 153 trees smaller than 7 inches DBH were recommended for young tree training. Since the number of existing young trees present is relatively small, and the benefit of beginning the YTT Cycle is substantial, Davey Resource Group recommends that approximately 52 trees be structurally pruned each year, beginning in Year One. 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.

Photograph 6. This young maple in Fancher-Davidge Park will greatly benefit from a young tree training prune.

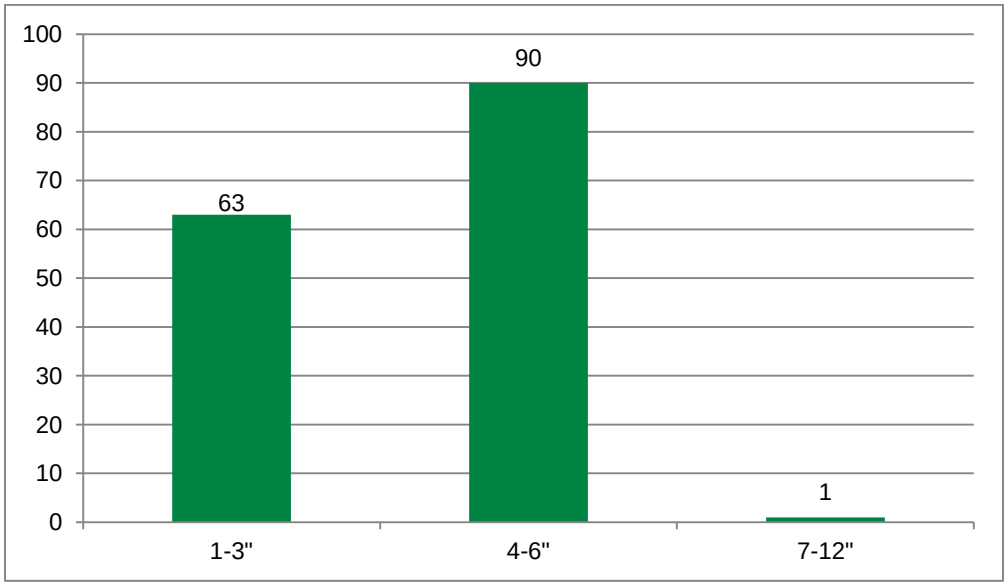
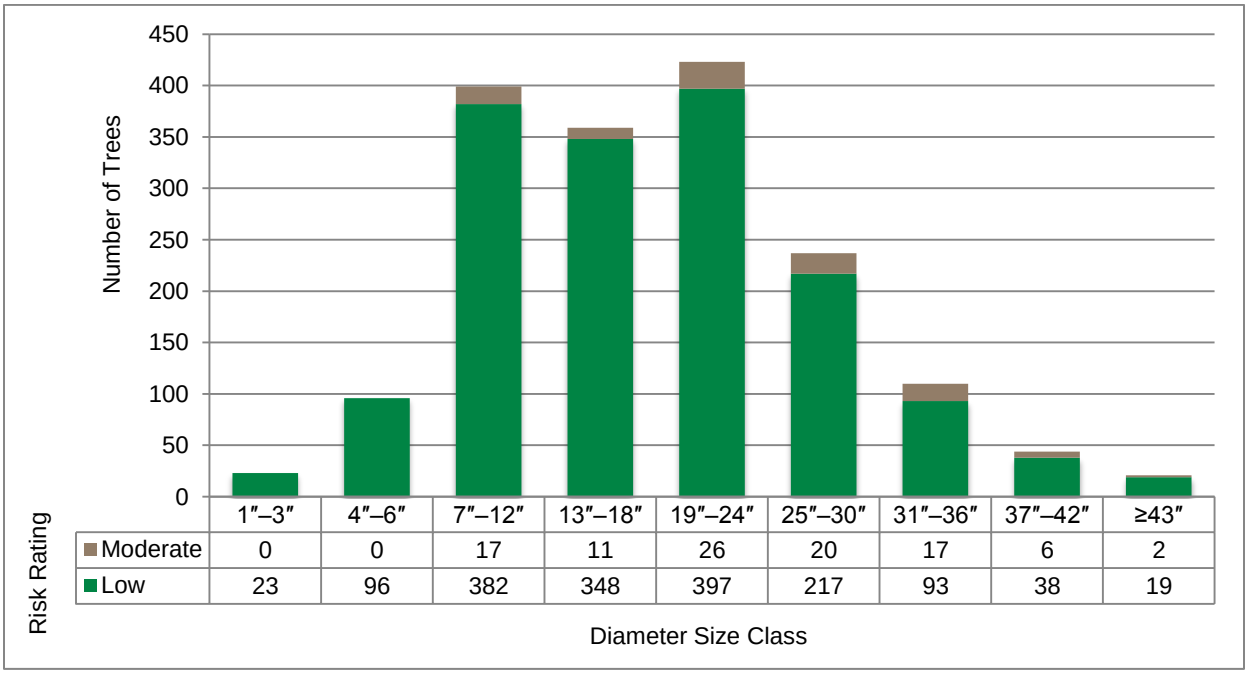


Figure 12. Trees recommended for the YTT Cycle by diameter size class.

RP 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 generally improves health and reduces risk as most problems can be corrected before they escalate into more costly priority tree work. Included in this cycle are Moderate and Low Risk trees that require pruning and that pose some risk but have a smaller size of defect and/or less potential for target impact. The hazards 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. The recommended RP Cycle for a tree population is generally 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	0	0	17	11	26	20	17	6	2
Low	23	96	382	348	397	217	93	38	19

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

Discussion/Recommendations

Davey Resource Group recommends that the city establish a five-year RP Cycle in which approximately one-fifth of the tree population would be pruned each year. The 2015 tree inventory identified approximately 328 trees that should be pruned each year. Davey Resource Group recommends that the RP Cycle begin in Year One of this five-year plan, after all Severe and High Risk trees are removed or pruned.

The inventory found that most trees (65%) in the population needed routine tree cleaning. 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.

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 well-equipped to provide proper care.

Trees in parks should and 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. In addition to locating potential hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Middletown has a large population of trees that are susceptible to pests and diseases, including oaks, a target of oak wilt. A brief discussion of key pests is found in Appendix C.

Tree Planting

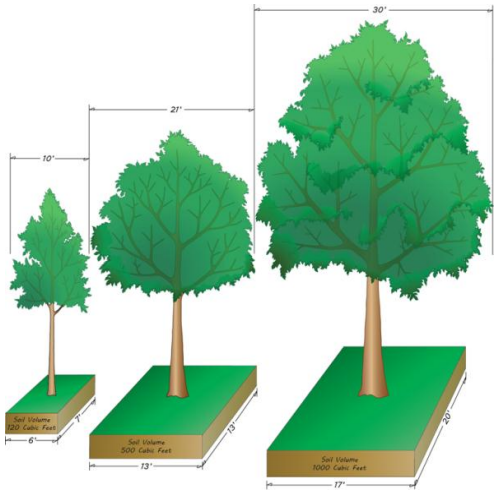
Planting trees is a worthwhile goal as long as trees species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to 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 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 based on tree size/dimensions. Illustration based on the work of Casey Trees 2008.

Findings

The inventory found 132 planting spaces, 41% of which were designated for small-sized mature trees, and 59% designated for large-sized trees (Figure 14). Plant small-sized trees where the growing space is either too small for a medium- or large-sized species or where overhead utilities are present.

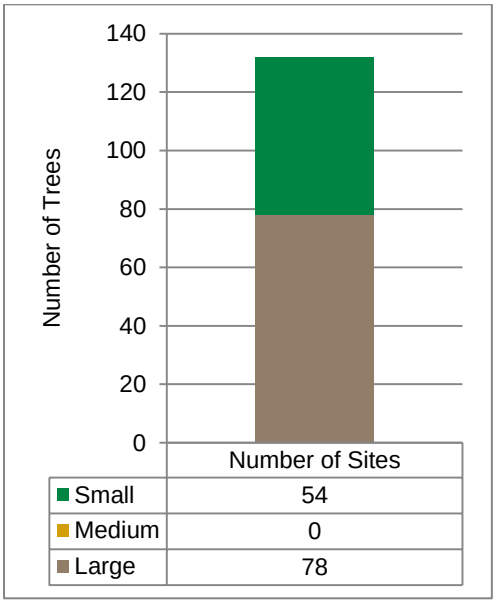


Figure 14. Vacant planting sites identified by mature tree size.

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 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.

Middletown is located in USDA Hardiness Zone 6b, which is identified as a climatic region with average annual minimum temperatures between −5°F and 0°F. Tree species selected for planting in Middletown 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 (drainage, nutrients, road salt, root spacing, soil pH, soil texture, and soil structure). 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. Such plants 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 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 offensive smelling/large fruit; male ginkgo trees, however, produce no 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. Deciduous trees that display bright colors in autumn can add a great deal of appeal to surrounding landscapes.

Appendix B lists tree species recommended for planting based on inventory findings; this list provides expected height at maturity for each species and is designed to promote species diversity.

Davey Resource Group recommends limiting the planting of oaks until the species distribution normalizes. Northern red oak already occupies 17% of the tree population, which far exceeds the recommended maximum for a species (10% of the population).

Tips for Planting Trees

To ensure a successful tree planting effort:

- 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 to 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 around the tree moist. Do not allow mulch to touch the trunk.

Newly Planted and Young Tree Maintenance

Equally important to planting trees is caring for them after they are planted. After a tree is planted, maintenance is essential 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 frequently 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 one to two inches, and the growing area should be covered. Mulch should not touch the tree trunk, nor should it be piled up around the tree.

Life-Long Tree Care

Once 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 ultimately decay; removing diseased or insect-infested limbs; creating better structure to lessen wind resistance and reduce 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, helps keep trees in good health and helps trees defend themselves 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 each site, and 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 in 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.

Community Outreach

The data that have been 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 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 the development of 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 utilized to advise citizens about threats to park trees, such as ALB, EAB, or oak wilt.

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 staples of the community. 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.

Middletown's data is a good barometer for identifying ways to provide tangible and meaningful outreach about the urban forest.

Inventory and Plan Updates

Davey Resource Group recommends that the inventory and management plan be updated 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/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) 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 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 parks, and update all data fields after five to seven years.
- Revise the *Tree Management Plan* after five or seven years when a re-inventory has been completed.

Maintenance Schedule

Utilizing data from the 2015 City of Middletown 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 the City of Middletown. A summary of the maintenance schedule is presented on this page. A complete table of estimated costs for Middletown's five-year tree management program is presented in Appendix D.

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

To implement the maintenance schedule, the city's tree maintenance budget should be no less than $258,000 for the first year of implementation, $184,000 for the second year, $95,000 for years three and five, and $91,000 for year four. Annual budget funds are needed to ensure that hazard trees are remediated and that critical YTT and RP 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 accomplishment 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.

FY 2016 — $257,495

- 33 High or Extreme Risk Removals
- 11 High Risk Prunes
- 142 Moderate Risk Removals
- 263 Ash Removals
- 34 Ash Treatments
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 52 Trees
- 175 Trees Recommended for Replacement Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2017 — $183,585

- 234 Low Risk Removals
- 118 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 52 Trees
- 175 Trees Recommended for Replacement Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2018 — $95,210

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 52 Trees
- 34 Ash Treatments
- 175 Trees Recommended for Replacement Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2019 — $90,825

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 52 Trees
- 175 Trees Recommended for Replacement Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY2020 — $94,490

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 52 Trees
- 34 Ash Treatments
- 175 Trees Recommended for Replacment Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

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 (*Ceratocystis fagacearum*), to seven years with emerald ash borer (EAB) (*Agrilus planipennis*) or more.

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

This chapter provides 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 E contains additional EAB reference materials.

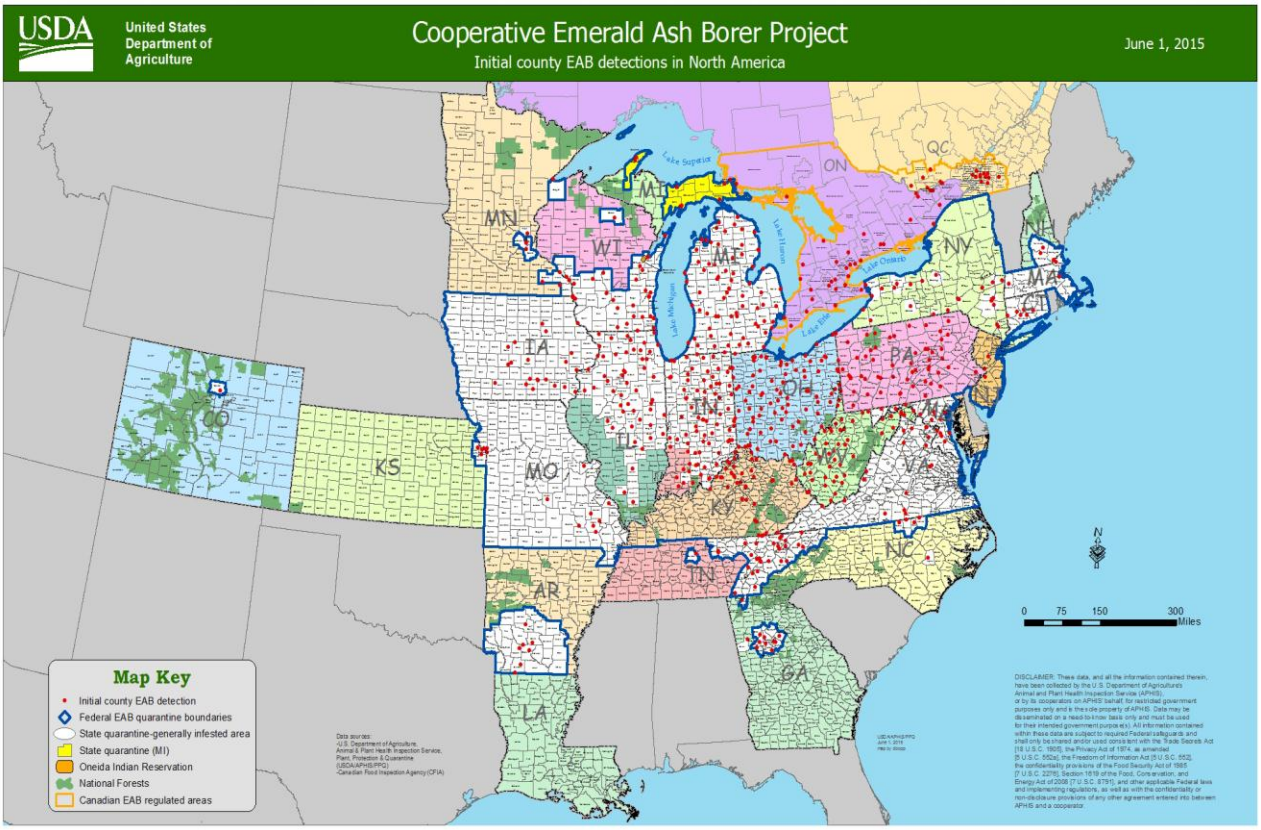


Figure 15. EAB detections throughout North America as of June 1, 2015. Map by United States Department of Agriculture, Animal and Plant Health Inspection Service.

Emerald Ash Borer

Emerald ash borer is a small insect native to Asia. In North America, the borer is an invasive species that is 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. By 1940, chestnut blight virtually wiped out most of the mature American chestnut population. Chestnut blight is believed to have been imported by chestnut lumber or through imported chestnut trees. Dutch elm disease (DED) is a fungus spread sexually by the elm bark beetle. DED 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. The presence of EAB has been confirmed in 14 states. It has killed at least 50–100 million ash trees and threatens another 7.5 billion ash trees throughout North America. New York's EAB infestation was discovered June 2009 just off Exit 16 of Route 17/I-86 in Cattaraugus County, New York. EAB was found in Orange County in 2011. See Map 2 for New York counties with known EAB infestations. EAB is a serious pest that threatens the health of all ash tree species in the state. With an estimated 11% ash trees at risk in New York's woods—and another 16% to 28% in cities and towns—the state is committed to early detection and thoughtful management of this pest. In the United States, EAB has been known to attack all native ash trees.

EAB has been identified in New York—specifically near Middletown, at West Point—and poses a serious threat to the health and condition of Middletown's urban forest.

Photograph 7. EAB adults grow to 5/8 inch in length (photograph credit www.wisconsin.gov).

Photograph 8. EAB larvae (photograph credit 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 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 9. Larvae consume the cambium and phloem, effectively girdling the tree and eventually causing death within a few years.

Photograph 10. This ash tree is declining from EAB infestation. The loss of water and nutrients from intense larvae tunneling can cause the trees to lose between 30% and 50% of their canopies during the first year of infestation. (Photograph courtesy 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 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.

New York/Federal Response

The New York Department of Agriculture (NASDA) is the leading agency responsible for control of invasive pests in New York. The federal agency USDA-APHIS assists with regulatory and control action of invasive pests. The NASDA has declared EAB a public nuisance in New York and has enacted a quarantine restricting the movement of ash trees and non-coniferous firewood.

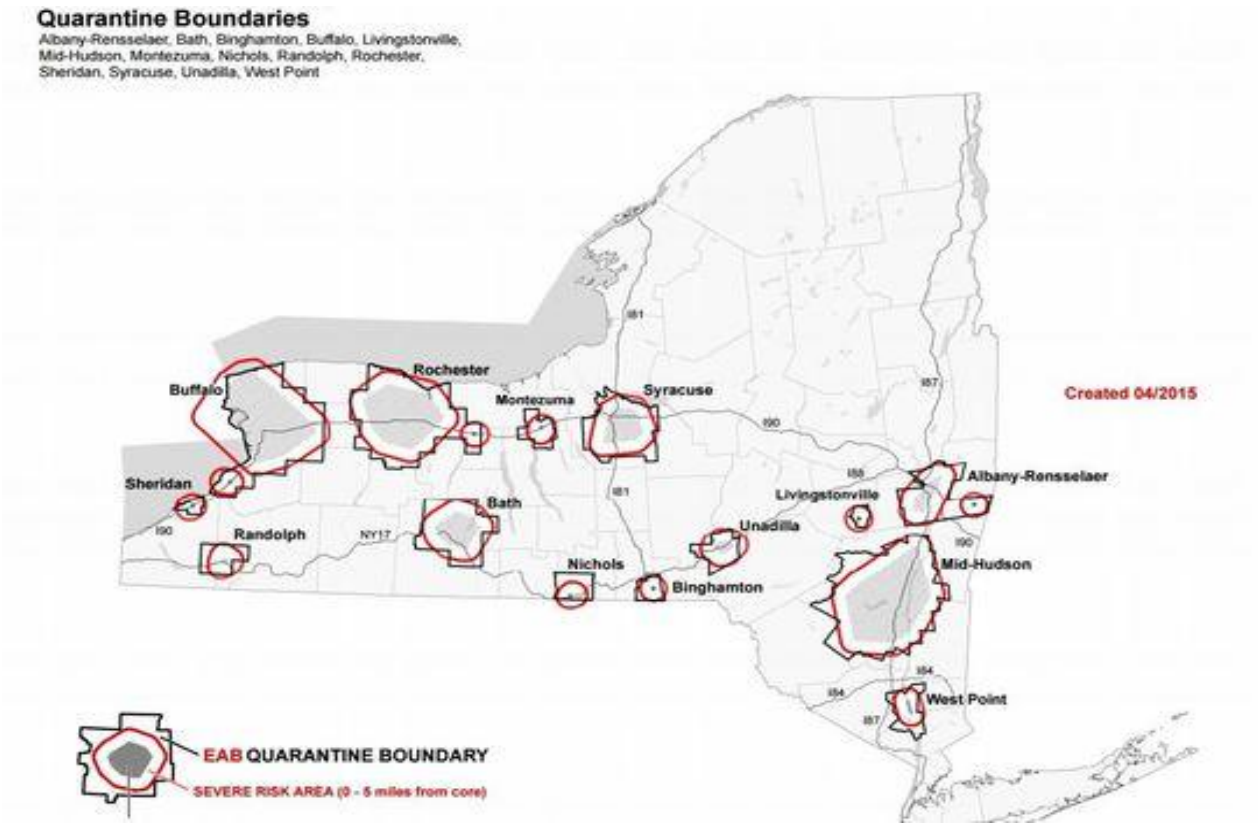


Figure 16. New York is under a federal quarantine to limit the spread of EAB.

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 has led to the discovery of several parasitoid wasps, namely *Tetrastichus planipennisi*, a gregarious larval endoparasitoid; *Oobius agrili*, a solitary, parthenogenic egg parasitoid; and *Spathius agrili*, a gregarious larval ectoparasitoid. These parasitoid wasps have been released into the Midwestern United States as a possible biological control of EAB. States that have released parasitoid wasps include Indiana, Michigan, and Minnesota.

Ash Population

With the threat of EAB nearing Middletown, it is crucial that the city has an action plan. Some of the most important questions to answer will be:

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

In order to answer these questions, Middletown 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 297 ash trees distributed throughout the city. Most of the ash trees were rated in Poor condition. Table 4 shows the diameter class of each ash tree by its condition class. Of the 297 ash trees inventoried, 53 currently show obvious signs of EAB.

Table 4. Tree Condition Versus Diameter Class Matrix

		Diameter Class (inches)									
		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
Condition Class	Excellent	0	0	0	0	0	0	0	0	0	0
	Very Good	0	0	0	0	0	0	0	0	0	0
	Good	2	4	0	0	1	0	0	0	0	7
	Fair	4	7	15	23	6	2	0	1	1	59
	Poor	0	16	40	22	10	2	0	0	0	90
	Critical	1	8	41	11	5	1	0	0	0	67
	Dead	1	17	29	19	6	2	0	0	0	74
	Total										297

Ash Tree Risk Reduction Pruning and Removals

As EAB infestation approaches Middletown, one of the city's top priorities is to prepare by budgeting funds and personnel to concentrate more closely on the ash tree population. Davey Resource Group recommends that Middletown perform both treatment and safety related activities on ash trees. These activities will end up saving the city money and increasing productivity. However, these activities are only recommended due to EAB and the eventual removal of infested ash trees.

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

In the event that Middletown decides to proactively remove ash trees, Davey Resource Group recommends that the city remove all ash trees less than 7 inches and trees that are rated as Dead, Poor, or Critical condition first. These trees provide little benefit to the community and the cost for removals should be less significant.

EAB Management

The following graphs demonstrate how management options decrease with prolonged infestation. Middletown should explore different options for managing EAB. Considering the current mortality rate, Middletown can be placed at Year Eight on both graphs after first EAB infestation. At this position, the city has little time to prepare as well as select a management option.

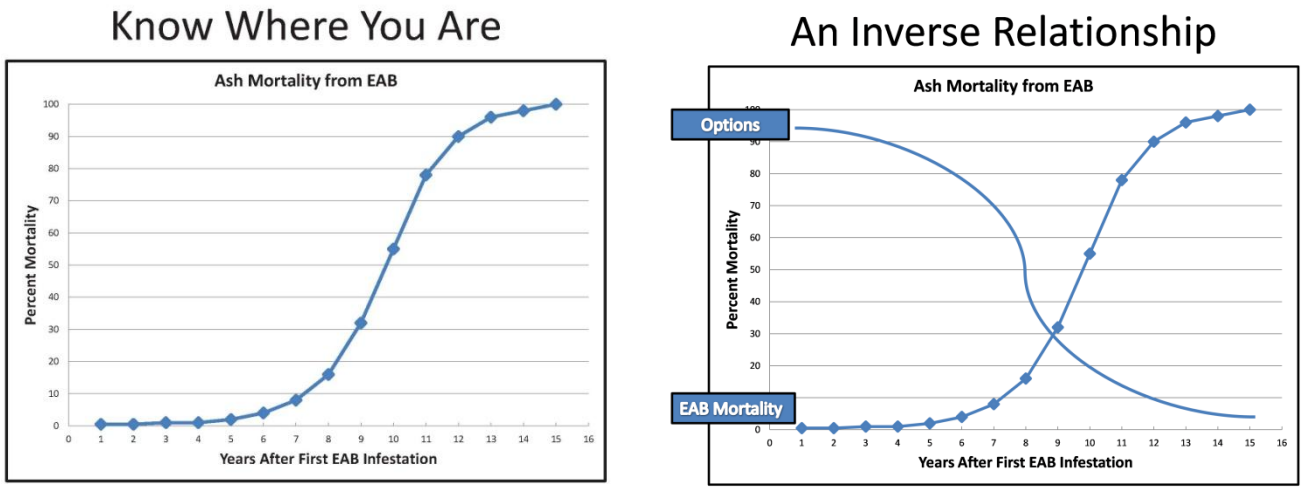


Figure 17: When infestation occurs, as depicted in the graph, the city's options for management decrease. Source: Emerald Ash Borer University 2012

EAB Management Options

With no specific strategy or budget in place for the impending infestation of EAB, Middletown should explore strategies for managing EAB that provide the most economic benefit and increase public safety. These EAB management strategies include doing nothing, removing and replacing all ash, treating all ash, or a combination of the strategies. These strategies and their associated costs are described below.

EAB Strategy 1: Do Nothing

This means letting EAB run its course and having no plan 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 11. 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 297 ash trees by 2016. 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 2016, 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 Middletown. Removal and replacement ultimately benefits Middletown by increasing public safety but will require significant upfront costs.

The total approximate cost for this strategy would be $159,250. The approximate cost to remove all ash trees is $83,720; the approximate cost to replace all ash trees is $65,340; and the approximate cost to remove all stumps is $10,190, as shown in Table 5.

Table 5. Cost to Remove and Replace all Ash

Management Strategy	Management Action	# of Trees	Cost
Remove and Replace All Ash Trees	Removal All	297	$83,720
	Replace All	297	$65,340
	Stump Removal	297	$10,190
	Total		$159,250

EAB Strategy 3: Treat all Ash

Treating all of Middletown's ash trees 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 the 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 are less desirable to retain.

After two years, injection treatment loses its effectiveness against combatting EAB. It is recommended that no ash tree go without treatment after two years of initial application. If Middletown wanted to biennially treat all of its 87 ash trees that are not recommended for removal, it would cost approximately $6,564 every two years. This means that it would cost the city approximately $3,282 annually to treat all of Middletown's 87 ash trees for the remainder of their lives. The cost to remove the 210 ash trees recommended for removal is approximately $56,670 and approximately $6,915 to remove all stumps. A two-year treatment period and removal of the recommended trees would cost the city an estimated $70,149 as shown in Table 6.

Table 6. Cost to Treat All Ash

Management Strategy	Management Action	# of Trees	Cost
Treat All Ash Trees	Treat all Ash Trees for Two Years	87	$6,564
	Ash Trees Recommended for Removal	210	$56,670
	Stump Removal	210	$6,915
	Total		$70,149

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 7 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 following sections explain why certain ash trees should be considered for removal or treatment.

Table 7. EAB Matrix Table

		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
Condition Class	Excellent	0	0	0	0	0	0	0	0	0	0
	Very Good	0	0	0	0	0	0	0	0	0	0
	Good	2	4	0	0	1	0	0	0	0	7
	Fair	4	7	15	23	6	2	0	1	1	59
	Poor	0	16	40	22	10	2	0	0	0	90
	Critical	1	8	41	11	5	1	0	0	0	67
	Dead	1	17	29	19	6	2	0	0	0	74
	Total	8	52	125	75	28	7	0	1	1	297

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

Remove _263_ Trees

- Trees in the "Poor," "Critical," and "Dead" condition classes are recommended for removal. These trees are recommended for removal because they are more susceptible to EAB infestation. If these trees are not removed, they could pose a public safety issue in the future. A total of 231 trees are recommended for removal and replacement.
- The remaining 32 trees are <12 inches DBH and are recommended for removal and replacement. These trees don't provide as many benefits to the community compared to mature ash trees. Even though these trees are in Good or Fair condition, their removal is ultimately beneficial because it would prevent future loss. The cost to remove these small, young trees is negligible compared to removing large trees. It would be in the best interest of Middletown to remove these trees and replace them with a more diversified mix of trees.

Chemically Treat 33 Trees (Low–Moderate Priority for Treatment)

- The intent here is to defer removal of a large block of trees within the matrix of "Fair" condition class between 13 inches and 43+ inches DBH. These 33 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, treating these trees can stabilize annual budgets and removals each year. Treatment can be economically beneficial and reduce the chance for a public safety issue in the near future.

Chemically Treat 1 Tree (High Priority for Treatment)

- Candidates for chemical treatment will exhibit "Good" condition or better, have no more than 30% dieback, and are located in an appropriate site (i.e., not under overhead

utilities). Treating this ash tree will help keep it around for a long time; the city will profit from the monetary benefits these ash trees provide.

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 it could be equal to or greater than the ash trees located on public property. During the inventory, it was evident to the 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 due to greater inaccessibility to these areas. It is crucial that the city promotes 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 explains more on how to minimize anxiety from private homeowners. The section also provides examples on how to go about informing the public about managing their ash trees.

Photograph 12. Hangers will help make private homeowners aware of the management options available for EAB.

Dying and infested ash trees on private property 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, Middletown should consider utilizing the city's tree ordinance.

Public Education

It is crucial for Middletown 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 expediting the reforestation process that will occur after removals for infected ash trees are complete. Middletown should inform the public when EAB has been discovered in the city. A well-informed public is more likely to accept what is happening without panicking and cooperate with the city's requests. Middletown could approach informing the public in the following ways:

Photograph 13. Posting information about EAB on ash trees around the city could encourage private homeowners to become more proactive in managing their ash trees.

- News releases
- City newsletter articles
- Post information about EAB on the city's website
- Display information packets at public buildings
- Postcard mailings to ash tree owners
- Door hangers explaining maintenance options
- Presentations to community groups
- 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 Middletown, the city will need to develop a plan to replant where ash trees have been removed. The city could potentially lose over 4% of its tree population due to EAB. Prompt reforestation is essential due to the numerous benefits provided by ash trees in Middletown's community. Benefits include removing pollutants from the air, helping moderate summer temperatures, reducing stormwater runoff and energy consumption, and providing social and psychological benefits.

If the city is able to replace all ash trees, it would cost approximately $65,340. This would be a huge financial burden on the city, but replacement is important and has long-term benefits. The cost of replanting ash trees could be spread out over multiple years by establishing a goal for planting a certain amount of trees each year. For example, if Middletown were to plant 100 trees each year, the city could replace all of the ash trees within three years. Costs could be reduced if the city works with private property owners and volunteers. 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 recommended species. Middletown should also explore grants for reforestation. Organizing volunteer groups to participate in planting trees could help decrease the costs 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% of the total public tree population, and that no one genus comprises more than 20% of the population. Since EAB has hit local communities, local nurseries may be susceptible to a shortage of trees. Middletown might want to consider tapping into nurseries in other regions for trees, or developing a relationship with local nurseries and encouraging price breaks for property owners who are replacing ash trees with approved species.

Conclusions

Every hour of every day, public trees in Middletown are supporting and improving the quality of life. The city's trees provide an annual benefit of $328,999. When properly maintained, trees provide numerous environmental, economic, and social benefits far in excess of 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 of Middletown should implement its selected EAB strategy 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, the town is well-positioned to thrive. If the management program is successfully implemented, the health and safety of Middletown's trees and citizens will be maintained for years to come.

Glossary

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: A report generated by i-Tree Streets that presents the tangible and intangible benefits of trees reflected in increases in property values in dollars ($).

air quality report: A report generated by i-Tree Streets that quantifies the air pollutants (ozone [O3], nitrogen dioxide [NO2], sulfur dioxide [SO2], coarse particulate matter less than 10 micrometers in diameter [PM10]) deposited on tree surfaces and reduced emissions from power plants (NO2, PM10, Volatile Oxygen Compounds [VOCs], SO2) 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.

block side (data field): Address information for a site that includes the *on street*, *from street*, and *to street*. The *on street* is the street that the site is actually located on. The *from street* is the cross street one is moving away from when moving in the direction of traffic flow. The *to street* is the cross street one is moving toward when moving in the direction of traffic flow.

benefit-cost ratio (BCR): 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 creates 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.

canopy assessment: See **urban tree canopy (UTC) assessment**.

canopy spread (data field): Estimates the width of a tree's canopy in 5-foot increments.

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

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

carbon dioxide report: A report generated by i-Tree Streets that 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.

clean (primary maintenance need): Based on *ANSI A300 (Part 1)*, selective removal of dead, dying, broken, and/or diseased wood to minimize potential risk.

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: A report generated by i-Tree Streets that 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: 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.

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 give you 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: Tree that cannot be cost-effectively or practically treated. Most High Risk trees have multiple or significant defects affecting more than 40% of the trunk, crown, or critical root zone. Defective trees and/or tree parts are most likely between 4–20 inches in diameter and can be found in areas of frequent occupation, such as a main thoroughfare, a congested streets, and/or near schools.

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.

IPED (data field): Invasive pest detection protocol. A standardized method for evaluating a tree for possible insect or disease.

inventory: See **tree inventory**.

i-Tree Streets: 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, site number, side, and block side.

Low Risk tree: Tree with minor visible structural defects or wounds in areas with moderate to low public access.

management costs: Used in i-Tree Streets; 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: Tree with defects that may be cost-effectively or practically treated. Most of the trees in this category exhibit several moderate defects affecting less than 40% of a tree's trunk, crown, or critical root zone. These trees may be in high-, moderate-, or low-use areas.

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 calculated according to category and summed. Net benefits are calculated as benefits minus costs.

nitrogen dioxide (NO_2): 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.

none (secondary maintenance need): Used to show that no secondary maintenance is recommended for the tree. Usually a vacant planting site or stump will have a secondary maintenance need of *none*.

notes (data field): Describes additional pertinent information.

observations (data field): When conditions with a specific tree warrant recognition, it was described in this data field. Observations include cavity decay, grate guard, improperly installed, improperly mulched, improperly pruned, mechanical damage, memorial tree, nutrient deficiency, pest problem, poor location, poor root system, poor structure, remove hardware, serious decline, and signs of stress.

ordinance: See **tree ordinance**.

ozone (O_3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms; a product of the photochemical process involving the Sun's energy; a major component of smog, 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.

particulate matter (PM10): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

plant tree (primary maintenance need): If collected during an inventory, this data field identifies vacant planting sites as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growspace available and the presence of overhead wires.

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 Level 2 qualitative risk assessment based on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, published by the International Society of Arboriculture (2011). Trees can have multiple failure modes with various risk ratings. One risk rating will be assigned per tree. 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. The data from the risk assessment is used to calculate the risk rating that is ultimately assigned to the tree.

risk rating (data fields): Calculated from the field risk assessment data (see **risk assessment**), 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 this Plan, the risk rating was used to identify the severity of risk assigned to a tree and to prioritize tree maintenance needs. The following categories were used:

- Extreme Risk tree
- High Risk tree
- Moderate Risk tree
- Low Risk tree
- None (used only for planting sites and stumps)

secondary maintenance need (data field): Recommended maintenance for a tree, which may be risk oriented, such as raising the crown for clearance, but generally was geared toward improving the structure of the tree and enhancing aesthetics.

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 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.

site number (data field): All sites at an address are assigned a *site number*. Sites numbers are not unique; they are sequential to the side of the address only (the only unique number is the tree identification number assigned to each site). Site numbers are collected in the direction of vehicular traffic flow. The only exception is a one-way street. Site numbers along a one-way street are collected as if the street were actually a two-way street, so some site numbers will oppose traffic.

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 one foot above ground level.

stored carbon report: A report generated by i-Tree Streets that 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 (SO2): 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 dollars per tree or total dollars.

topping: Topping, reducing tree size using internodal cuts without regard to tree health or structural integrity, is not an acceptable pruning practice.

tree: 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 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 one-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 (YTT, primary maintenance need): Data field based on *ANSI A300 (Part 1)*, pruning of young trees to correct or eliminate weak, interfering, or objectionable branches to improve structure. These trees, up to 20 feet in height, can be worked with a pole pruner by a person standing on the ground.

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Appendix A
Site Location Methods

Equipment and Base Maps

Inventory arborists use CF-19 Panasonic Toughbook® unit(s) and Trimble® GPS Pathfinder® ProXH™ receiver(s).

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

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
New York GIS Data Clearinghouse One Foot Imagery	2013	N AD 1983 State Plane New York East Feet
Orange County, NY GIS Services	2014	

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW sites; however, the *on street* would refer to the park and/or public space's name (not street names).

Street ROW Site Location

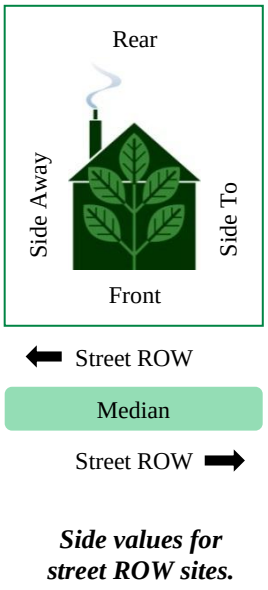
Individual street ROW sites (trees, stumps, or vacant planting sites) were located using a methodology developed by Davey Resource Group that identifies sites by *address number*, *street name*, *side,* and *block side*. This methodology allows for consistent assignment of location.

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 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 assigned an address number so that it matched opposite or adjacent addresses as closely as possible. An "X" was 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 values for street ROW sites.

Side Value and Site Number

Each site was assigned a *side value*. 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 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 of 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 physically 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 (for example, a site located on a side street).

Site Location Examples

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
Site Number:	1
On Street:	Davis Street
From Street:	Taft Street
To Street:	E. Mac Arthur Street.

The tree site circled in red represents the site that the crew is trying to locate. 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. Moving with the flow of traffic, the *from street* is Taft Street, and the *to street* is East Mac Arthur Street.

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

Corner Lot A

Address/Street Name:	205 Hoover St.
Side/Site Number:	Side To / 1
On Street:	Taft St.
From Street:	E Mac Arthur St.
To Street:	Hoover St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Side To / 2
On Street:	Taft St.
From Street:	E Mac Arthur St.
To Street:	Hoover St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Side To / 3
On Street:	Taft St.
From Street:	19th St.
To Street:	Hoover St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Front / 1
On Street:	Hoover St.
From Street:	Taft St.
To Street:	Davis St.

Corner Lot B

Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Side To / 1
On Street:	Davis St.
From Street:	Hoover St.
To Street:	E Mac Arthur St.
Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Front / 1
On Street:	E Mac Arthur St.
From Street:	Davis St.
To Street:	Taft St.
Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Front / 2
On Street:	E Mac Arthur St.
From Street:	Davis St.
To Street:	Taft 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 (USDA Hardiness Map Zone 6b) conditions found in Middletown and throughout all of the Hudson Valley in New York.

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 nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugarberry	
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 dioicus	Kentucky coffeetree	Prairie Titan®
*Juglans regia**	English walnut	'Hansen'
*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 × acerifolia	London planetree	'Yarwood'
*Platanus occidentalis**	American sycamore	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus ellipsoidalis	northern pin oak	

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

Scientific Name	Common Name	Cultivar
Quercus frainetto	Hungarian oak	
Quercus imbricaria	shingle oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus muehlenbergii	chinkapin oak	
Quercus phellos	willow oak	
Quercus prinus	chestnut 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	
*Broussonetia papyrifera**	paper mulberry	
Cladrastis kentukea	Kentucky yellowwood	'Rosea'
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	
Sorbus alnifolia	Korean mountainash	'Redbird'
Toona sinensis	Chinese toon	

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	
*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 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	

This recommended species list was compiled through the use of *Dirr's Hardy Trees and Shrubs* (Dirr 2003) and the *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1998). This list is not inclusive and is offered only as a recommendation based on Davey Resource Group's experience, as well as tree availability in the nursery trade.

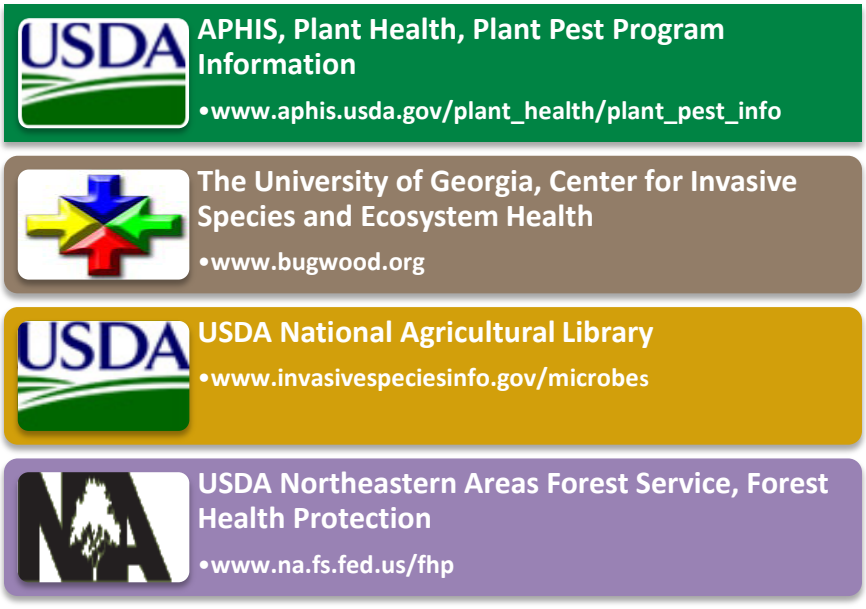
Appendix C
Invasive Pests and Diseases that Affect Trees

In today's worldwide marketplace, the high volume of international trade carries increased potential for pests and diseases to invade the U.S. 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 enter with some help from human activities. Their introduction to our country 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. Below is a list of key pests and diseases that have adversely affected 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.



Asian Longhorned Beetle

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an exotic pest threatening 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.

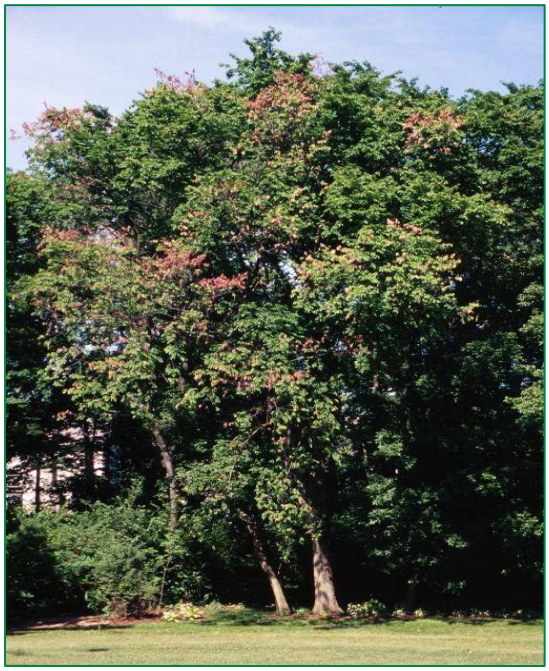
Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods including several maple species. Examples include *Acer negundo* (box elder), *A. platanoides* (Norway maple), *A. saccharinum* (silver maple), *Aesculus glabra* (buckeye), *A. hippocastanum* (horsechestnut), *Betula* (birch), *Platanus* × *acerifolia* (London planetree), red maple, *Salix* (willow), sugar maple, 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, it was present in several East Coast cities. By 1959, DED 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 and blocks 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, *Ophiostoma novo-ulmi*, 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)*.

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



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

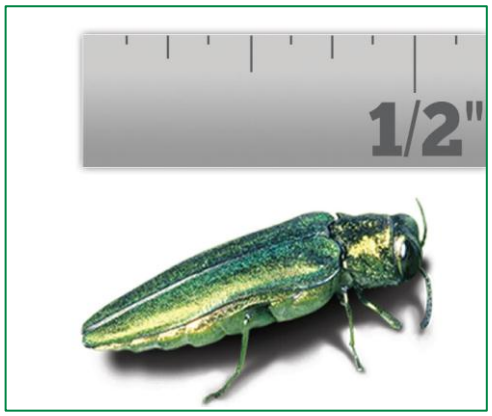
Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011).

Elongate Hemlock Scale

A heavy infestation of elongate hemlock scale. Photograph courtesy of Maine Forest Service.

Elongate hemlock scale—sometimes referred to as Fiorinia scale—is an armored scale found more prevalently in southeastern Pennsylvania. There are translucent, oval eggs beneath the scale covering of the female. The pale yellow crawlers are about 1/250 inch (0.1mm) long and have six short legs. When they settle to feed, the crawlers lose their legs and excrete an amber-colored, oval covering. Male and female scales develop differently and have different protective coverings. Immature males are about 1/20 inch (1.0–1.5mm) long and produce a whitened, waxy covering. Longer threads of wax are occasionally present and may lend the covering a fuzzy appearance. Immature females are longer at 1/14 inch (1.5–2.0mm) and produce a yellowish to orange-brown, parallel-sided covering. At maturity, the delicate, light brown, male scales emerge and fly to the sessile, wingless females. They may be mistaken for parasitoids as they crawl over the female coverings prior to mating.

Emerald Ash Borer



Close-up of the emerald ash borer.

Photograph courtesy of APHIS (2011).

The 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, it 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.

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 tree species preferred as hosts by the EAB are in the genus *Fraxinus* (ash).

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; however, the disease is more frequently 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 readily move from one tree to another.

Sirex Woodwasp

Sirex woodwasp (*Sirex noctillio*) has been the most common species of exotic woodwasp detected at United States ports-of-entry associated with solid wood-packing materials. Recent detections of sirex woodwasp outside of port areas in the United States have raised concerns because this insect has the potential to cause significant mortality of pines. Awareness of the symptoms and signs of a sirex woodwasp infestation increases the chance of early detection and, thus, the rapid response needed to contain and manage this exotic forest pest.

Close-up of female Sirex Woodwasp.

Photograph courtesy of USDA (2005).

Woodwasps (or horntails) are large robust insects, usually 1.0 to 1.5 inches long. Adults have a spear-shaped plate (cornus) at the tail end; in addition females have a long ovipositor under this plate. Larvae are creamy white, legless, and have a distinctive dark spine at the rear of the abdomen. More than a dozen species of native horntails occur in North America.

Sirex woodwasp can attack living pines, while native woodwasps attack only dead and dying trees. At low populations, sirex woodwasp selects suppressed, stressed, and injured trees for egg laying. Foliage of infested trees initially wilts and then changes color from dark green to light green, to yellow, and finally to red, during the 3 to 6 months following attack. Infested trees may have resin beads or dribbles at the egg laying sites which are more common at the mid-bole level. Larval galleries are tightly packed with very fine sawdust. As adults emerge, they chew round exit holes that vary from 1/8 to 3/8 inch in diameter.

Southern Pine Beetle

The southern pine beetle (SPB, *Dendroctonus frontalis*) is the most destructive insect pest of pine in the southern United States. It attacks and kills all species of southern yellow pines including *P. strobus* (eastern white pine). Trees are killed when beetles construct winding, S-shaped egg galleries underneath the bark. These galleries effectively girdle the tree and destroy the conductive tissues that transport food throughout the tree. Furthermore, the beetles carry blue staining fungi on their bodies that clog the water conductive tissues (wood) that transport water within the tree. Signs of attack on the outside of the tree are pitch tubes and boring dust, known as frass, caused by beetles entering the tree.

Adult southern pine beetles.

Photograph courtesy of Forest Encyclopedia Network

Adult SPBs reach an ultimate length of only 1/8 inch, similar in size to a grain of rice. They are short-legged, cylindrical, and brown to black in color. Eggs are small, oval-shaped, shiny, opaque, and pearly white.

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Appendix D
Estimated Costs for Middletown's Five-Year Tree Management Program

Estimated Costs for Each Activity			2016		2017		2018		2019		2020		Five-Year
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	Cost
Non-Ash Extreme and	1-3"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
High-Risk Removal	4-6"	$105	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$220	6	$1,320	0	$0	0	$0	0	$0	0	$0	$1,320
	13-18"	$355	9	$3,195	0	$0	0	$0	0	$0	0	$0	$3,195
	19-24"	$525	5	$2,625	0	$0	0	$0	0	$0	0	$0	$2,625
	25-30"	$845	7	$5,915	0	$0	0	$0	0	$0	0	$0	$5,915
	31-36"	$1,140	2	$2,280	0	$0	0	$0	0	$0	0	$0	$2,280
	37-42"	$1,470	3	$4,410	0	$0	0	$0	0	$0	0	$0	$4,410
	43"+	$1,850	1	$1,850	0	$0	0	$0	0	$0	0	$0	$1,850
Activity Total(s)			**33**	**$21,595**	0	$0	0	$0	0	$0	0	$0	**$21,595**
Non-Ash Moderate-	1-3"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Risk Removal	4-6"	$105	4	$420	0	$0	0	$0	0	$0	0	$0	$420
	7-12"	$220	33	$7,260	0	$0	0	$0	0	$0	0	$0	$7,260
	13-18"	$355	46	$16,330	0	$0	0	$0	0	$0	0	$0	$16,330
	19-24"	$525	27	$14,175	0	$0	0	$0	0	$0	0	$0	$14,175
	25-30"	$845	18	$15,210	0	$0	0	$0	0	$0	0	$0	$15,210
	31-36"	$1,140	8	$9,120	0	$0	0	$0	0	$0	0	$0	$9,120
	37-42"	$1,470	6	$8,820	0	$0	0	$0	0	$0	0	$0	$8,820
	43"+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**142**	**$71,335**	0	$0	0	$0	0	$0	0	$0	**$71,335**
Non-Ash Low-Risk	1-3"	$25	0	$0	11	$275	0	$0	0	$0	0	$0	$275
Removal	4-6"	$105	0	$0	28	$2,940	0	$0	0	$0	0	$0	$2,940
	7-12"	$220	0	$0	72	$15,840	0	$0	0	$0	0	$0	$15,840
	13-18"	$355	0	$0	61	$21,655	0	$0	0	$0	0	$0	$21,655
	19-24"	$525	0	$0	37	$19,425	0	$0	0	$0	0	$0	$19,425
	25-30"	$845	0	$0	14	$11,830	0	$0	0	$0	0	$0	$11,830
	31-36"	$1,140	0	$0	9	$10,260	0	$0	0	$0	0	$0	$10,260
	37-42"	$1,470	0	$0	2	$2,940	0	$0	0	$0	0	$0	$2,940
	43"+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			0	$0	**234**	**$85,165**	0	$0	0	$0	0	$0	**$85,165**
Ash Removal	1-3"	$25	8	$200	0	$0	0	$0	0	$0	0	$0	$200
	4-6"	$105	52	$5,460	0	$0	0	$0	0	$0	0	$0	$5,460
	7-12"	$220	125	$27,500	0	$0	0	$0	0	$0	0	$0	$27,500
	13-18"	$355	52	$18,460	0	$0	0	$0	0	$0	0	$0	$18,460
	19-24"	$525	21	$11,025	0	$0	0	$0	0	$0	0	$0	$11,025
	25-30"	$845	5	$4,225	0	$0	0	$0	0	$0	0	$0	$4,225
	31-36"	$1,140	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$1,470	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**263**	**$66,870**	0	$0	0	$0	0	$0	0	$0	**$66,870**
Ash Treatment	1-3"	$9	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"	$57	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$93	23	$2,139	0	$0	23	$2,139	0	$0	23	$2,139	$6,417
	19-24"	$129	7	$903	0	$0	7	$903	0	$0	7	$903	$2,709
	25-30"	$165	2	$330	0	$0	2	$330	0	$0	2	$330	$990
	31-36"	$201	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$237	1	$237	0	$0	1	$237	0	$0	1	$237	$711
	43"+	$276	1	$276	0	$0	1	$276	0	$0	1	$276	$828
Activity Total(s)			**34**	**$3,885**	0	$0	**34**	**$3,885**	0	$0	**34**	**$3,885**	**$11,655**
Stump Removal	1-3"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$25	0	$0	2	$50	0	$0	0	$0	0	$0	$50
	7-12"	$25	0	$0	30	$750	0	$0	0	$0	0	$0	$750
	13-18"	$40	0	$0	31	$1,240	0	$0	0	$0	0	$0	$1,240
	19-24"	$60	0	$0	22	$1,320	0	$0	0	$0	0	$0	$1,320
	25-30"	$85	0	$0	15	$1,275	0	$0	0	$0	0	$0	$1,275
	31-36"	$110	0	$0	6	$660	0	$0	0	$0	0	$0	$660
	37-42"	$130	0	$0	4	$520	0	$0	0	$0	0	$0	$520
	43"+	$160	0	$0	8	$1,280	0	$0	0	$0	0	$0	$1,280
Activity Total(s)			0	$0	**118**	**$7,095**	0	$0	0	$0	0	$0	**$7,095**
Non-Ash Extreme and	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
High-Risk Prune	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$120	1	$120	0	$0	0	$0	0	$0	0	$0	$120
	19-24"	$170	6	$1,020	0	$0	0	$0	0	$0	0	$0	$1,020
	25-30"	$225	2	$450	0	$0	0	$0	0	$0	0	$0	$450
	31-36"	$305	1	$305	0	$0	0	$0	0	$0	0	$0	$305
	37-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$590	1	$590	0	$0	0	$0	0	$0	0	$0	$590
Activity Total(s)			**11**	**$2,485**	0	$0	0	$0	0	$0	0	$0	**$2,485**
Non-Ash Routine	1-3"	$20	4	$80	4	$80	4	$80	4	$80	3	$60	$380
Pruning	4-6"	$30	17	$510	17	$510	17	$510	17	$510	16	$480	$2,520
	7-12"	$75	75	$5,625	75	$5,625	75	$5,625	75	$5,625	75	$5,625	$28,125
	13-18"	$120	67	$8,040	67	$8,040	67	$8,040	66	$7,920	66	$7,920	$39,960
	19-24"	$170	83	$14,110	83	$14,110	83	$14,110	83	$14,110	82	$13,940	$70,380
	25-30"	$225	47	$10,575	47	$10,575	47	$10,575	47	$10,575	47	$10,575	$52,875
	31-36"	$305	22	$6,710	22	$6,710	22	$6,710	22	$6,710	22	$6,710	$33,550
	37-42"	$380	9	$3,420	9	$3,420	9	$3,420	8	$3,040	8	$3,040	$16,340
	43"+	$590	4	$2,360	4	$2,360	4	$2,360	4	$2,360	4	$2,360	$11,800
Activity Total(s)			**328**	**$51,430**	**328**	**$51,430**	**328**	**$51,430**	**326**	**$50,930**	**323**	**$50,710**	**$255,930**
Young Tree Training	1-3"	$20	21	$420	21	$420	21	$420	21	$420	21	$420	$2,100
Pruning	4-6"	$30	30	$900	30	$900	30	$900	30	$900	30	$900	$4,500
	7-12"	$75	1	$75	1	$75	1	$75	1	$75	1	$75	$375
Activity Total(s)			**52**	**$1,395**	**52**	**$1,395**	**52**	**$1,395**	**52**	**$1,395**	**52**	**$1,395**	**$6,975**
Tree Planting	Purchasing	$110	175	$19,250	175	$19,250	175	$19,250	175	$19,250	175	$19,250	$96,250
	Planting	$110	175	$19,250	175	$19,250	175	$19,250	175	$19,250	175	$19,250	$96,250
Activity Total(s)			**350**	**$38,500**	**350**	**$38,500**	**350**	**$38,500**	**350**	**$38,500**	**350**	**$38,500**	**$192,500**
Young Tree	Mulching	TBD	0		0		0		0		0		$0
Maintenance	Watering	TBD	0		0		0		0		0		$0
Activity Total(s)			0		0		0		0		0		$0
To Be Determined	TBD		0	$0	0	$0	0	$0	0	$0	0	$0	$0
	TBD		0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Grand Total			**1,213**		**1,082**		**764**		**728**		**759**		**4,546**
Cost Grand Total				**$257,495**		**$183,585**		**$95,210**		**$90,825**		**$94,490**	**$721,605**

Appendix E
Emerald Ash Borer Information

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.

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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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New York State
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Division of Lands & Forests
Bureau of Private Land Services (PLS)

Bureau of Private Land Services

Emerald Ash Borer Management Response Plan

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I. Introduction:

The Division of Lands & Forests is charged with the protection and conservation of trees and forests in rural and urban settings across New York State. Attacks by invasive exotic insects represent one of the greatest threats to our state's trees and forests and to forest owners, forest-dependent businesses and industries, communities, homeowners and urban residents.

Emerald ash borer, *Agrilus planipennis* (Fairmaire), or EAB, is a non-native wood-boring pest of North American ash trees. This devastating pest was first found in 2002 in North America where it was discovered in southeastern Michigan and adjacent areas in Windsor, Ontario, Canada. It is thought to have been introduced in the 1990's on solid wood packing material originating from Asia. This extremely destructive beetle poses an enormous threat to all of North America's rural and urban ash resources.

Unlike many other wood boring beetles, EAB aggressively kills stressed ***and*** healthy ash trees; most dying within two to three years of becoming infested. Currently, EAB has no known natural enemies in North America, no effective control options over the forested landscape, and few, expensive options for protecting individual, high-value specimen trees. If EAB is not contained or its population growth and spread are not slowed, this pest will continue to infest and kill all species of trees in the genus *Fraxinus (ash)*. The impact on ash in North America has been compared to the effects of chestnut blight and Dutch elm disease, which devastated rural and urban forests in the 20th century.[1]

Since its initial North American discovery in Michigan, EAB has spread across the upper Midwest and by 2009, had been found in 12 States (excluding New York) and the provinces of Ontario and Quebec, Canada. Forestry experts and stakeholders in New York have been keeping a keen eye on the progression of EAB eastward and been cooperating with USDA Animal Plant Health Inspection Service (APHIS) and New York State Department of Agriculture and Markets (NYSDAM) on extensive detection surveys and trapping efforts to try to detect any infestations in our State as early as possible. As of August, 2010, 15 states and 2 Canadian provinces (Ontario and Quebec) have confirmed EAB discoveries.

According to the APHIS National EAB Program Manual (2009), "The Emerald Ash Borer Program has transitioned from an eradication program to a management program. Effective and cost efficient control technologies are not currently available to apply area-wide to effect pest eradication. In the future additional tools may become

[1] USDA–APHIS. 2009. *Emerald Ash Borer Program Manual, Agrilus planipennis* (Fairmaire) USDA–APHIS–PPQ–Emergency and Domestic Programs–Emergency Planning, Riverdale, Maryland

available to suppress the dispersal of the pest. Program partners are conducting extensive research to develop additional tools and methodologies." (See footnote 1) Based on the latest New York satellite discoveries, and following established EAB response protocols outlined by USDA APHIS and the latest scientific information, the Bureau of Private Land Services, in conjunction with the US Forest Service, has developed this EAB Management Response Plan to guide program investments and activities.

New York's EAB Response Plan will be a multi-year effort, including multiple components and involving multiple partners. Federal, State and local governments and agencies, environmental non-governmental organizations, forest and nursery industries, utilities, forest owners, homeowners, all have a stake and will need to be engaged. Some of these activities are already underway, using existing resources or grants, but others will require new (or renewed) funding to implement this year and in future years.

II. Current situation:

In June of 2010, outreach by a Cornell University researcher, funded by APHIS, in Randolph resulted in a report by a landowner that he had a suspicious tree on his property. This report was in the general vicinity of the 2009 EAB discovery in Randolph, Cattaraugus County. Seasonal DEC Forest Health field staff, funded by the USDA Forest Service (USFS), were dispatched to investigate and discovered numerous additional EAB-infested ash trees, mostly within ½ mile of the original discovery site, and as far out as 1 mile. Collaborating researchers from Cornell University, ESF and USDA ARS, who were already setting up research studies in the Randolph area, were immediately notified and visited the new discoveries. Samples were sent to E. Richard Hoebeke, a USDA-approved EAB National Identifier, to verify the identification. Within a week, the number of infested ash trees identified in the immediate Randolph-area had grown to 75. Visible, extensive woodpecker damage on the boles of ash trees was the primary indicator of infestation and was what drew the attention of the survey crews. This increased woodpecker activity on ash trees, seeking out EAB larvae, has frequently been cited as an indicator or EAB presence in other infested States.

New York's "Summer of EAB" got much busier from that point on. On June 19, confirmation was received of a single EAB adult caught in a purple prism trap placed in an identified, high-risk site in Bath, Steuben County. Subsequent intensive surveying around that site failed to locate any evidently-infested or EAB-killed trees, or detect any additional beetles in traps. On July 20, another purple prism trap yielded confirmed EAB adults in Saugerties, Ulster County, on the eastern edge of the Catskill Park. Field investigations revealed an established population covering approximately 15 square miles and extending mostly south and east from Saugerties.

By the end of August, four additional satellite EAB occurrences had been detected and confirmed in Cementon, Greene County; Caledonia, Livingston County; Scottsville, Monroe County; and Pembroke, Genesee County. In each case, delimitation surveys were conducted by staff from participating agencies, primarily DEC, USDA APHIS, NYSDAM and Cornell to determine the extent of the infestations and counties involved (for future regulatory purposes.) All were smaller in size than the Ulster satellite.

The State Forester's office initiated an interagency discussion with APHIS, USFS, NYSDAM, NYS Office of Parks, Recreation and Historic Preservation (OPRHP) and NYS Department of Transportation (DOT) to gather input and develop response to these new discoveries. Input was also solicited from the scientific community, particularly the NY Forest Health Advisory Council and researchers from Cornell, USDA ARS and ESF already working on EAB in the Randolph area.

The three agencies with regulatory authority – DEC, NYSDAM and USDA APHIS – met with regulatory stakeholders to discuss potential quarantine expansions in response to the six new satellite discoveries. On September 8, 2010, NYSDAM and NYSDEC imposed parallel Emergency Quarantine Orders, on 16 counties in western New York and 2 Counties in eastern New York, to restrict the human-assisted movement of EAB and to support businesses by facilitating the industrial uses and movement of regulated articles. The counties included are Chautauqua, Cattaraugus, Niagara, Erie, Orleans, Genesee, Wyoming, Allegany, Monroe, Livingston, Steuben, Wayne, Ontario, Yates, Schuyler, Chemung, Ulster and Greene. The Federal government, USDA APHIS, is simultaneously moving forward with their own quarantine covering interstate movement of EAB and regulated articles that will mirror the State orders and cover the same counties. Each agency will continue to work aggressively outside the quarantine boundaries to find new infestations, and enforce the quarantine restrictions.

This DRAFT EAB Management Response Plan for activities within the New York EAB quarantine area has been developed out of those discussions further informed by other States' EAB Response Plans, current "SLow Ash Mortality" research and activities pioneered in Michigan and discussions with Dr. Nate Siegert, formerly with Michigan State University and now with the US Forest Service Northeastern Area, based in Durham, NH.

III. Private Land Services Authorities, Program Areas and Partners

The Division of Lands & Forests is charged, under the Environmental Conservation Law, with the protection and conservation of trees and forests in rural and urban settings across New York State. Within the Lands and Forests, the Bureau of Private Land Services is responsible for DEC's Forest Health Management Program, Private Forestry
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Assistance Program, Urban & Community Forestry Program, and the Saratoga Tree Nursery. These programs, and their Federal partners and counterparts in the US Forest Service State & Private Forestry Program, all have integral, unique and complementary roles in responding to invasive species attacks on New York trees and forests. The Bureau collaborates and cooperates closely with numerous other public, private and academic sector partners in EAB response, including Cornell University and Cornell Cooperative Extension, NY Forest Owners Association, SUNY ESF, NYS OPRHP, NYS Urban & Community Forestry Council, NY Society of American Foresters, Empire State Forest Products Association, USDA NRCS, Regional Resource Conservation & Development Councils, County Soil & Water Conservation Districts, USDA APHIS, NYSDAM, and, of course, our sister Bureaus of State Lands and Forest Preserve in the Division of Lands & Forests.

IV. Private Land Services EAB Management Response Plan Goal: "SLow Ash Mortality" or "SLAM"

Simply stated, our Bureau's goal in responding to EAB is to keep as many ash trees alive as possible, in as much of New York State as possible, for as long as possible.

Our mantra for EAB, and all other invasive, exotic forest pests, has been: "early detection, rapid response". When exclusion efforts fail, the next best protection tool is intensive surveying and monitoring which enables infestations to be detected quickly, and early, while they are still relatively small. Early detections must then be delimited, and evaluated, to determine their extent, intensity and (where possible) age. While infestations are still relatively small and isolated, a suite of appropriate control measures can then be rapidly implemented to (1) reduce the pest's population, minimize the population's growth and limit its natural spread to adjacent areas. These measures will, in turn, reduce or slow the rate of ash mortality from EAB infestation. This concept, as being developed by the research community, is known as "Slow Ash Mortality", or SLAM.

Aggressively pursuing a SLAM approach, on our multiple program fronts, will achieve numerous benefits for the State. We can:

- Save economic value and preserve value growth as long as possible on ash timber trees on private forests, to the direct benefit of forest owners;
- Save yard and community ash trees for as long as possible, providing continuing, tangible benefits for homeowners and municipalities;
- Forestall the need for expensive and repeated chemical treatments of high-value landscape or urban trees to protect them from imminent EAB attack;
- Postpone time when urban ash trees are killed by EAB, become hazards and must be removed, forcing costs on homeowners and communities;
- Buy time for research to develop better protection and control measures(chemical, biological);

- Buy time for communities to budget and prepare for calculated and planned ash treatments, removals, disposal and replacement;
- Support ash timber markets and ash-dependent industries for as long as possible by maintaining a steady supply of raw material, and avoid flooding markets with ash timber unnecessarily and beyond the markets' capacity to absorb (i.e. baseball bats, tool handles, basket-making) which would drive value and prices down.

The US Forest Service's Gypsy Moth "Slow-The-Spread Program", implemented at the perimeter of the known Gypsy moth infested area since 1993, has demonstrated that considerable economic and ecological benefits can be gained by slowing the rate at which gypsy moth populations build and spread spatially. A similar approach, applied to EAB, could yield even greater benefits. In the past five years, scientists have learned much about the biology of this invasive pest. Technology and methods for EAB survey and control have progressed considerably. Continued research may yield more options for EAB management and increase the effectiveness of existing technology.

V. Private Land Services EAB Management Response Plan: A "Tiered" and "Threat-Based" Approach

The NYSDEC Division of Lands and Forests has the primary mission for protecting, conserving and sustainably managing New York's urban and rural forest resources. We share this mission with our principal Federal forestry partner, the USFS Northeastern Area State & Private Forestry program, as well as other Federal and state collaborators.

Research has shown that the rate at which ash tree mortality advances is directly related to the density of EAB. As "outlier", or satellite populations build, spread and coalesce, the area and number of dead, dying and declining ash trees increases dramatically. A do-nothing approach to EAB or a regulation-only approach to EAB means that EAB will advance unchecked, more rapidly killing billions of ash trees in forests, rural and urban areas in a relatively short amount of time. Continued expansion of EAB threatens the long-term viability of at least 15 ash species native to the U.S. and will drastically alter the ecology of forests in New York. It also threatens communities faced with tree removal and replacement costs, forest owners faced with the loss of valuable timber resources, forest industries that rely on ash wood, and even the National pastime – baseball – that features the use of North American ash bats. (Ironically, ash became the bat wood of choice to replace chestnut that was no longer available due to Chestnut blight.)

To achieve fulfill our mission and achieve our goals, the Bureau of Private Land Services will expand our activities to help the most directly-impacted stakeholders – private forest owners and municipalities closest to identified EAB satellite occurrences - live with,

and manage the economic, environmental and social impacts of EAB in their midst and immediate vicinity. Primarily, these efforts all only "buy time":

- Time that is needed for researchers to develop better means of controlling EAB or protecting trees.
- Time for communities and forest owners to prepare for EAB arrival.
- Time for governments to spread out the inevitable costs of dealing with EAB-killed, public ash trees.

As a Milwaukee, Wisconsin DPW Supervisor recently said, "We want to remove these trees on our schedule rather than the beetle's."

In order to set priorities and wisely invest limited fiscal and staff resources, we have developed a new, targeted management response approach, in cooperation with Nate Siegert with the US Forest Service. Our approach focuses PLS program efforts in and around our satellite infestations, and first characterizes these EAB occurrences into 3 "Tiers", based on specific criteria concerning the nature and extent of each new discovery. We then establish three "Management Response Areas" or "Levels" around Each delimited Satellite Core Area" and develop appropriate program responses based on relative threat, correlated directly to proximity to infested core areas. From these assessments, we then develop a matrix showing our program management responses appropriate to each Tier and Threat-level. Our intent is to apply this strategic approach to all our Private Forestry Program areas – Private Forest Stewardship, Urban & Community Forestry, Forest Health Management and Utilization & Marketing, as well as our EAB outreach efforts. It will guide our development of grant proposals, preparation of regional workplans and targets, and allocation of available staff and fiscal resources. Using this process, we can focus our efforts to provide the most assistance to the most-immediately threatened stakeholders, while still providing information and scaled assistance to landowners and communities farther from this threat, both in distance and time.

A. Survey, Detection and Delimitation

To achieve our mission and goal of keeping as many ash trees alive, in as much of New York State as possible, for as long as possible, it is critically important that we continue to monitor and evaluate identified satellite EAB occurrences. This need will continue until the various satellite occurrences coalesce and the entire state becomes infested, or available resources are exhausted.

PLS proposes to maintain a statewide EAB detection and monitoring program, around the delimited satellite occurrences, within the quarantined counties, and in high-risk locations across the non-quarantined areas of the State. We will continue to enhance the delimitation surveys to monitor the identified satellite occurrences, track EAB movement and expansions of detectable, infested areas, and assess population changes. Special emphasis will be placed on enhancing our surveying and population monitoring to the east of the Hudson Valley detections in Ulster and Greene Counties, to better track any movement

of EAB toward Massachusetts, Connecticut and Vermont, and down the Hudson River toward the New York City metropolitan area. Data gathered will be used to set response priorities, target management activities and evaluate results of our SLAM efforts.

B. Tier criteria and characterization

Our Tier system for classifying EAB satellite occurrences uses three simple criteria, and assigns satellites to one of 3 Tiers.

1. Trigger Criteria: Initial, confirmed EAB discovery

The entry point or trigger for our classification system is an initial EAB discovery in a new location. This may be a single EAB adult caught in a purple prism trap, larva discovered in a sentinel tree, EAB life stages in or around dying or dead ash with galleries present, or other verifiable, confirmed evidence. An initial discovery automatically makes the delimited site a Tier 1, pending further evaluation.

2 Criteria Two: Number of discovered, EAB-killed ash trees within the delimited core area.

The extent and severity of an EAB infestation can be measured and characterized by the number of EAB-killed ash trees found within the delimited are. Number of EAB-killed trees directly relates to the size of the population. It will also reflect the physical size of the infested area, which also comes into play in Criteria 3. Ash mortality also provides an indirect indication of the age of the infestation (which will be supplemented by dendrochronology analysis, if suitable samples can be taken).

Tier 1 = 0 EAB-killed ash trees found in delimited area
Tier 2 = < 25 EAB-killed ash trees found in delimited area
Tier 3 = > 25 EAB-killed ash trees found in delimited area

3. Criteria Three: Greatest distance between EAB discoveries in the delimited area

Upon discovery of a new EAB satellite occurrence, a delimitation survey will be conducted to more accurately define the area infested, to the best extent possible with existing technology and resources. Additional EAB occurrences (trap catches, infested or killed trees, gallery evidence,

etc.) will be plotted on a GIS, allowing a map to be made showing the detected, infested core area. For our planning purposes, the delimited "Core Area" will be defined and mapped by connecting the outermost identified occurrences around the initial satellite detection. Our metric for Criteria 3 will the distance between the two farthest identified points associated with the new detection.

Tier 1 = 0- 500 feet
Tier 2 = 501 feet - 6 miles
Tier 3 = > 6 miles

C. Threat-based Management Response Areas

Around these Tiered satellite infestations, and their delimited "Core Areas", we propose to create "Management Response Areas" or "Priority Response Areas", at increasing distances, that will correspond to differing types and intensities of management responses undertaken by DEC, L&F PLS and (potentially) willing partners. This system of responding based on threat will be incorporated in our plans for our Private Forest Stewardship Program, our Urban & Community Forestry Program and our Forest Health Management Program. Our objectives are to provide information, assistance and direct responses appropriate to the nature of the identified and delimited infestation and appropriate to the threat or risk to PLS customers and constituents. Those constituents are primarily (a) rural private forest landowners, (b) communities - homeowners and municipal governments, (c) ash using industries and stakeholders, and (d) state and Federal government.

1. Satellite Core Area

The Satellite Core Area will be determined based on the initial detection, intensified first-year delimitation surveys and subsequent, annual monitoring and delimitation surveying. Our plan is to annually evaluate, re-assess and redefine the individual Satellite Core Areas, until such time as they coalesce with adjacent satellites. The limits of each Satellite Core Area will be delineated by a line drawn on the GIS map connecting the outermost, detected EAB occurrences around each initial detection. Each delimited area may be as small as a single point (i.e. one EAB caught in one trap) or may cover many square miles.

In Tier 1, the initial detection does not include any dead ash trees and may not include any discovered EAB-infested trees. Response in this situation would be limited to increased surveillance and monitoring,

including use of girdled trap trees. In Tiers 2 and 3, stakeholders likely already have EAB-infested, dead and dying ash. All ash trees in this Core, or infested area should be evaluated for condition and steps should be taken to prioritize removals to salvage value (in woodlots) and reduce hazards and liability on municipal property and around homes. Infested ash are at imminent risk of death, in as little as 1-3 years, so these actions must be begun immediately.

2. First Management Response Area, "Level 1" (Threat Level "Red")

The First Management Response Area, or "Level 1", corresponds to the highest threat from EAB and extends 0-5 miles out from the delimited Satellite Core Area. Next to those stakeholders within the Core Area, these landowners, homeowners and communities are most imminently at-risk from EAB, and should be taking immediate steps to respond to that risk. Given current detection capability, and the inherent difficulty in finding low-level EAB populations, it is highly likely that ash trees in this Level 1Response Area may already be infested, or the EAB population in the Core Area could spread to these ash trees within the next year or two.

Stakeholders should have already inventoried and assessed their ash resources or should do so immediately, to determine their potential exposure and liability. Woodlot owners should be contacting a DEC or private sector forester for forest management advice and assistance in harvesting their ash-containing stands to salvage ash value and promote regeneration of non-host tree species to replace ash in their woodlots for the future. If homeowners or municipalities have high-priority, individual ash trees, they should look into chemical treatment options and decide if they want to invest in treatment to protect them from attack.

3. Second Management Response Area (Threat Level "Orange")

The Second Management Response Area, or Level 2, extends from 5-10 miles out from Satellite Core, again following the delimited perimeter. Ash stands and trees in this area are at an elevated risk, but are not immediately threatened with attack or mortality. EAB has not been found here yet and this area is beyond the projected annual flight range of EAB. It is unlikely that existing populations, even unimpeded, will grow or spread naturally to affect ash resources in the Level 2 Area within the next 2-5 years.

Forest owners, homeowners and municipalities should definitely be assessing their ash resources and making plans to respond or take proactive measures, but they have some time to prepare and act in a prudent and measured manner. Inventories should be conducted, ash resources should be evaluated and annually monitored, stakeholders may opt to participate in specific SLAM strategies such as biocontrol releases, ash volume reduction, detection trapping or establishing girdled sentinel trees.

4. Third Management Response Area (Threat Level "Yellow")

The Third Management Response Area, or Level 3, comprises those areas > 10 miles from the Satellite Core Area, extending out in the state until you encounter another Satellite Core Area Level 2 boundary. Graphically, and for our management planning and response purposes, this area is essentially the remainder of the State. This extensive area may already be within State and Federal EAB quarantine boundaries or could extend outside those counties to the State lines. Based on the distance from the individual Satellite Core Areas, these forests and communities are considered to be at the lowest risk of imminent infestation and, barring additional human-assisted spread, forest owners and municipal officials likely have the most time to plan and prepare for EAB's arrival. We would anticipate at least 5-10 years before EAB is detected in the Level 3 regions of the State.

Program efforts in Level 3 will focus on early detection surveying, outreach, education and planning for direct response when EAB is detected much closer to potentially-impacted forest owners, homeowners or communities.

VI. Forest Health Program Management Responses

Tier 1: "Detection only"

Level 1:

- Increase detection surveying, supplementing purple prism traps with girdled trap trees, sentinel trees, bio-surveillance and visual surveillance. (See attached protocols). Target establishment of 10-25 trap trees, evenly-spaced around the initial detection, out to ½ mile

- Continue increased trapping for 3 years or until additional detections warrant move satellite occurrence to Tier 2 or 3.

Level 2:

- Continue detection surveying following USDA APHIS National EAB Program protocols using trap trees and the purple prism traps (PPT). Follow the National EAB grid survey pattern, as well as targeting additional "high-risk areas", deploying traps at campgrounds, rest areas, mills, industrial areas and other potential entry points for EAB. The goal is to detect new infestations of EAB, or spread of EAB populations, as quickly as possible, using the best tools available and site selection criteria informed by current science.

Level 3:

- Same as Level 2.

Tier 2: "Small-scale, or early infestation"

Level 1:

- Increase detection surveying, as in Tier 1, Level 1.
- Coordinate research and SLAM efforts with EAB Science Team
- Reduce known EAB populations by removing and disposing of infested trees, preferably prior to emergence/flight season or after adults have mated and laid their eggs on host trees. Priority will be placed on removing large diameter trees, known to be infested, farthest from the core (per latest guidance from Dr. Nathan Siegert at Michigan State University). Results of visual detections, sentinel trees assessments and trap catches will all be used to identify and target priority tree removals.
- Annually, create clusters of girdled trap trees as "sinks" to attract EAB adults and hold populations within the known infested "core" as long as possible.
- Establish "sentinel trees" extending out from periphery of delimited infestation area (the "core action area") to assess effectiveness of SLAM efforts and detect any spread of EAB outside the core action area.
- Promote removal of EAB-infested ash trees from forested areas (and communities), during non-flight seasons, as part of a comprehensive Forest Stewardship management plan, to reduce the size of the coming summer's potential EAB populations, as well as to capture economic value for forest landowners.
- Conduct and collaborate in **biocontrol research** with USDA Agricultural Research Service, USDA APHIS, USFS, and the

academic research community. Research will include permitted release of approved parasitoids, monitoring of release sites and sampling of ash trees to determine fate of introduced parasitoids and rates of parasitism.

- Conduct and collaborate on insecticide research, trials and applications with USDA APHIS, USFS, Cornell Cooperative Extension, academic researchers, community governments and land or homeowners to protect high-value, individual landscape ash trees. Provide outreach, information and education on available insecticides, techniques and decision-criteria to homeowners, communities, arborists and applicators.

Level 2:

- Establish sentinel trees to monitor EAB population growth and track movements. Data gathered will be used to annually adjust Tiers and Threat Levels, and determine new priorities and targets for management responses.

Level 3:

- Same as Tier 2, Level 2.

Tier 3: "Large-scale or established infestation"

Level 1:

- Same as Tier 2, Level 1

Level 2:

- Same as Tier 2, Level 2

Level 3:

- Same as Tier 3, Level 3

VII. Private Forest Stewardship Management Responses

We have developed Private Forest Stewardship Response "Components" that will be applied relative to the Tier and Threat Level for each Satellite EAB occurrence. We apply these Components across the response matrix, with some repeating in multiple scenarios.

Component #1 -Targeted outreach to landowners (ranging from direct mailings to forest owners in highest risk areas identified from local tax records to press releases, media contacts, presentations to stakeholder groups, etc) within established distances from infestation promoting the following:

- Awareness of signs and symptoms of EAB infestation
- Encouragement of vigilance and reporting of suspicious tree mortality or presence of insect
- Information about SLAM and discussion of landowner participation
- Information about Forest Stewardship
- Encourage annual inspection of trees / forest

Outreach to municipalities within delimited core and from 0 to 5 miles out (Threat Level 1) with following :

- Awareness of EAB signs and symptoms
- Information about SLAM and advice being provided to forest landowners
- Role of local laws & ordinances that regulate forestry activities

Component #2 - Press outreach to inform the public and municipal officials about EAB

- Awareness of signs and symptoms of EAB infestation
- Information about SLAM
- Sources of forestry assistance

Component #3 – Provide Forest Stewardship technical assistance to promote the following:

- Landscape level strategy to address needs and opportunities to conduct tree cutting/harvesting actions on private forest land, to reduce ash component, capture economic value, and reduce EAB larvae populations in infested trees, consistent with recommended levels
- Provide technical assistance to individual owners to:
    - Inventory tree resource on individual properties
    - Develop Landowner Forest Stewardship Plans
    - Develop silvicultural cutting strategy/prescriptions
    - Provide detailed information on the marketing of timber products in federal and state quarantine areas
    - Direct landowners to private sector professional services to facilitate implementation of tree cutting strategies

Component #4 – Conduct municipal & community educational outreach to:
Inform officials about EAB as it pertains to local forestry regulation:

- Awareness of signs and symptoms of EAB infestation
- Stewardship actions that can slow ash mortality (SLAM)
- Role of local laws & ordinances that regulate forestry activities

Response Levels

	RED 0 to 5 mile radius	**ORANGE** 5 to 10 mile radius	**YELLOW** >10 mile radius
Tier 1	Component 1	Component 2	Component 2
Tier 2	Components 1 3 4	Components 1 & 4	Component 2
Tier 3	Components 1,3, 4	Components 1,3, 4	Component 2

VIII. Urban and Community Forestry Program Management Responses

Our Urban & Community Forestry Program management response plan is designed to assist at-risk local communities in developing and implementing their own "Community EAB Preparedness and Response Plans".

The greatest economic impacts from EAB will be felt by communities when EAB infestations reach them. Ash trees that die deteriorate quickly and become hazards and liabilities to municipalities and homeowners. New York communities are largely unprepared and, especially now, are under severe economic constraints, leaving them highly vulnerable to the potential impacts on EAB infestations. While we work to slow the spread of EAB across the state, and forestall the day when EAB invades our communities, it is also important to takes steps now to help communities understand their risk and exposure, make plans for dealing with the impacts, and start budgeting now for necessary response and recovery measures. As we previously have outlined, individual communities' risk, urgency to respond, and the appropriate actions to take will be determined by a number of factors.

A. Risk

The most important determinants of a community's risk from EAB factor are the **amount and condition of ash trees in the community's urban forest**. Now that EAB has been found in New York state, all communities should be looking at their **street tree inventories** and past tree management records to assess how many ash they are responsible for on public properties (rights-of-way, around public buildings, in school yards, in parks, etc.). If the community does not yet have a street tree inventory, they should be looking at ways to get that information now. Communities with a high number of ash trees and/or a high percentage of their urban forest resource comprised of ash, face a much greater risk and liability than those with few ash trees, or a more diversified mix of trees on public and private lands. Municipal street tree inventories tend to focus only on those trees that are the responsibility of the municipality, in right-of-way or on public property. These are the trees the municipality must maintain, remove and potentially replace and the ones that present public liability issues when they die, deteriorate and start falling down. Municipalities – and homeowners or property owners in communities - should also be assessing how many ash trees are on private property in town, as that also affects the risk and potential spread of EAB should it appear. Green ash, for example, has become a very popular landscape tree in recent years and is often planted around existing homes and in new developments.

B. Urgency

The urgency of getting street tree inventory information is directly related to the community's **proximity to EAB occurrences** ("Threat Level") and the nature of that occurrence, or Tier. Communities within a delimited core area are probably already dealing with dead or dying ash trees, or will be shortly, and need this inventory data immediately for work planning and budgeting purposes. Conversely, communities beyond 10 miles (Threat Level 3), particularly around Tier 1 occurrences, and in counties that do not yet have a detection, have more time to get this information, perhaps 3-5 years, but still need to be working in that direction.

C. Necessary and Appropriate Responses

Management preparations and responses that are necessary and appropriate for any given community are also directly related to the Tier and Threat Level of their closest documented EAB occurrence. Communities that are within the delimited core, or within 5 miles, should be removing dead, dying and infested trees, identifying trees to protect through chemical treatment and applying those treatments, and replacing removed ash trees with non-host trees appropriate to the site. Communities with a large number of dead or dying trees will have to prioritize removals based on their location, hazard condition and potential liability concerns. Municipal budgets will have to be adjusted to account for increased tree removal and disposal costs.

1. Outreach and education

Cornell Cooperative Extension, NYSDEC and the US Forest Service will partner and collaborate in providing **outreach and education to municipal governments** in EAB awareness, recognition and preparedness planning through workshops, web materials, publications, personal contact and development of a "Municipal Guide for EAB Response" (underway by Cornell, under APHIS contract). Information will be provided to help municipal officials and residents understand the potential impacts of EAB infestation, the response options and their pros and cons, and the importance of wisely using the preparation time being provided to them through our comprehensive SLAM and regulatory efforts.

2. Direct technical assistance

DEC's Urban & Community Forestry Program, working with the NYS Urban & Community Forestry Council, Cornell Cooperative Extension, Cornell University's Student Weekend Arborist Teams (SWAT) and private sector urban forestry consultants can **provide direct technical assistance** to municipalities in developing response plans, conducting municipal tree inventories, training municipal staff, developing grant proposals, and selecting appropriate replacement trees for municipal spaces. Priority for outreach and technical assistance will be based on the previously-outlined Tier and Threat Level characterization system.

3. Chemical treatment advice and guidance

Cornell University, Cornell Cooperative Extension, DEC's Urban & Community Forestry Program and the US Forest Service will continue to provide **advice, guidance and criteria** to help municipalities, homeowners and property owners determine if **chemical treatments** are warranted and meet their needs and desires, understand what chemicals are approved for use on EAB in New York State, and gain access to the latest scientific information about their effectiveness, impacts and applicability.

4. Additional financial resources

DEC and our urban and community forestry partners and advocates, including the NYS Urban & Community Forestry Council, will also **seek and advocate for additional financial resources needed for communities** to inventory public ash resources and undertake necessary response activities including tree removals and disposal, tree replacement, chemical treatment of high-value trees, staff training and equipment purchases (wood chippers, tub grinders, mulching equipment, etc).

Ideally, municipalities receiving State or Federal EAB assistance funding would be encouraged to share equipment, training, skills and resources for EAB response (as Monroe County already does with other public works equipment) to maximize efficiency and reduce overall costs.

Urban & Community Forestry Program EAB Response Levels

	Level 1 - RED 0 to 5 mile radius	**Level 2 -ORANGE** 5 to 10 mile radius	**Level 3 - YELLOW** >10 mile radius
Tier 1	- Outreach and education - Preparedness planning training	- Outreach and education - Preparedness planning training	-Outreach and education
Tier 2	Same as Tier 1 plus: - Street tree inventories - Tech assist with staff training - Preparedness planning assistance - Assistance with grant proposals - Provide criteria to help determine if pesticide treatments are appropriate - Provide information, training and assistance with ash utilization or disposal	Same as RED, Tier 2	- Outreach and education - Preparedness planning training
Tier 3	Same as Tier 2	Same as RED, Tier 3	- Outreach and education - Preparedness planning training - Street tree inventories

Appendix A. SLAM Operational Tactics

Action elements:

A. Survey

1. **Detection trapping.** Following USDA APHIS National EAB Program protocols, NYS has been cooperating since 2004 in the National EAB survey (using trap trees and the purple prism traps (PPT) as part of the National EAB grid survey, as well as additional "high-risk area" surveying that locates traps at campgrounds, rest areas, mills, industrial areas and other potential entry points for EAB. The goal is to detect new infestations of EAB as quickly as possible, using the best tools available and site selection criteria informed by current science and risk assessments.
2. **Biosurveillance using Cerceris fumipennis wasp.** DEC will continue to collaborate with USFS, SUNY CESF researchers and other partners to seek funding to continue evaluating and advancing the use of the native ground wasp Cerceris fumipennis. Biosurveillance efforts will focus on high priority areas outside of known and confirmed infested areas and will provide additional early detection capability.

3. **Intensified delimitation surveying.** Once an initial detection is confirmed, DEC, USDA APHIS and NYSDAM will immediately coordinate and begin an expanded delimitation survey, focusing on adjacent counties, for the specific purpose of informing future quarantine discussions and decisions. This surveying will use all available and practical methods - within fiscal and human resources available - including, but not limited to, ground-based field visual inspections of ash trees and ash-containing forests, inspection of high-risk, accessible, ash trees using aerial bucket trucks, destructive sampling of symptomatic ash trees, aerial surveying and remote sensing. Survey crews will identify and GPS locate infested trees and "suspect" or "watch list trees" for future action or ongoing monitoring (may include other visual marking such as flagging watch trees). Priority will be placed on areas with symptomatic or unhealthy-looking ash, areas with high ash volumes or composition, and high-risk areas (roadsides, forest edges, near camping areas or near ash-using facilities (mills, firewood producers, etc.), proximity to facilities that receive imported solid wood packaging. Surveys will be concluded when the participating agencies are satisfied they have identified the counties involved in any infestation, to the extent infestation can be determined at the time.

4. **SLAM Assessment and Evaluation.** After the regulatory delimitation has been accomplished, it is necessary for SLAM planning to further delimit and

characterize the extent and nature of an identified EAB infestation and the forest and tree resources in and around the infested area. This involves a closer delimitation of the limits of the identifiable infestation, even if that is within a single quarantined county. Provided funding is available, either for research or implementation projects, this "core area delimitation can be accomplished through additional ground-based visual surveys spiraling out from the known infested area, establishment and subsequent removal and evaluation of girdled "sentinel trees", and through aging of the infestation using dendrochronology techniques. Target density for sentinel trees would be 1 per 20 acres with increased density along the periphery of the known-infested area, decreasing towards the center. Girdled sentinel trees will also have a purple prism trap (PPT) hung in them, without additional chemical lures, as an additional detection tool, serviced as deemed necessary for research purposes. Before the next flight season, all girdled trap trees will be removed and sampled for presence of EAB and new sentinel trees will be established in their place.

Development of more detailed ash (and overall forest)inventory data for core action area (based on delimitation and dendrochronology) is also needed, including density, size, condition and distribution. Data can be collected through field plot sampling supplemented by aerial photography analysis and satellite imagery. Data should be entered into an accessible GIS database for use by all program partners. Standardized data management protocols need to be collaboratively developed for consistent use by all involved partners: NYSDEC, NYSDAM, USDA APHIS, USDA Forest Service, NYS Office of Parks Recreation & Historic Preservation (NYSOPRHP), NYS Department of Transportation (NYSDOT) and various academic, State and Federal researchers.

B. Management (SLAM)

The USDA National EAB Program Plan dictates that APHIS has transitioned from an eradication program to a management program for this invasive, exotic pest. Effective and cost efficient control technologies are not currently available to apply area-wide to effect pest eradication. In the future additional tools may become available to suppress the dispersal of the pest. Program partners are conducting extensive research to develop new tools and methods to suppress EAB populations, inhibit their growth, minimize their spread and delay the death of ash trees.

The rate at which ash tree mortality advances is related to EAB density. Therefore, an over-riding theme within the "Low Ash Mortality" or "SLAM" approach is to reduce EAB numbers and the growth of EAB populations. This can occur by destroying EAB life stages before adults can disperse and reproduce and by concentrating adult beetles and eliminating their progeny before the next emergence season. As outlier populations build and coalesce, the area encompassing dead, dying and declining ash trees increases dramatically. A do-nothing or a regulation-only approach means that EAB populations will build and advance unchecked. Under that scenario,

extensive local tree mortality is likely to occur much sooner than under a SLAM management scenario

Applying a SLAM approach will not eradicate EAB, nor will it eliminate tree mortality. The goal of this management strategy is to slow the local invasion process and allow land managers time to be proactive rather than simply reacting to overwhelming numbers of dead, often hazardous trees. When EAB was first identified in North America in 2002, little information about this beetle was available. Tools available for EAB survey and control have progressed considerably. Continued research and methods development will yield more options for EAB management and increase the effectiveness of existing technologies. Slowing the movement of EAB and the advance of ash mortality buys time for research and technology development. Since New York is really the "gateway" to New England, our efforts to slow the spread of EAB eastward will have innumerable benefits to the New England states – Connecticut (hard hit by Hemlock wooly adelgid), Massachusetts (already reeling from ALB), Vermont (whose maple industry lives in fear of ALB), New Hampshire, Maine and Rhode Island. SLAM investments in New York now will greatly benefit those states and their ash resources, possibly for years to come.

The SLAM initiative, is a forest pest management effort, and as such is primarily a role of, and is supported by the USDA Forest Service, the research community and State Forestry agencies. NYSDEC proposes to aggressively seek funding for, collaborate and implement SLAM, on an operational rather than research-oriented basis, around known populations of EAB in New York State. If funding is available, this effort will continue at least until, or unless, the generally-infested area in the State becomes so large that this approach is deemed ineffective.

C. SLAM Operational elements:

1. **Reduce known EAB populations** by removing and disposing of infested trees, preferably prior to emergence/flight season or after adults have mated and laid their eggs on host trees. Priority will be placed on removing large diameter trees, known to be infested around the perimeter of the delimited core (per latest guidance from Dr. Nathan Siegert at Michigan State University). (Larger trees have greater potential to harbor EAB larvae and, consequently, produce more emerging adults.) Results of visual detections, sentinel trees assessments and trap catches will all be used to identify and target priority tree removals. Consideration will also be given to focusing infested tree removals in areas closest to uninfested (or, at least, undetected) ash-heavy stands or areas, and/or in line with high-value and high-risk ash resources in nearby communities.

2. **Annually, create clusters of girdled trap trees as "sinks"** to attract EAB adults and hold populations within the known infested "core" as long as possible. Protocol will be:
   - seek landowner permission to girdle, inspect and eventually remove trap trees

- physically girdle trap trees in clusters, according to most current research-based protocols
- collect and record GPS location data for each trap tree and cluster
- remove trap trees prior to next flight season and dispose of them per regulations
- sample trap trees to detect and evaluate EAB attack/catch

Establishment of sinks (research and/or management purposes) to be coordinated among participating agencies, research teams and other partners through the DEC EAB Program Manager in coordination with the NY EAB Science Panel.

3. **Establish "sentinel trees"** extending out from periphery of delimited infestation area (the "core action area") to assess effectiveness of SLAM efforts and detect any spread of EAB outside the core action area. Sentinel trees should be created by girdling selected ash trees that have attractive features to EAB (large diameter, open or edge-grown, dominant canopy position, etc., based on current science) and hanging the latest trap model, according to the current trapping protocols (if additional traps and lures are available) . These trees would be GPS-located, removed at the end of each flight season, and destructively sampled to look for evidence of EAB attack.

4. **Ash reduction and utilization.** DEC and other potential partners, including , US Forest Service, Cornell Cooperative Extension, NY Forest Owners Association, NY Society of American Foresters, and others, will provide outreach, information and technical assistance to private forest owners, forest owner organizations, private sector foresters, timber harvesters, wood-using industries, non-governmental environmental organizations and other State and local natural resource-related agencies to encourage reduction (and quarantine-compliant utilization) of ash within 20 miles of the infested "core action areas". Research has shown that that removal of merchantable ash trees from a forest as part of a comprehensive forest management plan can be an effective way to reduce the size of potential EAB infestations, and capture economic value before EAB attack.

5. **Conduct and collaborate in biocontrol research** with USDA Agricultural Research Service, USDA APHIS, USFS, and the academic research community. Research will include permitted release of approved parasitoids, monitoring of release sites and sampling of ash trees to determine fate of introduced parasitoids and rates of parasitism. Research activities to be coordinated through the NYS EAB Science Panel in close cooperation with USDA Agricultural Research Service, APHIS EAB researchers in Brighton, MI, academic researchers in Michigan and US Forest Service Forest Health program specialists. Activities will follow the Emerald Ash Borer Biological Control Program 5-Year Implementation Strategy (FY2010-2014), October, 2009,

(http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/eab-biocontrol-5yr-plan.pdf) and the Emerald Ash Borer Biological Control Release Guidelines published in 2010 by USDA APHIS, ARS and Forest Service, (http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/EAB-FieldRelease-Guidelines.pdf)

6. **Conduct and collaborate on insecticide research/trials/applications** with USDA APHIS, USFS, Cornell Cooperative Extension, academic researchers, community governments and land or homeowners to protect high-value, individual landscape ash trees. Provide outreach, information and education on available insecticides, techniques and decision-criteria to homeowners, communities, arborists and applicators. Latest insecticide options, criteria and protocols may be found on the EAB info website and in a 2009 publications from Herms, DA, McCullough DG, Smitley DR, Sadof C, Williamson RC and Nixon PL. 2009. Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin, 12 pp.

7. **Participate in National Ash Tree Seed conservation initiatives.** The USDA NRCS Rose Lake Plant Materials Center leads a cooperative "National Ash Tree Seed Collection Initiative" that involves USDA Natural Resources Conservation Service, USDA Forest Service, USDA Agricultural Research Service and other partners across the North American ash range. We will collaborate with this national effort to collect store ash seed for conservation purposes. NYSDEC will develop a program, following National guidelines, using staff and volunteers to collect, process and store seed at our Saratoga Tree Nursery and share our resources, capabilities and seed with the NRCS Rose Lake Plant Materials Center and the USFS National Seed Laboratory, which also is pursuing their own "Ash Genetic Conservation Plan" including seed collection and conservation.

8. **Annually evaluate and report on all activities** in writing, distributed to all partners and stakeholders, through electronic media, and through a stakeholder conference (dependent upon funding).

D. Outreach and Education

Continue public and stakeholder outreach and education. There are a great many organizations who have, or want to have authority and responsibility (and funding) for public and stakeholder outreach and education, addressing the needs of a wide range of audiences. It will be critical for all partners and players to work collaboratively to increase public awareness, observation, detection, reporting, regulatory compliance and appropriate voluntary landowner and ash tree-owner management responses. DEC has organized an EAB Outreach Team under its EAB Multi-Agency Coordinating Committee. This would be the appropriate place for all interested parties to come together to develop plans,

coordinate outreach efforts, develop budgets and funding requests, jointly advocate for additional funding and staffing and share resources. Numerous outreach and education initiatives are already underway, both specific to EAB and peripherally related through our on-going "don't' move firewood" and firewood regulation outreach. Cornell (Mark Whitmore) has an outreach grant from USDA APHIS that is supporting workshops and development of a Community Response Plan handbook. NYSDAM and the NY Chapter of The Nature Conservancy are partnering in an EAB awareness and outreach project, also funded by USDA APHIS, that includes community workshops, declaration of August as "Forest Pest Awareness Month", and training of citizen volunteers to aid in EAB surveying and reporting. NYSDEC has an on-going program focusing on our firewood regulation (DEC-funded) and EAB-specific outreach focusing on campers, private campground owners, firewood dealers, forest owners, homeowners and the general public (with USDA APHIS and USF funding). Various County Cooperative Extension agencies are also involved in local EAB outreach activities and the State's new Partnerships for Regional Invasive Species Management, or PRISMs, are also becoming more engaged in EAB outreach efforts targeting a variety of audiences.

E. Quarantine Enforcement

Quarantines to restrict the human-assisted movement of EAB on ash material and products are an important element of the overall State and Federal response to EAB and complement to the Bureau of Private Land Services' EAB management response plan. Three agencies, USDA APHIS, NYSDAM and NYSDEC, each have regulatory authority and have imposed parallel quarantines that regulate the interstate (APHIS) and intra-state movement (NYSDAM and NYSDEC) of "regulated articles", including EAB itself, ash logs, green (not kiln-dried) ash lumber, ash nursery stock and firewood, of all species. Each of these agencies has committed to enforcing the EAB quarantine regulations and have agreed to cooperate and coordinate their enforcement efforts.

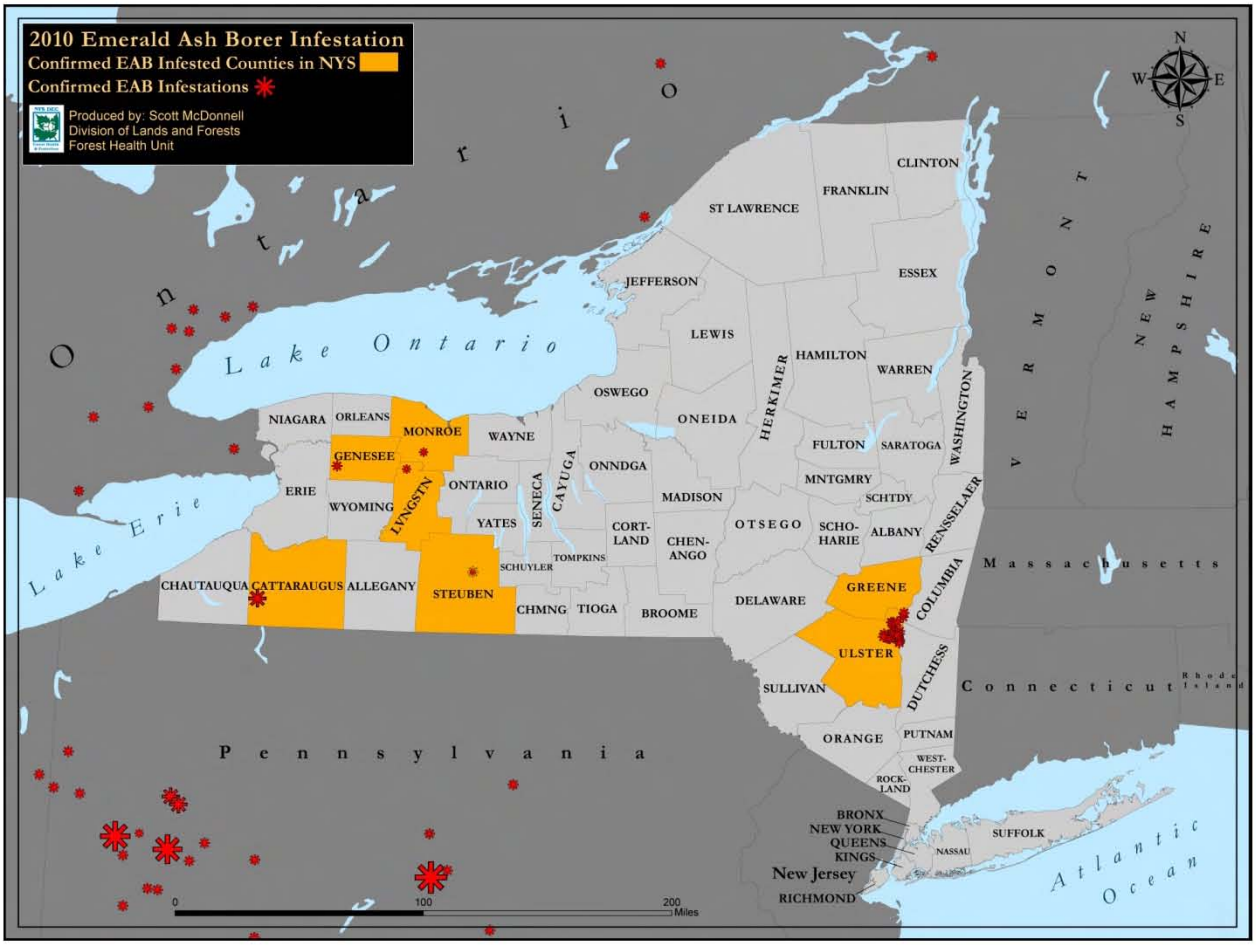
In addition to the expanded EAB quarantines, NYSDEC adopted regulations on the import and movement of firewood 2 ½ years ago which complement and support the EAB regulations. DEC's firewood regulations prohibit the movement of untreated firewood into the State, mandate source-identification and labeling of untreated, NYS-produced firewood, and limit the movement of NYS-produced, untreated firewood to no more than 50-miles from its declared source. The regulation also established treating standards for firewood, requiring it be heat-treated to a core temperature of 71C (160F) for 75 minutes.

The Bureau of Private Land Services is not a law enforcement program and does not have enforcement authority. Therefore, it does not have any direct role in organizing, staffing or conducting enforcement actions. However, The Bureau and Division are committed to supporting Law Enforcement actions to enforce

the EAB quarantine and DEC firewood regulations, and works closely with DEC Law Enforcement to provide training office and field staff support and resources (such as trailers to handle confiscated firewood) to support enforcement efforts. The bureau will continue to work with all Law Enforcement and regulatory authorities to pursue and assist, as appropriate, with enforcement actions that support our EAB and firewood regulations, and serve our goal of keeping as many ash trees alive as possible, in as much of New York State as possible, for as long as possible.

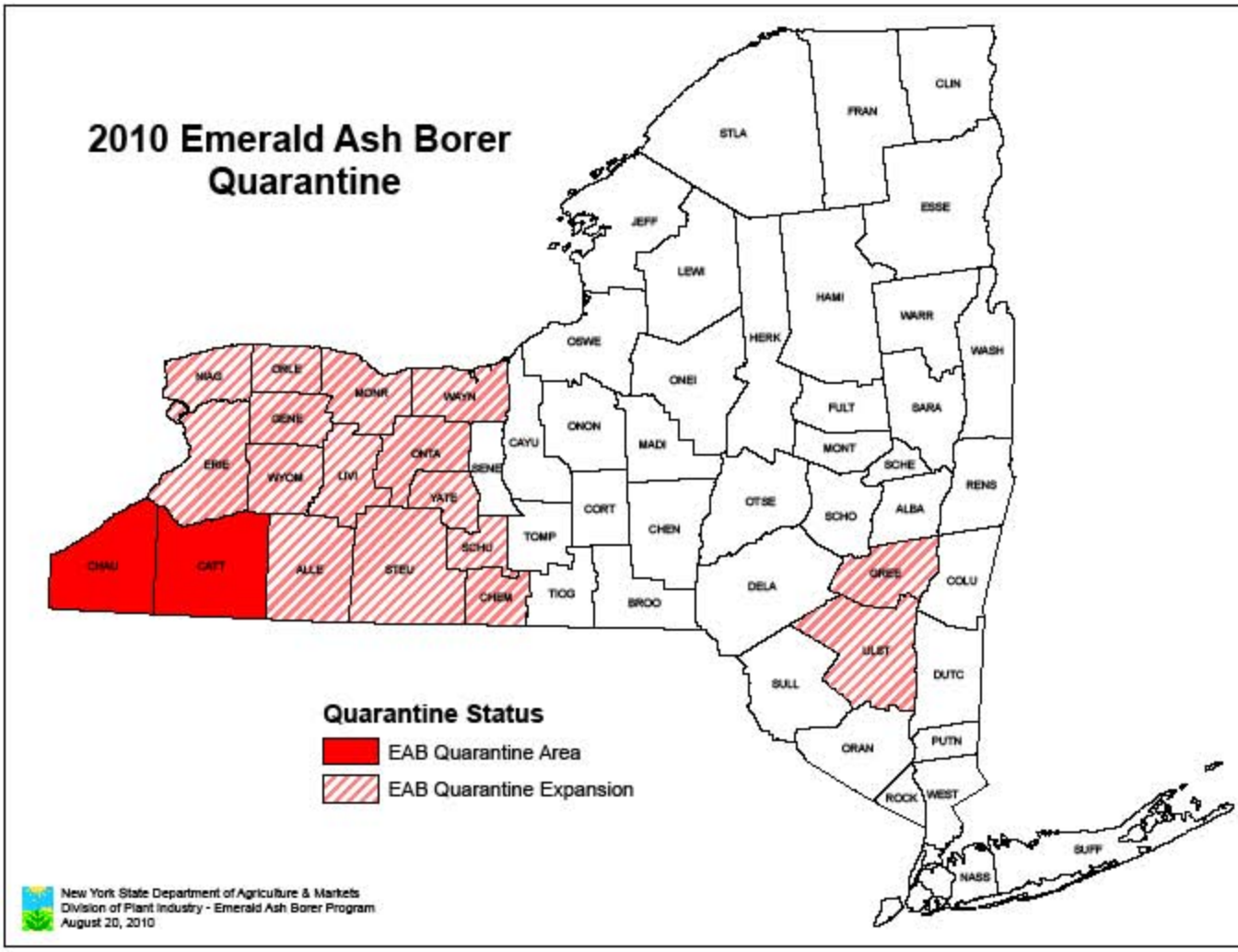
Appendix B.

Location of detected EAB occurrences in New York as of September 17, 2010.



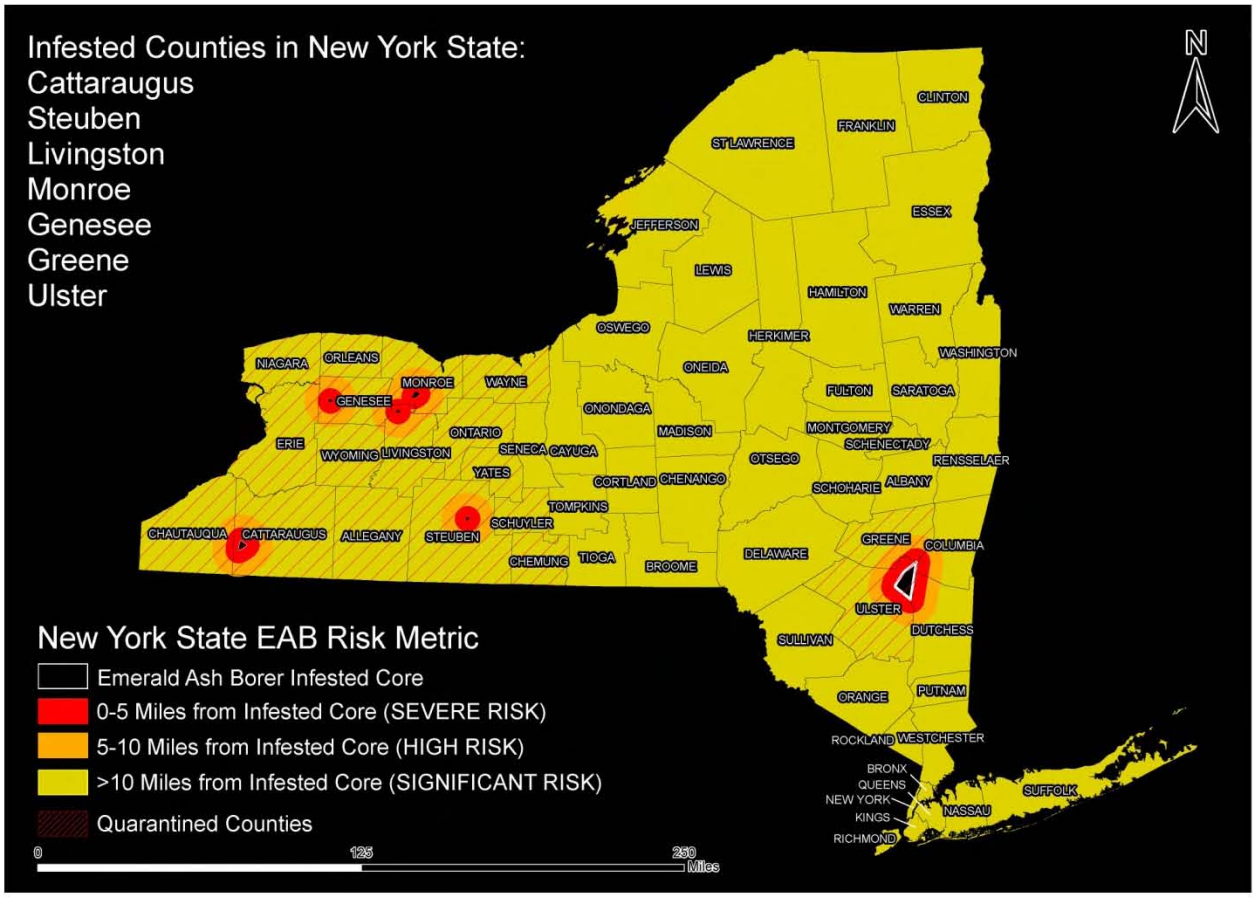
Appendix C.

NYSDEC and NYSDAM EAB quarantine areas, imposed in September, 2010.



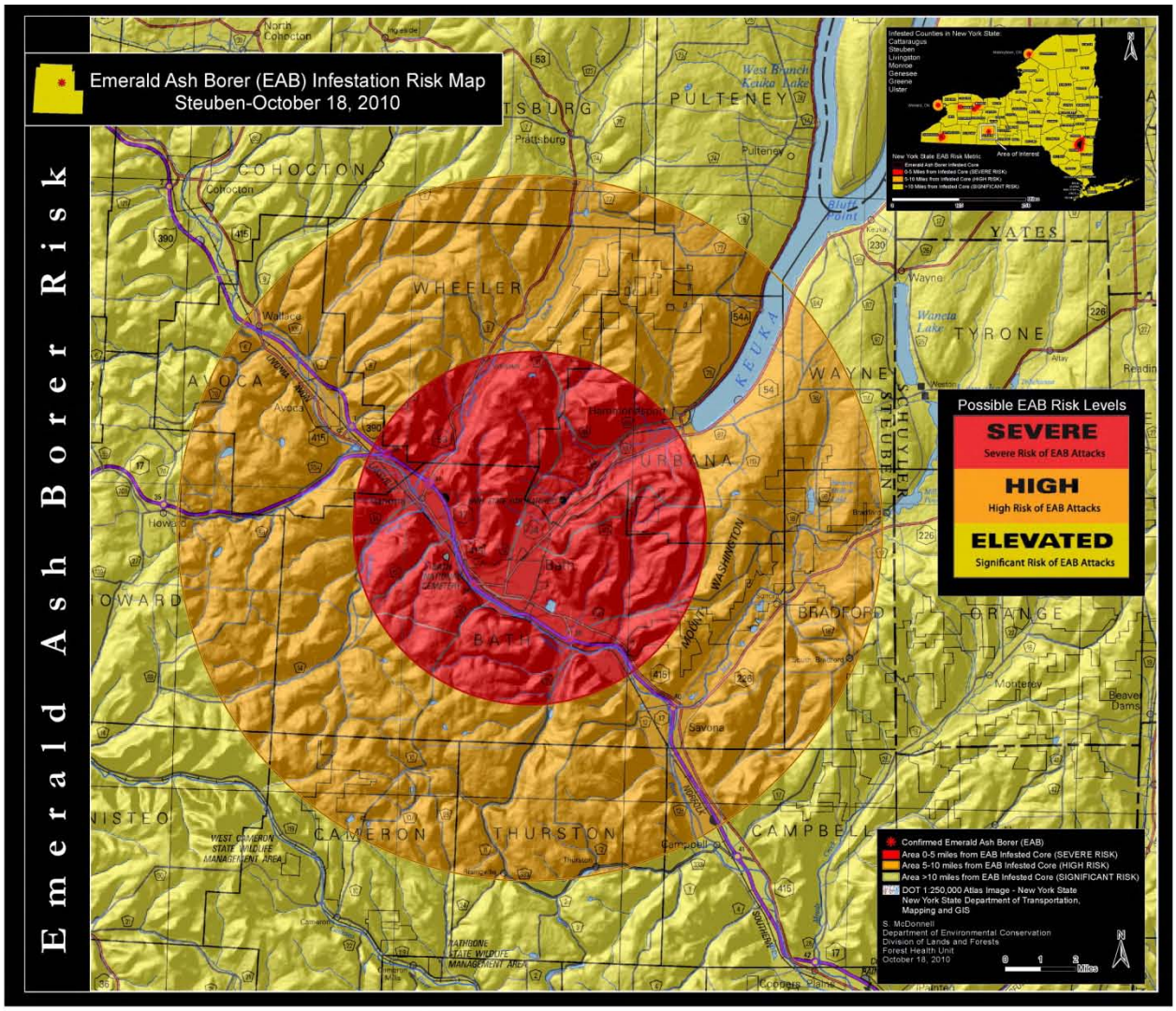
Appendix D.

Detected and delimited EAB occurrences in NYS, as of 10/1/10

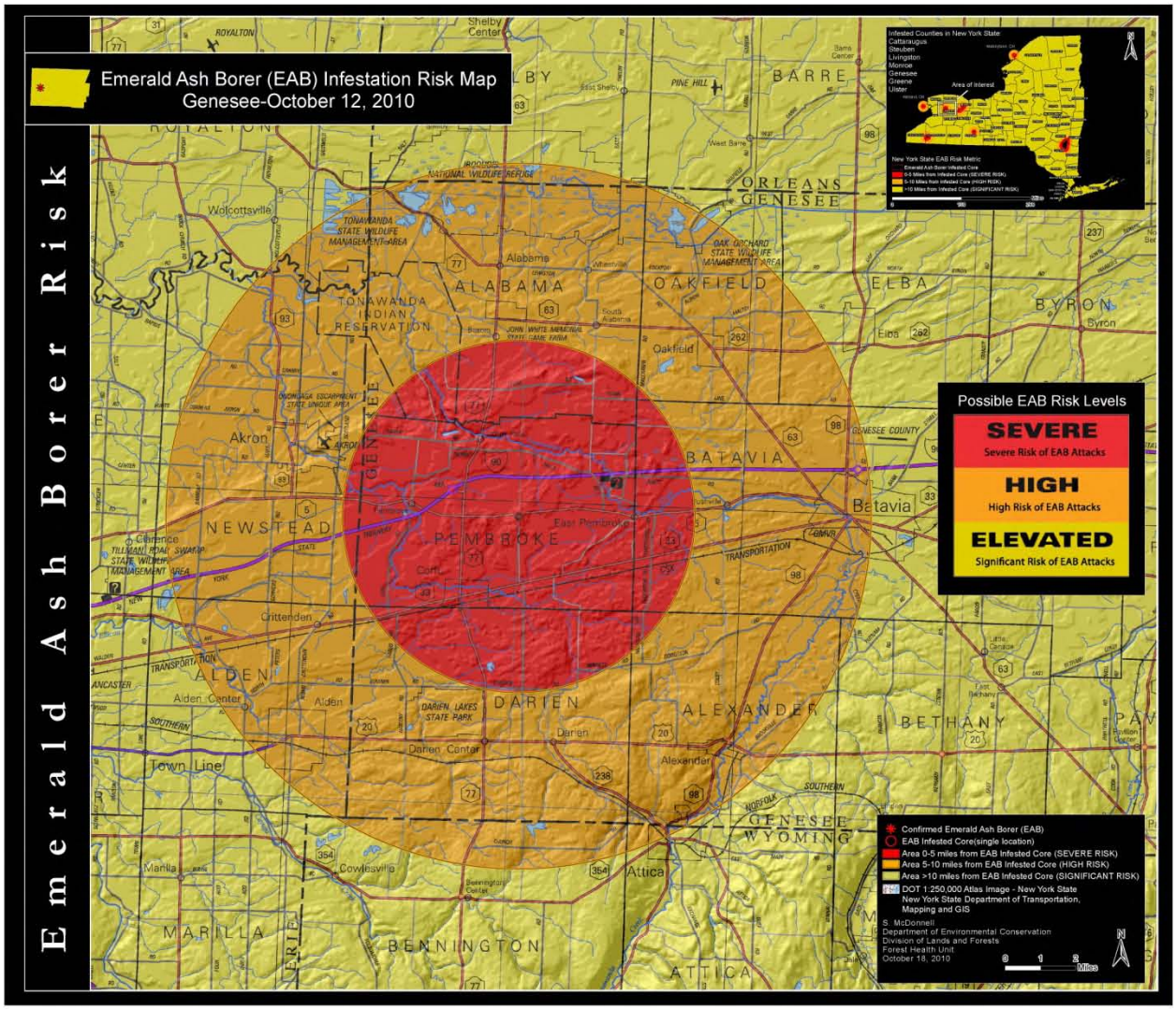


Appendix E.

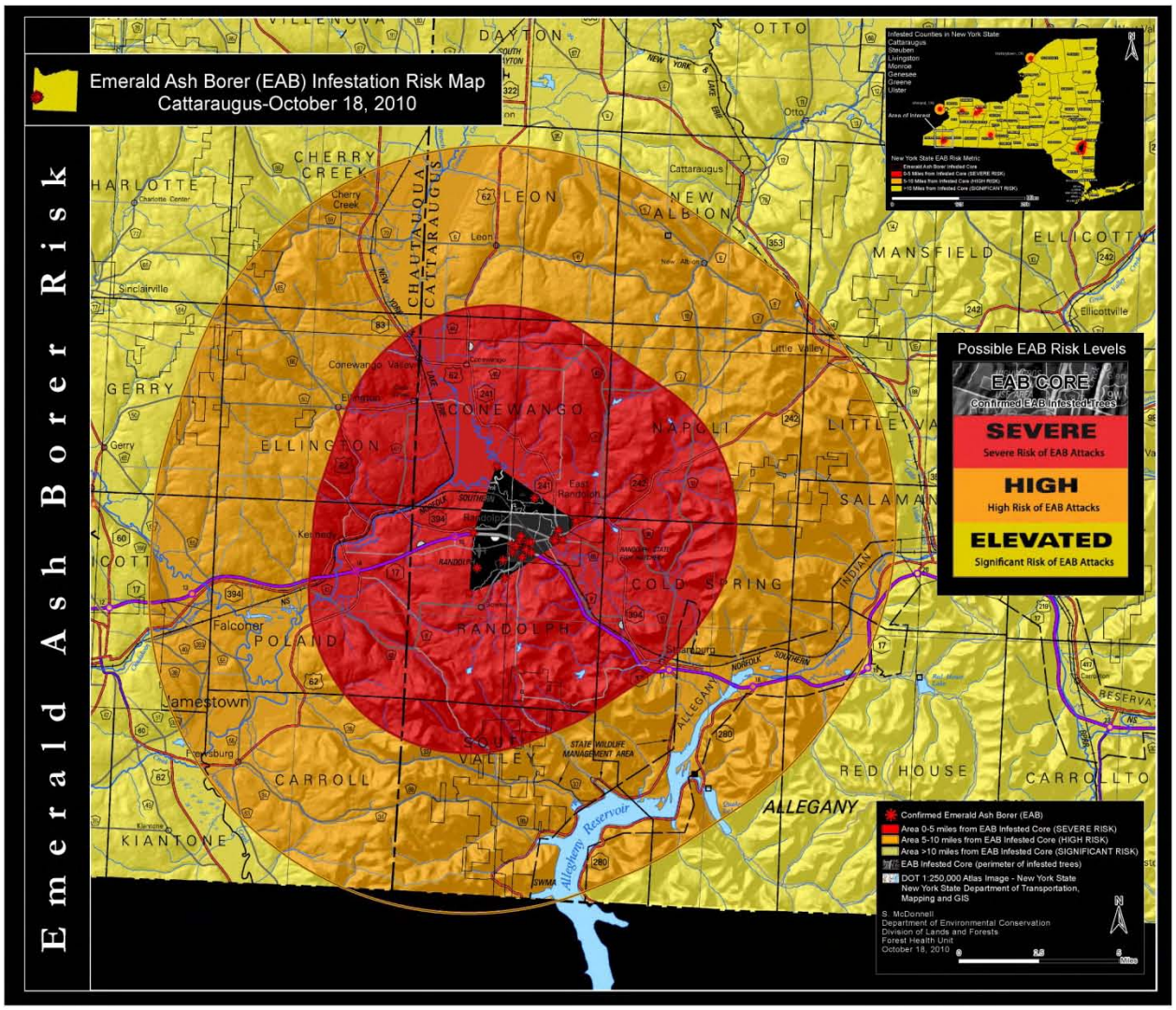
Steuben County EAB satellite occurrence, Tier 1



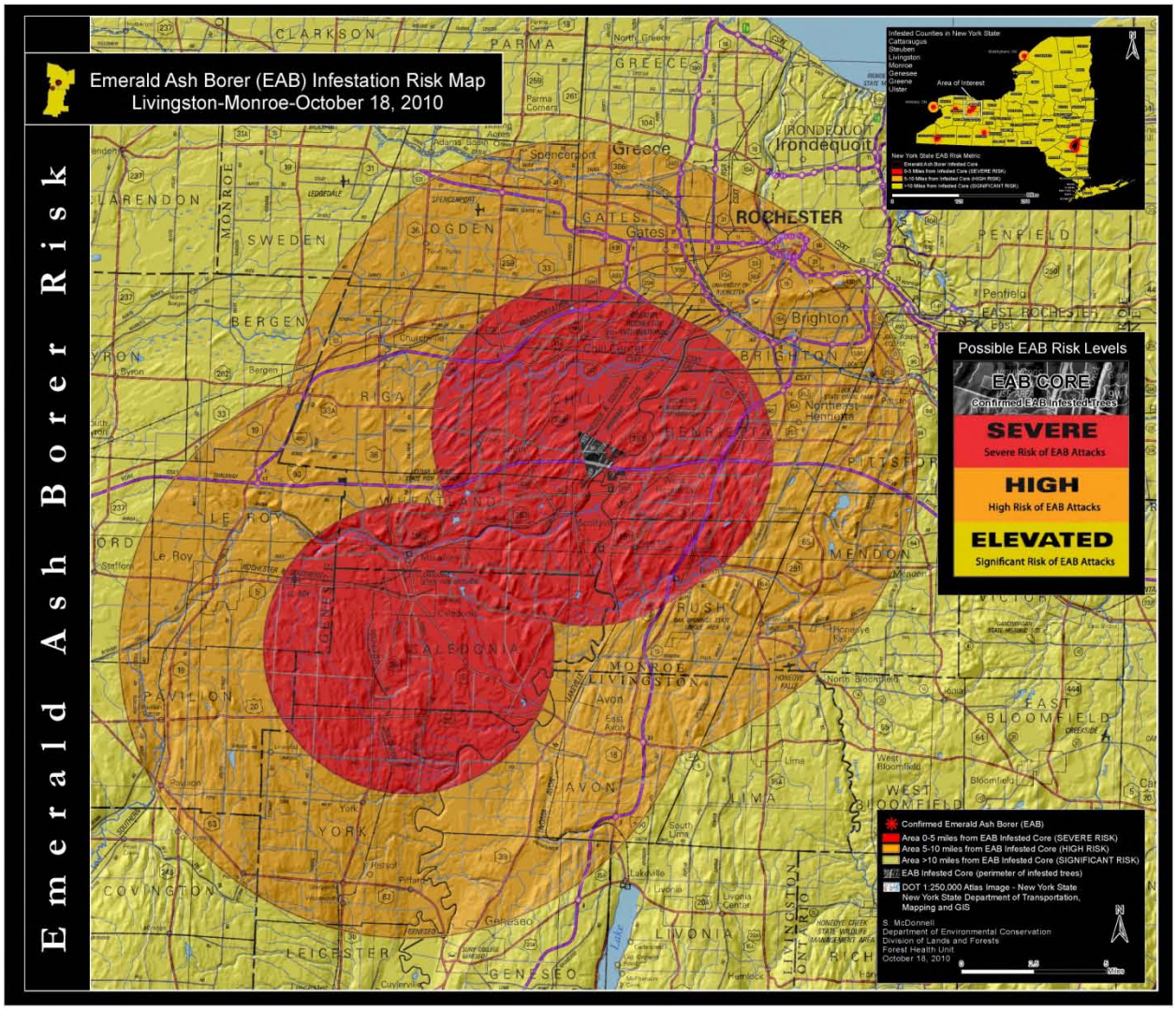
Genesee County EAB satellite occurrence, Tier 1



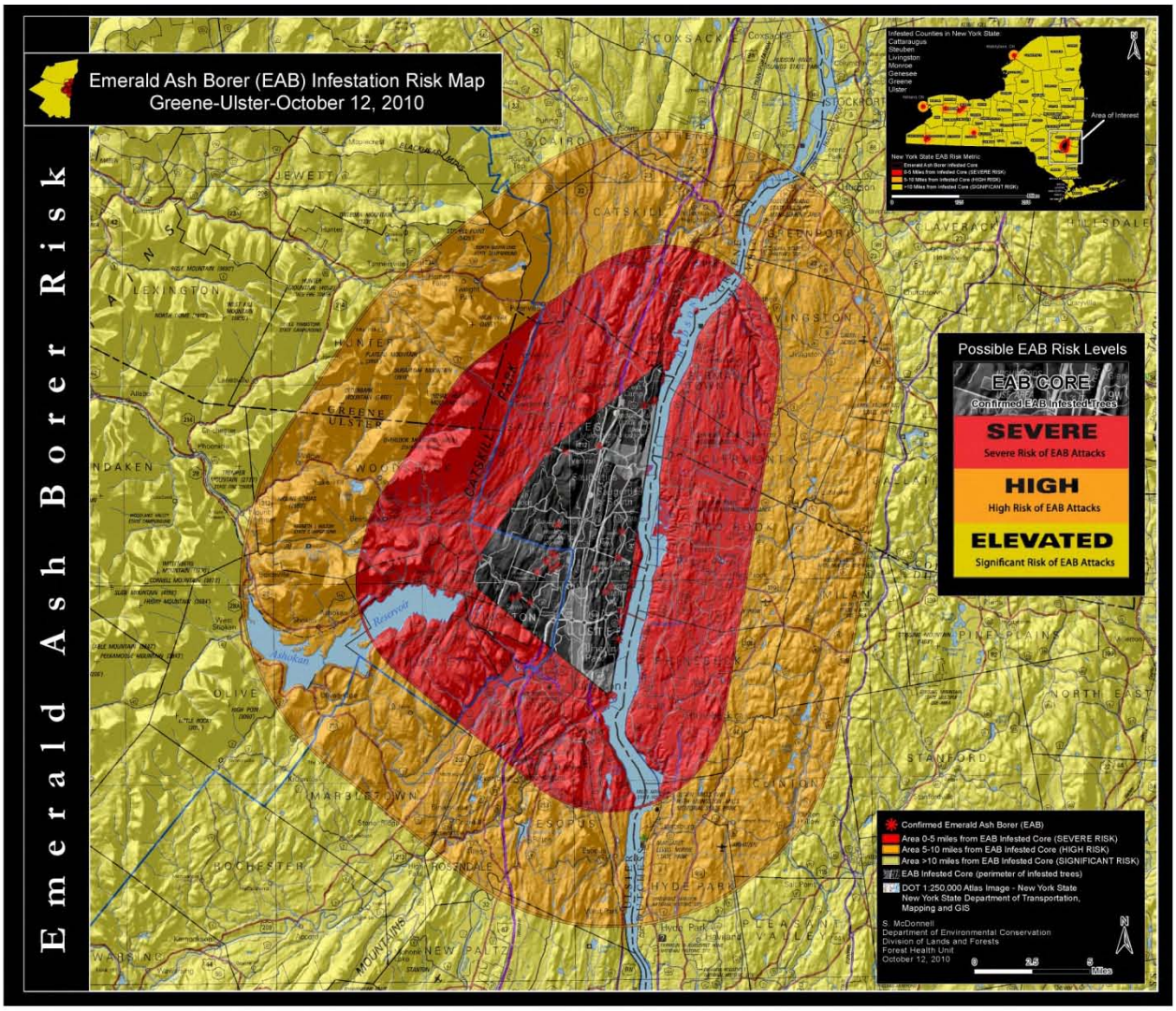
Cattaraugus County EAB satellite occurrence, Tier 2



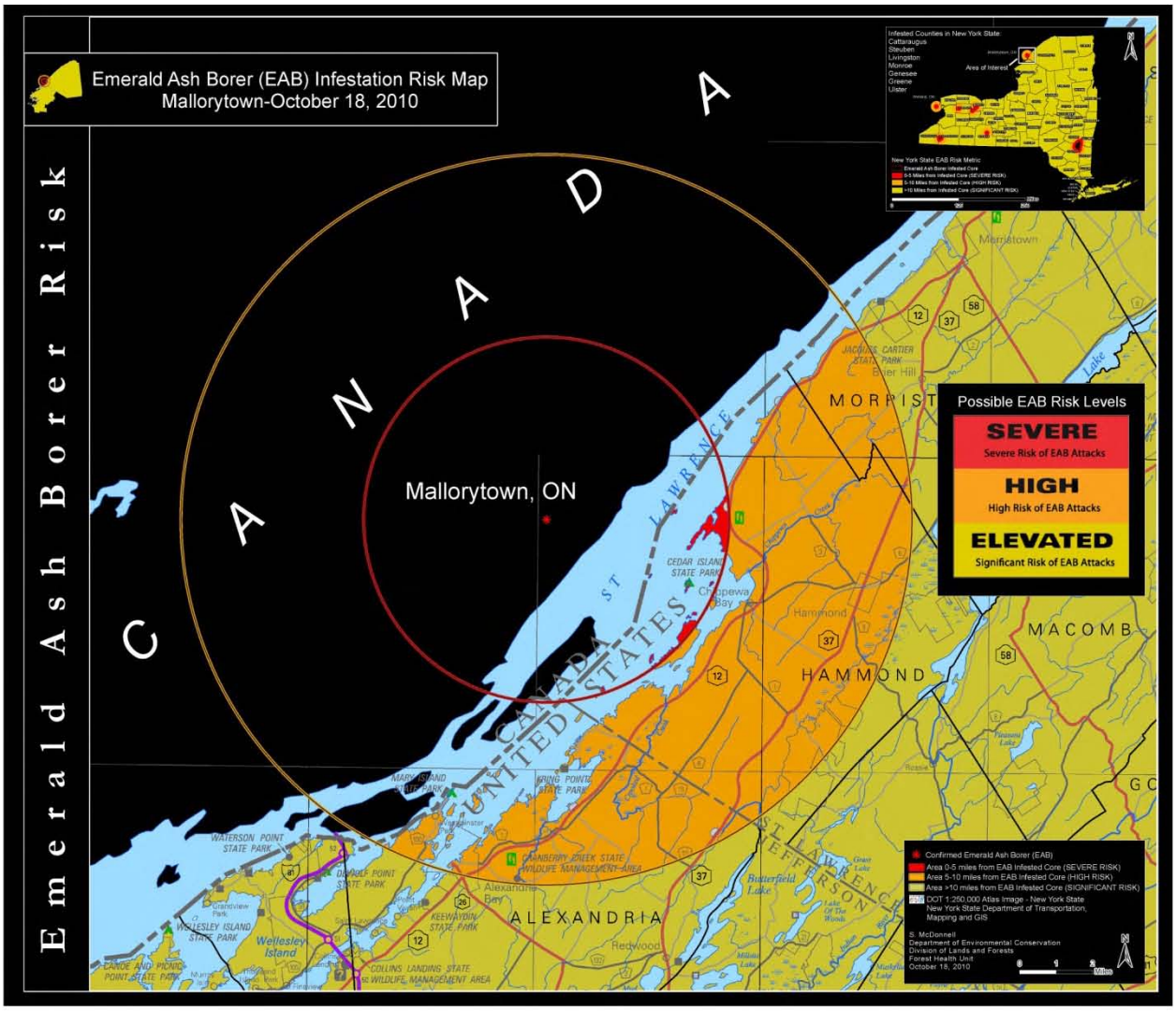
Livingston/Monroe EAB satellite occurrence(s), Tier 2



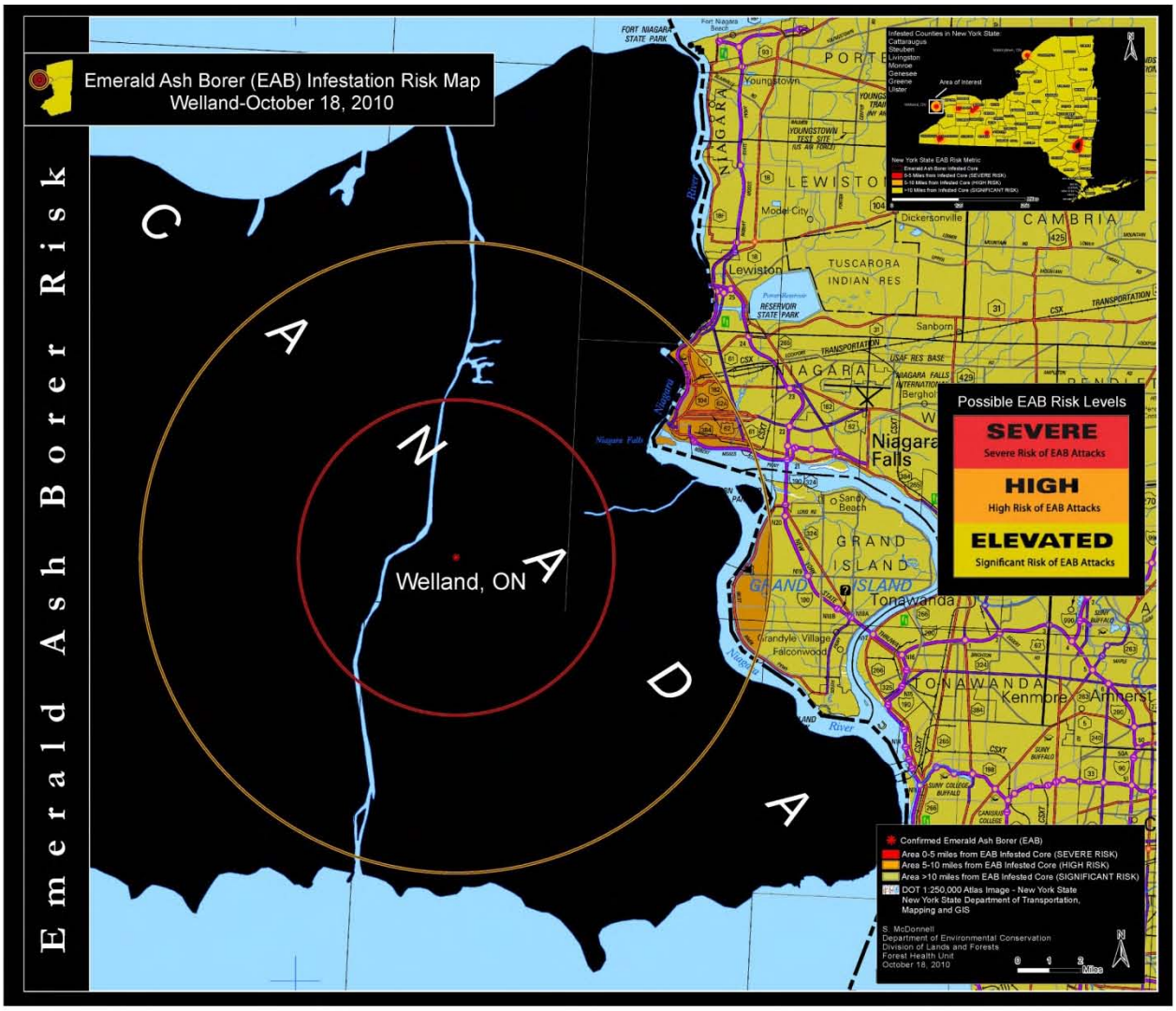
Ulster Greene EAB satellite occurrence (Tier 3)



Mallorytown, Ontario, Canada EAB detection (Tier unknown, presented as Tier 1)



Welland, Ontario, Canada detection (Tier unknown, presented as Tier 1)



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.

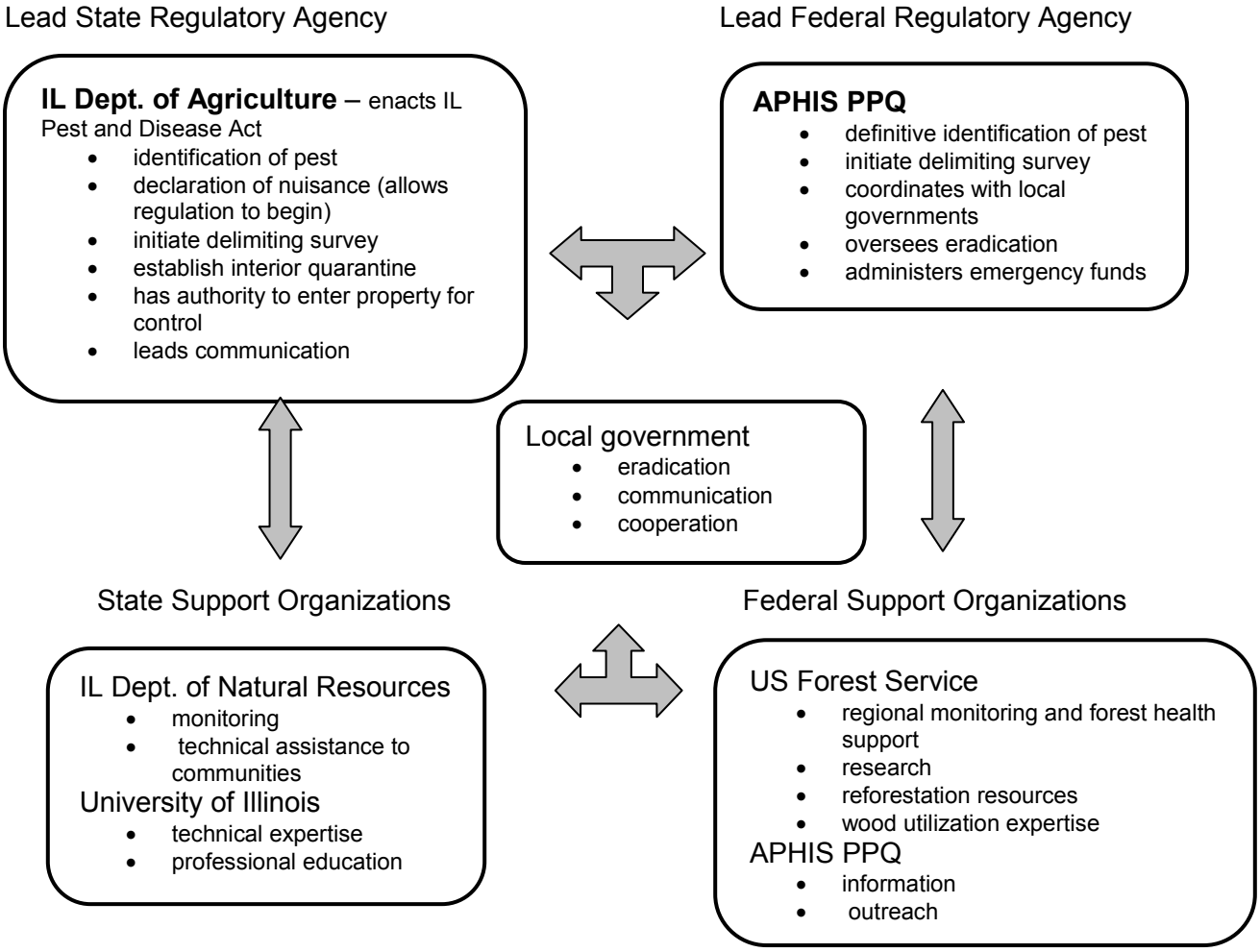
- Invasive Species Manager's Toolkit
  http://www.invasivespecies.gov/toolkit/main.shtml

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



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. <u>Administrative Readiness</u>
      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. <u>Technical Readiness</u>
      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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