Davey Resource Group

November 2020

BETHLEHEM STREET TREE INVENTORY ANALYSIS AND MANAGEMENT PLAN

Prepared for:

Town of Bethlehem
Town Hall
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VISION STATEMENT

The Town of Bethlehem maintains a healthy street tree canopy using best arboricultural practices. The street tree canopy is equitably distributed and provides a wide range of physical and mental health benefits. It has positive impacts on property values, pedestrian travel, and calms vehicular traffic. Street trees are carefully selected and planted in appropriate places and there are few to no conflicts with utilities and roadway intersections. Street trees mitigate some of the impacts of the changing climate as they improve stormwater management, reduce the urban heat island effect, increase carbon dioxide storage, and minimize the risk posed by invasive plant and insect species and diseases. This vision will ensure canopy continuity, which will reduce stormwater runoff and improve aesthetic value, air quality, and public health.

ACKNOWLEDGMENTS

Bethlehem is thankful for the grant funding it received from the New York State Department of Environmental Conservation (NYSDEC). The Town of Bethlehem *Street Tree Inventory Analysis and Management Plan* was financially supported by a 2019 NYSDEC Urban and Community Forestry grant. The funding is made available through New York State's Environmental Protection Fund, providing crucial assistance for communities to help develop and implement comprehensive projects to create healthy forests and enhance quality of life for residents.

Project staff is grateful for the volunteer efforts of the Street Tree Advisory Committee, who participated in committee meetings and contributed their insight into how to improve Bethlehem's street tree canopy:

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EXECUTIVE SUMMARY

This plan was developed for the Town of Bethlehem, New York by Davey Resource Group, Inc. "DRG" with a focus on addressing short-term and long-term maintenance needs for inventoried public street trees. DRG completed a tree inventory to gain an understanding of the needs of the existing public trees and to project a recommended maintenance schedule for tree care. Analysis of inventory data and information about the Town's existing program and vision for the street tree canopy were utilized to develop this *Street Tree Inventory Analysis and Management Plan*. Also included in this plan are economic and environmental benefits provided by the inventoried trees in Bethlehem.

State of the Inventoried Tree Population

The public tree inventory was conducted in September and October of 2019 and included trees, stumps, and planting sites along state and county road rights-of-way (ROW), trees and stumps along town road ROWs, and trees and stumps in specified parks (4) and public facilities (3). A total of 6,649 sites were recorded during the inventory: 4,849 trees, 143 stumps, and 1,657 planting sites. Analysis of the tree inventory data found the following:

- On the street ROW, maple (*Acer* spp.) were found in abundance (31%), which is a concern for Bethlehem's biodiversity.
- One species, Norway maple (*Acer platanoides*), comprises a large percentage of the street ROW (11%), also a concern for biodiversity.
- The size class distribution of the inventoried tree population trends toward the ideal, with a greater number of young trees than established, maturing, or mature trees.
- The overall condition of the inventoried tree population is rated Fair.
- Approximately 48% of the inventoried trees had dead and dying parts.
- Overhead utilities interfering with street trees occur among 3% of the inventoried population.
- Asian longhorned beetle (*Anoplophora glabripennis*) and spotted lanternfly (*Lycorma delicatula*) pose the biggest threat to the health of the inventoried population.

Environmental, Economic, and Social Benefits of Trees

The trees growing along public streets constitute a valuable community resource. Their shade and beauty contribute to a community's quality of life and soften the hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide numerous tangible and intangible environmental (pollution control, stormwater management, wildlife habitat), economic (higher property value, energy reduction), and social (education, aesthetics, human health and safety) benefits that can justify the time and money invested in planting, pruning, protection, and removal. Various examples of the benefits derived from trees are shown in the following figure.

Environmental Benefits

- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. One hundred mature tree crowns intercept roughly 100,000 gallons of rainfall per year (United States 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.

Economic Benefits

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

Social Benefits

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

Tree Benefit Analysis

Up until recently, the services and benefits of trees in urban and suburban settings were once considered difficult to quantify. Using extensive scientific studies and practical research, these benefits can now be estimated using tree inventory information. One such tool is i-Tree, a program based on peer-reviewed, United States Forest Service research. An analysis was used to provide insight into the overall health of the town's public trees and the management activities needed to maintain and increase the benefits of trees into the future. The results are presented in this report, and summarized below:

Photograph 1. The Town of Bethlehem recognizes that its public tree resource is critical to ecosystem health and economic growth. Planning and action are central to promoting and sustaining the street tree canopy in town.

- Bethlehem's trees have an estimated replacement (structural) value of $8,419,176.
- The inventoried trees provide approximately $14,927 in the following annual benefits:
  - *Carbon sequestration*: valued at $5,575 per year.
  - *Air pollution removal*: 1,844 pounds of pollutants removed valued at $2,357 per year.
  - *Avoided stormwater runoff*: 104,640 cubic feet (ft^3) avoided valued at $6,995 per year.
  - *Total carbon stored*: 3,337 tons valued at $569,135.

Street Tree Program Needs

Recommended maintenance needs include: Tree Removal; Stump Removal; Routine Pruning; Young Tree Training; and Tree Planting. Maintenance should be prioritized by addressing trees with the highest Risk first. Low and Moderate Risk trees should be addressed after all elevated risk tree maintenance has been completed. Trees should be planted to mitigate the negative effects of removals and to create canopy. A summary of the program needs is presented in Figure 2.

Tree Removal: Trees that have been rated High Risk should be removed or pruned immediately. The removal of stumps is a lower priority.

Young Tree Training and Routine Pruning: Inventoried trees 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.

New Tree Plantings: Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). Planting a variety of species each year will offset these losses, increase canopy, maximize benefits, and account for ash tree loss, based on a five-year plan.

Tree Removal

- Total = 328 trees
- Extreme Risk = 1 tree *(determined to be located on private property)*
- High Risk = 3 trees
- Moderate Risk = 36 trees
- Low Risk = 288 trees

5-Year Routine Pruning Cycle

- Total = 3,527 trees
- Include 59 "priority prune" trees (58 low and 1 moderate risk rating) in 1st year
- Number of trees in cycle each year = approximately 705

3-Year Young Tree Training Cycle

- Total = 994 trees
- Number of trees in cycle each year = at least 331

Tree Planting & Stump Removal

- Annual plantings = at least 331
- Stumps = 143

Town-wide tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy.

Town of Bethlehem Tree Management Program

As shown in the figure below, adequate funding will be needed for the Town to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $428,721. This total will decrease to approximately $267,000 per year by Year 4 of the program.

Year 1 — **$428,721**

- **3 High Risk Removals**
- **162 Moderate or Low Risk Removals**
- **44 Stump Removals**
- **RP Cycle: 1/5 of Public Trees Cleaned**
- **Young Tree Training (YTT) Cycle: 331 Trees**
- **541 Trees Recommended for New and Replacement Planting and Follow-Up Care**
- **Newly Found Priority Tree Work (Removal or Pruning): Costs To Be Determined (TBD)**

Year 2 — **$421,547**

- **162 Low Risk Removals**
- **49 Stump Removals**
- **RP Cycle: 1/5 of Public Trees Cleaned**
- **YTT Cycle: 331 Trees**
- **542 Trees Recommended for new and replacement Planting and Follow-Up Care**
- **Newly Found Priority Tree Work (Removal or Pruning): Costs TBD**

Year 3 — **$294,507**

- **50 Stump Removals**
- **RP Cycle: 1/5 of Public Trees Cleaned**
- **YTT Cycle: 332 Trees**
- **381 Trees Recommended for New and Replacement Planting and Follow-Up Care**
- **Newly Found Priority Tree Work (Removal or Pruning): Costs TBD**

Year 4 — **$266,987**

- **RP Cycle: 1/5 of Public Trees Cleaned**
- **YTT Cycle: 331 Trees**
- **331 Trees Recommended for Planting and Follow-Up Care**
- **Newly Found Priority Tree Work (Removal or Pruning): Costs TBD**

Year 5 — **$266,657**

- **RP Cycle: 1/5 of Public Trees Cleaned**
- **YTT Cycle: 331 Trees**
- **331 Trees Recommended for Planting and Follow-Up Care**
- **Newly Found Priority Tree Work (Removal or Pruning): Costs TBD**

These cost estimates are based on private contractor rates. It is expected that implementation of the Plan will be undertaken by various Town departments and use of Town Highway Department staff for tree care management would occur when resources and schedule allow. Utilizing Town staff to perform the work would allow the costs to be realized over annual budgeting operations.

High-priority tree removal and pruning is costly; since most of this work is scheduled during the first several years of the program, the budget is higher for those years. After high-priority work has been completed, the management program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower. Tree planting to fill vacant sites can also be spread over a longer period than the five years of the management plan, lowering planting and young tree maintenance costs each year. These cost estimates are based on contractor rates.

The implementation table following on the next page summarizes next steps by Town Departments.

Implementation Step	Responsible Department(s)
Update inventory database to reflect trees removed to date	Economic Development and Planning Department and Highway Department
Verify ROW for any remaining High Risk Trees	Department of Public Works
Perform Maintenance on/Remove High Risk Trees	Highway Department
Capture Tree Removals in Database Update	Economic Development and Planning Department
Verify ROW for Moderate Risk Trees	Department of Public Works
Perform Level III Risk Assessments	Highway Department
Perform Maintenance on/Remove Moderate Risk Trees	Highway Department
Discuss and decide a Town EAB strategy	Highway Department and Economic Development and Planning Department
Capture Tree Removals in Database Update	Economic Development and Planning Department
Closely Monitor and/or Inspect All Trees Recommended for Further Inspection	Highway Department
Verify ROW for Low Risk Removals	Department of Public Works
Remove Low Risk Trees	Highway Department
Capture Tree Removals for Database Update	Economic Development and Planning Department
Begin 5 Year Routine Pruning Cycle	Highway Department
Begin 3 Year Young Tree Training Cycle	Highway Department
Verify ROW for Stumps	Department of Public Works
Remove Stumps	Highway Department
Verify ROW for Identified Planting Sites as Trees are Planted	Department of Public Works and Highway Department
Expand Planting Program	Supervisor’s Office

Town Programs and Knowledge Resources

The Town's existing programs are detailed in this section of the plan. Knowledge resources for the Town include a planting list, guidance for tree planting with development projects, a review of Town Code related to street trees and recommendations for future changes, and notes on how the climate crisis may impact street trees or change their benefits or management.

Pest and Disease Risk Management

Pests and diseases pose serious risk to tree health. Awareness and early diagnosis are essential to ensuring the health and longevity of urban trees. Pests and diseases can 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. Additionally, a case study of a management program is presented in the report as an example of a typical management plan for the control of invasive pests and disease. Asian longhorned beetle (ALB) (Anaplophora glabripennis), spotted lanternfly (SLF) (Lycorma delicatula), elongate hemlock scale (EHS) (Fiorinia externa), and gypsy moth (Lymantria dispar) are the pest species with the potential to impact the greatest portions of the inventoried trees. Emerald ash borer (EAB) is more of an immediate concern due to its known activity in the town.

Conclusion

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

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INTRODUCTION

The Town of Bethlehem is home to more than 35,000 full-time residents who enjoy the beauty and benefits of their urban forest. The Town's Highway Department manages and maintains trees on public property, including trees, stumps, and planting sites in specified parks, public facilities, and along the town street rights-of-way (ROW).

In September and October 2019, a tree inventory was conducted by DRG, the first ever tree inventory for Bethlehem which was then used to craft a preliminary management plan. While the Town does not currently have a dedicated urban forestry division, it is looking to expand its urban forest management efforts in the future by becoming a member of Tree City USA, reviewing and amending the Town Code in regards to street tree regulations, and using this management plan as a guide to effectively manage and improve the existing street tree population within Bethlehem.

The following tasks were completed by DRG:

- Inventory of trees, stumps, and planting sites along the street ROW in the primary study area and of trees and stumps along additional street ROWs and in selected parks and public facilities.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

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, build strategic planting plans, draft cost-effective budgets based on projected needs, and ultimately minimize the need for costly, reactive solutions to crises or urgent hazards. Several resident requests have been made to appoint a Town Arborist. Having a Town Arborist would help implement and guide recommended urban forestry management practices based on this Management Plan.

This *Standard Inventory Analysis and Management Plan* considers the diversity, distribution, and general condition of the inventoried trees and provides a prioritized system for managing public trees.

Inventory Scope

The inventory collected sites along streets and within specified parks and public facilities:

- State and county road rights-of-way (ROW), width varies – trees, stumps, and planting sites.
- Town road ROW, width varies – trees and stumps.
- Select parks and public facilities – trees and stumps.

Parks:

- Veteran's Memorial Park
- Selkirk Park (trees in the unmaintained areas and edges excluded)
- Firefighter's Memorial Park (trees in the unmaintained areas and edges excluded)
- Unnamed pocket park at the corner of Adams Place and Hawthorne Avenue

Public Facilities:

- Town Hall
- Kenwood Avenue Public Parking Lot
- Planters by Key Bank at the corner of Delaware Avenue and Kenwood Avenue

Management Plan Scope

The Standard Inventory Analysis and Management Plan is divided into five main sections with an additional section focused on specific Town programs and resources:

- *Section 1: Tree Inventory Analysis* – summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Benefits of the Urban Forest* – summarizes the economic, environmental, and social benefits that trees provide to the community; includes statistics from an i-Tree Eco benefits analysis.
- *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: Invasive Species and Detection and Management Strategy* – presents an overview of typical management strategies for invasive pests. Emerald ash borer and ash trees are provided as a case study.
- *Section 5: The Road to Tree City USA* – outlines the steps necessary to become a Tree City USA member.
- *Town Programs and Knowledge Resources* – A set of resources and guidance for Town staff in implementing the Management Plan.

SECTION 1: TREE INVENTORY ANALYSIS

In September–October 2019, contracted arborists assessed and inventoried trees, stumps, and planting sites along the street ROW and within specified parks and public facilities. A total of 6,649 sites were collected during the inventory: 4,849 trees, 143 stumps, and 1,657 planting sites (see Figure 1).

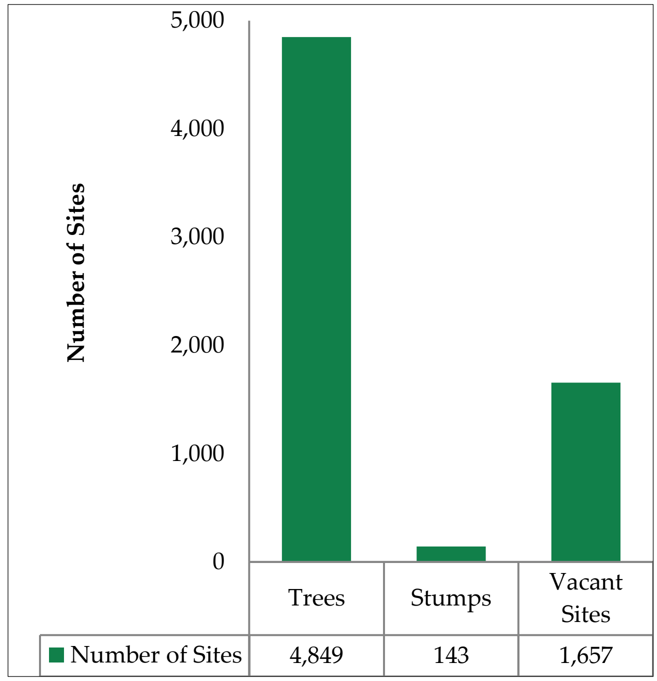


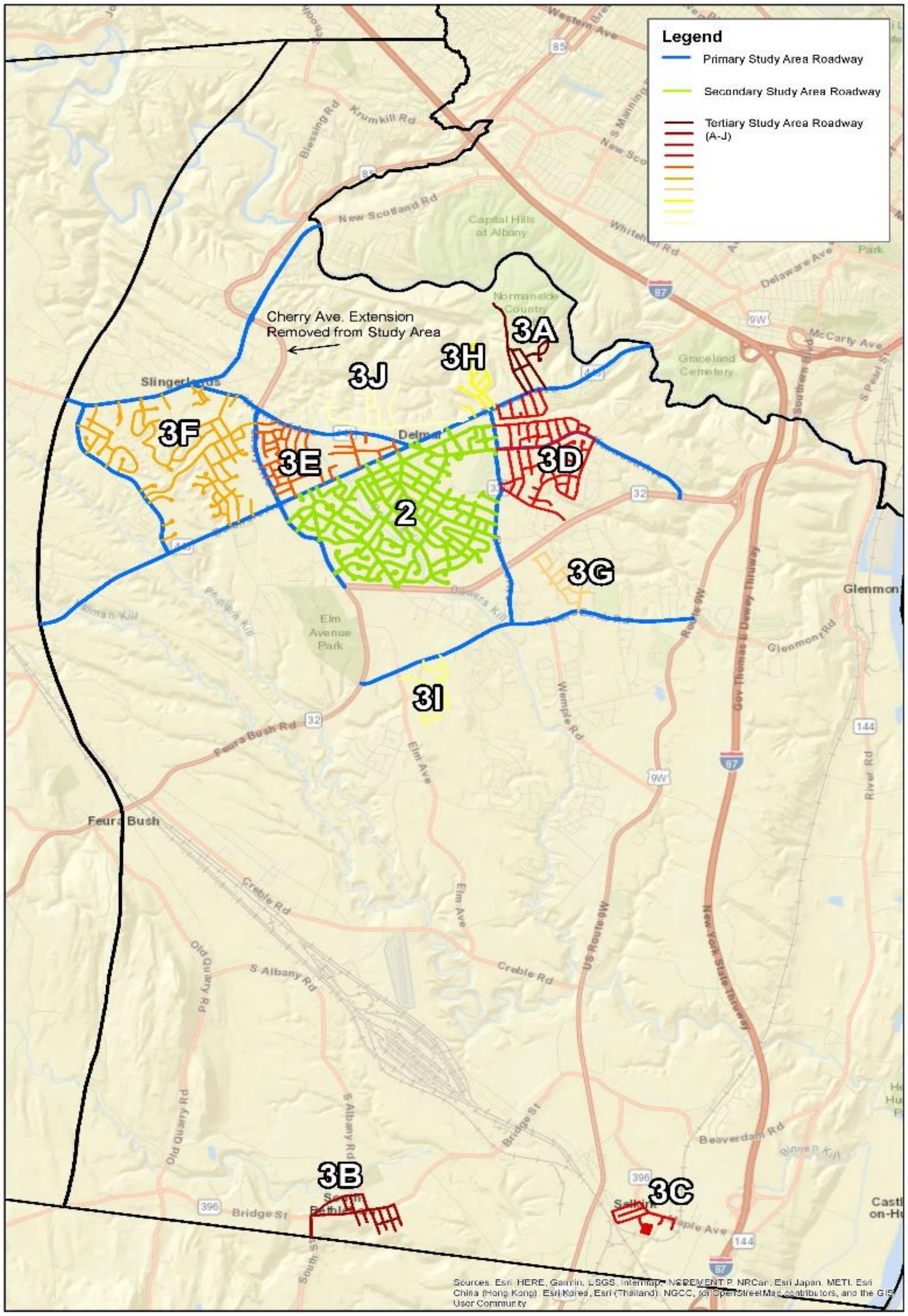
Figure 1. Summary of site types collected during the Bethlehem, NY tree inventory.

Map 1 provides a summary of the roads along which sites were collected in 2019. The selected streets and neighborhoods were identified based on Town leadership's knowledge of the presence of street trees. Principal arterials and collector roads in the town were selected since they provide the most opportunity for travelers to experience our street tree canopy. Neighborhood streets such as those in Slingerlands, Delmar, Elsmere, Selkirk, and South Bethlehem were selected since these are older established neighborhoods and were developed at a time when trees were permitted to be planted in the street right-of-way.

Around 1980, development design standards in the town changed, restricting the planting of trees in the street right-of-way due to concern for conflicts with underground public water, sanitary sewer, and stormwater infrastructure as well as private electric and internet infrastructure. This restriction is apparent in the street tree environment of residential neighborhoods south of the Delmar By-pass (generally known as Glenmont area), where street trees are absent from the street right-of-way. Trees planted in the front yards of homes are set back at least 23 feet from the edge of pavement on private property. As a result, neighborhoods in the Glenmont area were not included in the inventory except for Lauralana Heights and Colonial Acres, which were developed in the 1960s. Due to this design standard, planting sites were only collected within the primary study area along state routes (blue roads in Map 1).

The parks selected for the inventory included: Veteran's Memorial Park, Selkirk Park, Firefighter's Memorial Park, and the unnamed pocket park at the corner of Adams Place and Hawthorne Avenue. Trees in unmaintained areas and unmaintained edges of Selkirk Park and Firefighter's Memorial Park were excluded from the inventory. The public facilities selected for the inventory included: Town Hall, the Kenwood Avenue Public Parking Lot, and the planters by Key Bank at the corner of Delaware Avenue and Kenwood Avenue.

It is important to keep in mind that the inventoried trees account for only a fraction of the total trees within Bethlehem; trees on private property, trees within unmaintained areas of the ROW, and many publicly owned trees were not collected during the 2019 inventory. As a result, the analyses and recommendations contained in this report should not be considered representative of, or applicable to, the entire urban forest of Bethlehem.



Assessment of Tree Inventory Data

When analyzing the state of an inventoried tree population, data analysis and professional judgment are used to make generalizations and provide recommendations. Recognizing trends in the data can help guide short-term and long-term management planning.

The following criteria and indicators were assessed:

- *Species Diversity* refers to the variety of species in a specific population. It is used as an indicator of the population's ability to withstand threats from invasive pests and diseases and can inform tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Size Class Distribution* is the statistical distribution of a given tree population's trunk-size class as measured in diameter. It is used to estimate the relative age of a tree population and is used to calculate tree-related benefits and project maintenance needs and costs, planting goals, and canopy continuity.
- *Large Diameter Trees* provides a brief list of the largest diameter trees collected during the inventory.
- *Condition* describes the general health of a tree population. It is used to determine how well trees are performing given their site-specific conditions and can inform short-term and long-term maintenance needs and costs, as well as canopy continuity.

Photograph 2. Arborists inventoried trees to collect information that could be used to assess the state of the inventoried tree population in Bethlehem, NY.

- *Defects*, or structural flaws in a tree, can provide insight into past maintenance practices and growing conditions and may affect future management decisions. Not all trees have prominent structural defects, but when present the most significant condition is recorded.
- *Conflicts with Overhead Utilities* is used to identify the location of trees growing underneath overhead utility lines and further details whether the tree is conflicting with that utility line. This data can be used to help determine which trees should be routinely pruned by the utility company versus the Town.
- *Further Inspection* is used to identify trees that require additional inspection, such as a more involved Level III tree risk assessment (*ANSI A300, Part 9* (2011)), or placement on a periodic inspection cycle due to particular conditions that may cause the tree to be a future safety risk or hazard.
- *Pests and Diseases* outlines the biggest forest health threats to the town's trees. This information is based on the pests and diseases of special concern in New York as applied to their host tree species found within Bethlehem.

For more information on the tree inventory data collection methods used, see Appendix A (Data Collection and Site Location Methods).

Species Diversity

Species diversity affects maintenance costs, planting goals, canopy continuity, and the manager's ability to respond to threats from invasive pests or diseases. Low species diversity (a large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as chestnut blight, Dutch elm disease, and emerald ash borer.

Case Study: Dutch elm disease (*Ophiostoma novo-ulmi*)

Dutch elm disease is one of the most destructive shade tree diseases in the United States and Canada and has killed millions of elm trees since its introduction from Europe in 1930. Massive numbers of American elm (*Ulmus americana*), a popular street tree in midwestern cities and towns, perished (Karnosky 1979), leaving these communities stripped of most of their mature shade trees and creating a drastic void in canopy cover. In the wake of Dutch elm disease, ash and maple trees were popular direct replacements and were often overplanted, leaving these communities open to similar destruction from pests such as emerald ash borer (EAB) (*Agrilus planipennis*) and Asian longhorned beetle (ALB) (*Anoplophora glabripennis*). Maintaining a diverse urban forest is one of the best ways to prevent these wide-scale impacts.

The composition of a tree population should follow the 10-20-30 Rule for species diversity: a single species (e.g., silver maple [*Acer saccharinum*]) should represent no more than 10% of the urban forest, a single genus (ex: maple [*Acer*]) no more than 20%, and a single family (ex: maple [*Aceraceae*]) no more than 30%.

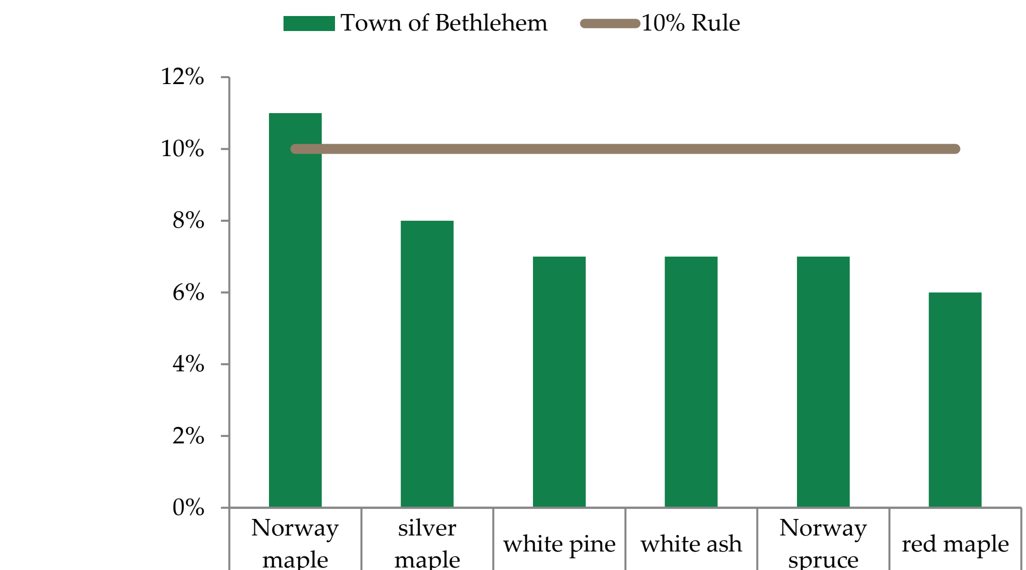
Analysis of Bethlehem's tree inventory data indicated that the inventoried tree population had relatively good diversity, with 52 genera and 109 species represented. Table 1 summarizes the tree species collected, specifically listing those comprising more than 2% of the total population.

Table 1. Most common tree species collected in Bethlehem, NY (greater than 2% of total trees)

Most Common Tree Species Collected During Inventory		Number Trees Inventoried	Percent of Total Trees
Common Name	Scientific Name		
Norway maple[1]	*Acer platanoides*	556	11.5%
silver maple	*Acer saccharinum*	381	7.9%
eastern white pine	*Pinus strobus*	341	7.0%
white ash	*Fraxinus americana*	329	6.8%
Norway spruce	*Picea abies*	322	6.6%
red maple	*Acer rubrum*	303	6.2%
apple	*Malus* spp.	197	4.1%
northern white cedar	*Thuja occidentalis*	189	3.9%
eastern hemlock	*Tsuga canadensis*	140	2.9%
blue spruce	*Picea pungens*	129	2.7%
sugar maple	*Acer saccharum*	124	2.6%
northern red oak	*Quercus rubra*	103	2.1%
white mulberry	*Morus alba*	102	2.1%
green ash	*Fraxinus pennsylvanica*	101	2.1%
other street trees		1,532	31.6%
Inventory Total		4,824	100.0%

[1] Includes 'Crimson King' cultivar of *Acer platanoides*.

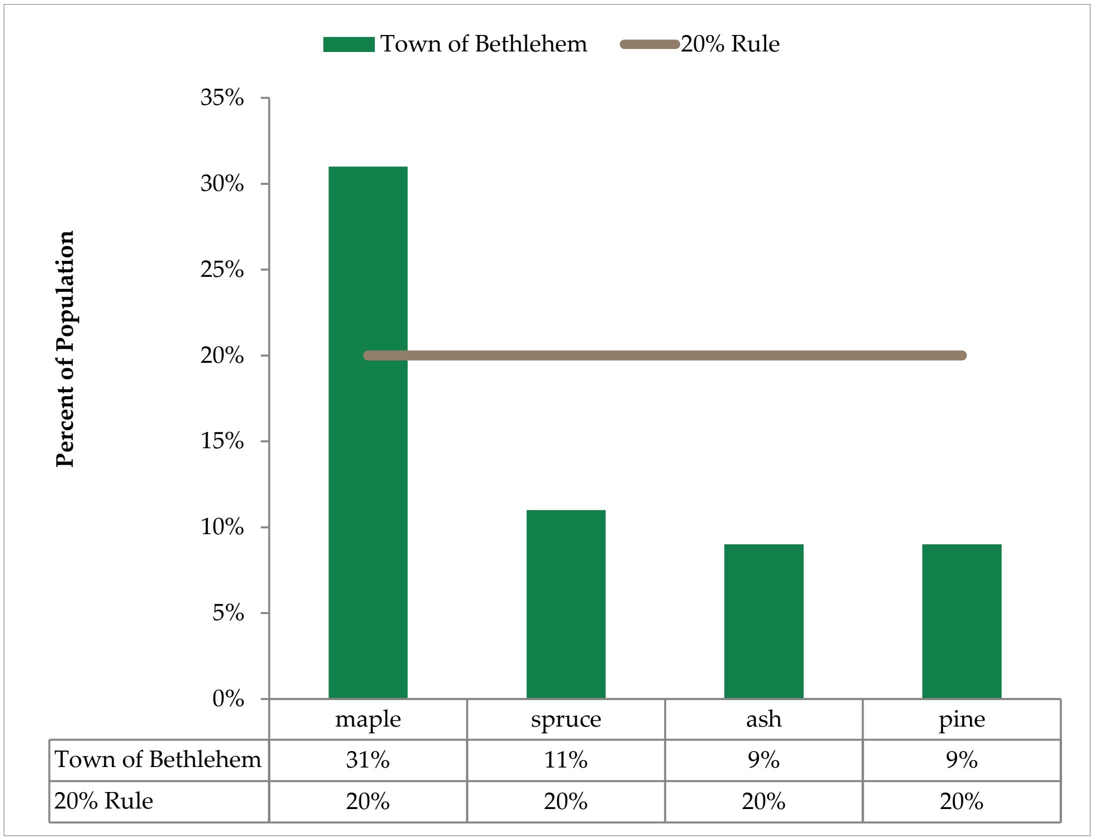
Figure 2 compares the six most common species identified during the inventory to the 10% Rule (a single species should represent no more than 10% of the urban forest). Only Norway maple exceed the recommended 10% maximum for a single species in a population, comprising over 11% of the inventoried tree population. Other common species include silver maple (*Acer saccharinum*, 8%), eastern white pine (*Pinus strobus*, 7%), white ash (*Fraxinus americana*, 7%), Norway spruce (*Picea abies*, 7%), and red maple (*A. rubrum*, 6%).



	Norway maple	silver maple	white pine	white ash	Norway spruce	red maple
Town of Bethlehem	11%	8%	7%	7%	7%	6%
10% Rule	10%	10%	10%	10%	10%	10%

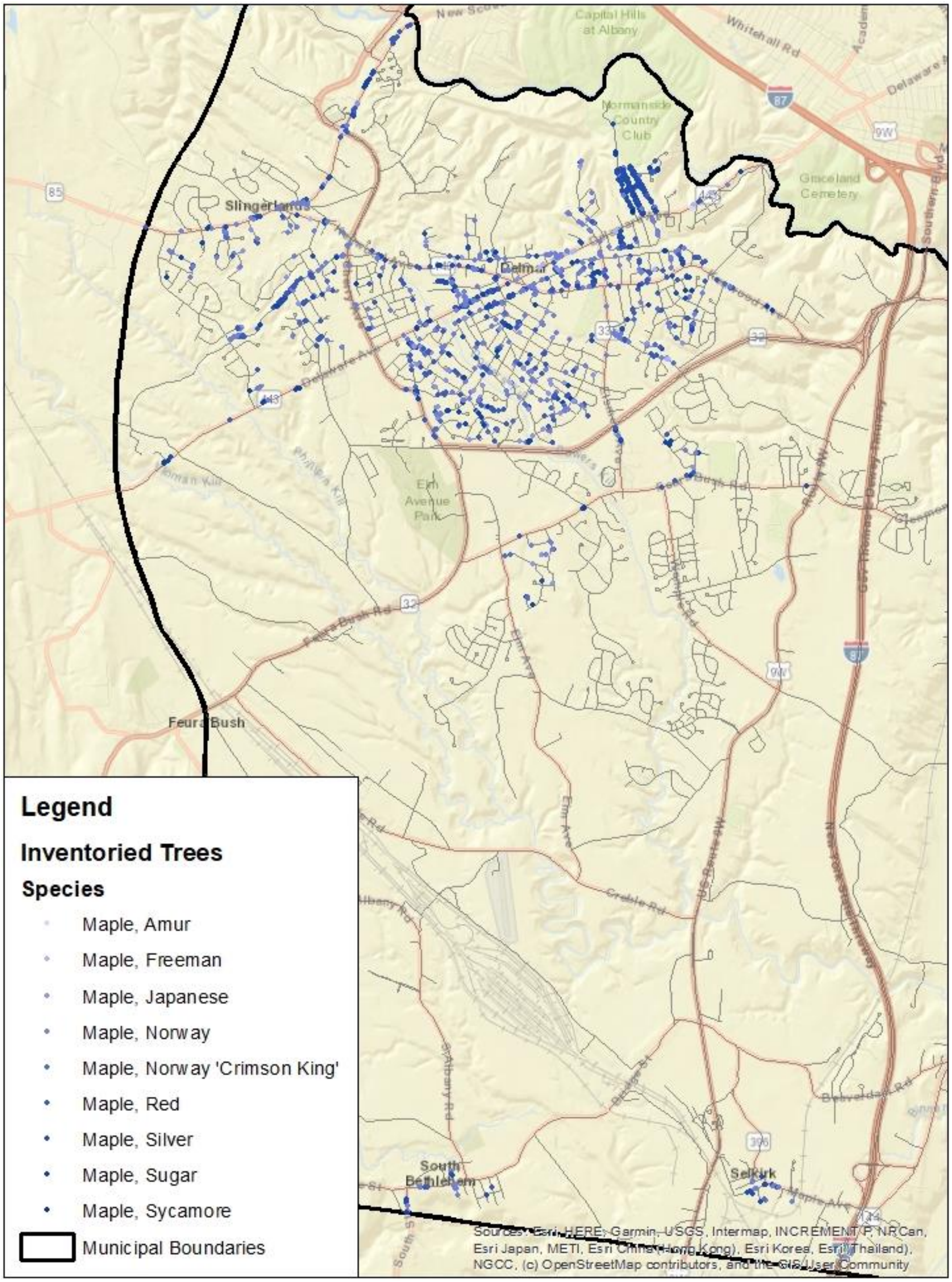
Figure 2. The six most common species collected in the Bethlehem, NY tree inventory compared to the 10% Species Diversity Rule.

Figure 3 uses the 20% Rule (a single genus should represent no more than 20% of the urban forest) to compare the percentages of the four most common genera identified during the inventory to the inventoried tree population. Maple (*Acer*) far exceed the recommended 20% maximum for a single genus in a population, comprising 31% of the inventoried tree population. Other common genera include spruce (*Picea*, 11%), ash (*Fraxinus*, 9%), and pine (*Pinus*, 9%), all of which are well below the recommended 20% maximum threshold.



Only one family of trees exceeded the 30% Family Diversity Rule: maple (*Aceraceae*, 31%). Of mention, the Pinaceae family, which includes fir (*Abies*), larch (*Larix*), spruce (*Picea*), pine (*Pinus*), Douglas-fir (*Pseudotsuga*), and hemlock (*Tsuga*), is approaching this threshold at nearly 24%, and which should be considered in future planting plans.

Norway maple (*Acer platanoides*), and maple species in general, clearly dominate the inventoried area of Bethlehem, New York. Norway maple is considered an invasive species. The dominance of maple in the landscape is a concern, as the town could lose a large portion of its canopy if pests or diseases that target maple are introduced to the region. Continued diversity of tree species is an important objective that will ensure Bethlehem's urban forest is sustainable and resilient to future forest health issues. The continued planting of maple should be minimized to achieve the Town's goal for species diversity and forest health. Map 2 below shows the locations of various maple species across the town.


Legend
Inventoried Trees
Species
Maple, Amur
Maple, Freeman
Maple, Japanese
Maple, Norway
Maple, Norway 'Crimson King'
Maple, Red
Maple, Silver
Maple, Sugar
Maple, Sycamore
Municipal Boundaries
Slingerlands
Delmar
Feura Bush
South Bethlehem
Selkirk
Elm Avenue Park
Normanside Country Club
Capital Hills at Albany
Graceland Cemetery
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Size Class Distribution

Analyzing the size class distribution provides an estimate of the relative age of a tree population and offers insight into maintenance practices and needs. Tree size is measured using a standardized methodology of taking the diameter measurement of a tree 4.5 feet from the ground – this is known as the diameter at breast height, or 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 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 (greater than 24 inches DBH). These categories were chosen so that the population could be analyzed according to Richards' ideal distribution (Richards 1983). Richards proposed an ideal 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, while a smaller fraction (approximately 10%) should be in the large-diameter size class (mature trees). Following this recommendation, an urban tree population with an ideal distribution would have an abundance of newly planted and young trees, and a lower proportion of established, maturing, and mature trees.

Figure 4 compares the inventoried population's size class distribution to the ideal proposed by Richards (Richards 1983). Bethlehem's distribution generally aligns with the desired per Richards; young trees (44%) slightly exceed the ideal, established (25%) and maturing trees (14%) fall slightly short of the ideal by 5% and 6%, respectively, and mature trees (17%) exceed the ideal.

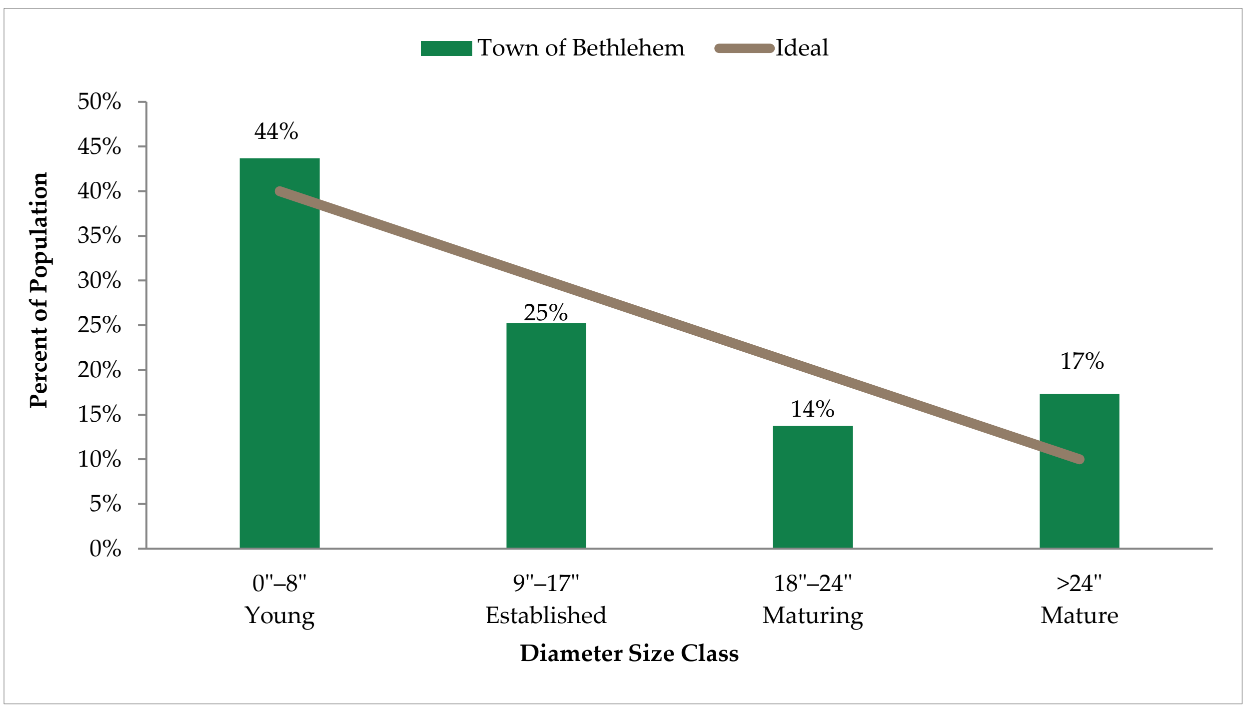


Figure 4. Comparison of size class distribution of inventoried trees in Bethlehem, NY to the Richards size class distribution ideal.

One of Bethlehem's objectives is to have an uneven-aged distribution of trees at the street, park, and town-wide levels. It is recommended that Bethlehem support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in street tree canopy, replace older, declining trees, and maintain the ideal size class distribution. While new tree planting is essential to long-term urban forest maintenance, the Town must also promote tree preservation and proactive tree care to ensure the long-term survival of older trees. See Appendix B for information on proactive tree care cycles. See Appendix C for a recommended tree species list for planting. See Appendix D for information on best practices for planting new trees.

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

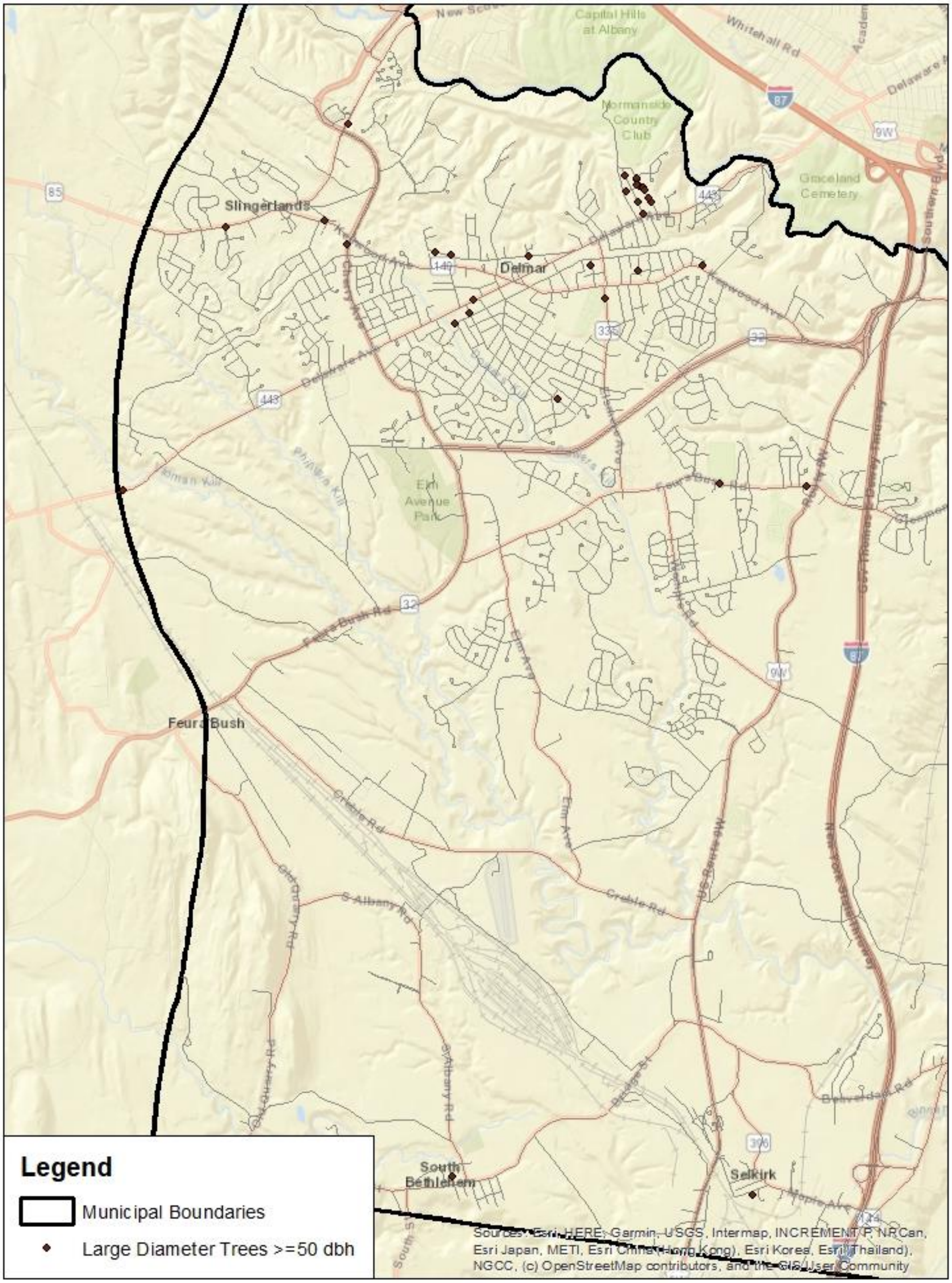
Large Diameter Trees

While diameter alone does not provide a complete picture of the health, inherent worth, or environmental benefits provided by a tree, particularly large trees are a striking feature of the urban landscape. Citizens may be motivated to provide greater care for large-diameter trees, and more public outcry is typically produced due to the removal of large-diameter trees as compared to small-diameter trees.

Table 2 lists the 14 trees with the largest diameter at breast height (DBH) identified during the inventory. Map 3 shows that trees with diameters larger than 50 DBH are found throughout the town, but that a concentration of these large trees is found in Elsmere to the south of the Normanside Country Club. Due to their size, large diameter trees may require greater investment of time and money to maintain their health, especially considering that a number of the large trees are of species not recommended for future planting. However, their stature makes them more valuable both in environmental benefits and in the eyes of many citizens, and their upkeep is well worth the investment.

Table 2. The 14 largest diameter trees collected in Bethlehem, NY

DBH (inches)	Species		Location
	Common Name	Scientific Name	
70	eastern cottonwood	*Populus deltoides*	176 Hudson Ave
65	silver maple	*Acer saccharinum*	380 Fuera Bush Rd
63	silver maple	*Acer saccharinum*	56 Hudson Ave
60	weeping willow	*Salix babylonica*	1374 New Scotland Rd
59	silver maple	*Acer saccharinum*	24 Marlboro Rd
58	silver maple	*Acer saccharinum*	15 Burhans Pl
58	silver maple	*Acer saccharinum*	2 Capitol Ave
58	white oak	*Quercus alba*	1075 Delaware Ave
58	silver maple	*Acer saccharinum*	188 Winne Rd
57	silver maple	*Acer saccharinum*	9 Capital Ave
57	silver maple	*Acer saccharinum*	431 Delaware Ave
57	silver maple	*Acer saccharinum*	13 Euclid Ave
57	silver maple	*Acer saccharinum*	21 Euclid Ave
57	black locust	*Robinia pseudoacacia*	188 Hudson Ave


Legend
Municipal Boundaries
Large Diameter Trees >=50 dbh
Slingerlands
Delmar
Feura Bush
South Bethlehem
Selkirk
Elm Avenue Park
Normanside Country Club
Graceland Cemetery
Capital Hills at Albany
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Condition

The condition of individual trees was 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 or diseases. Using these factors, the condition of each inventoried tree was rated Good, Fair, Poor, or Dead. In this plan, the general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. The vast majority of the inventoried trees were either in Good or Fair condition, 34% and 59%, respectively (Figure 5). Based on these data, the general health of the overall inventoried tree population in Bethlehem, NY is rated Fair to Good.

Figure 5 shows tree condition by size distribution and illustrates that most of the young trees were in Good condition where most of the established, maturing, and mature trees were in Fair condition. Trees in the young diameter size class were generally installed, trained, and maintained very well. The Fair condition of the larger size classes indicates that while most trees in Bethlehem have some flaws, historical maintenance practices have been adequate to maintain tree health and minimize hazards to the community.

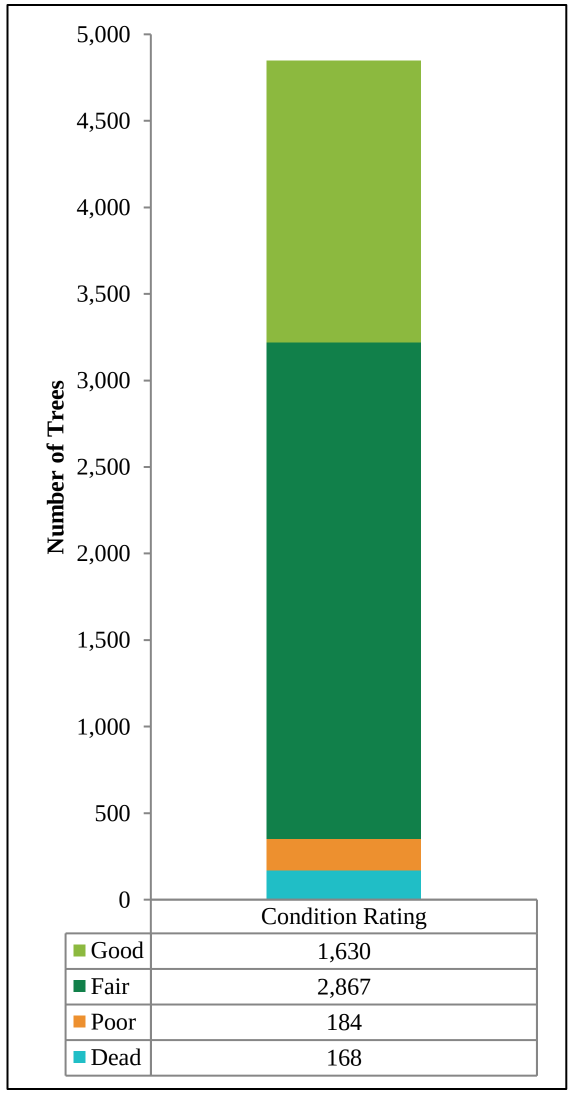


Figure 5. Condition of trees inventoried in Bethlehem, NY.

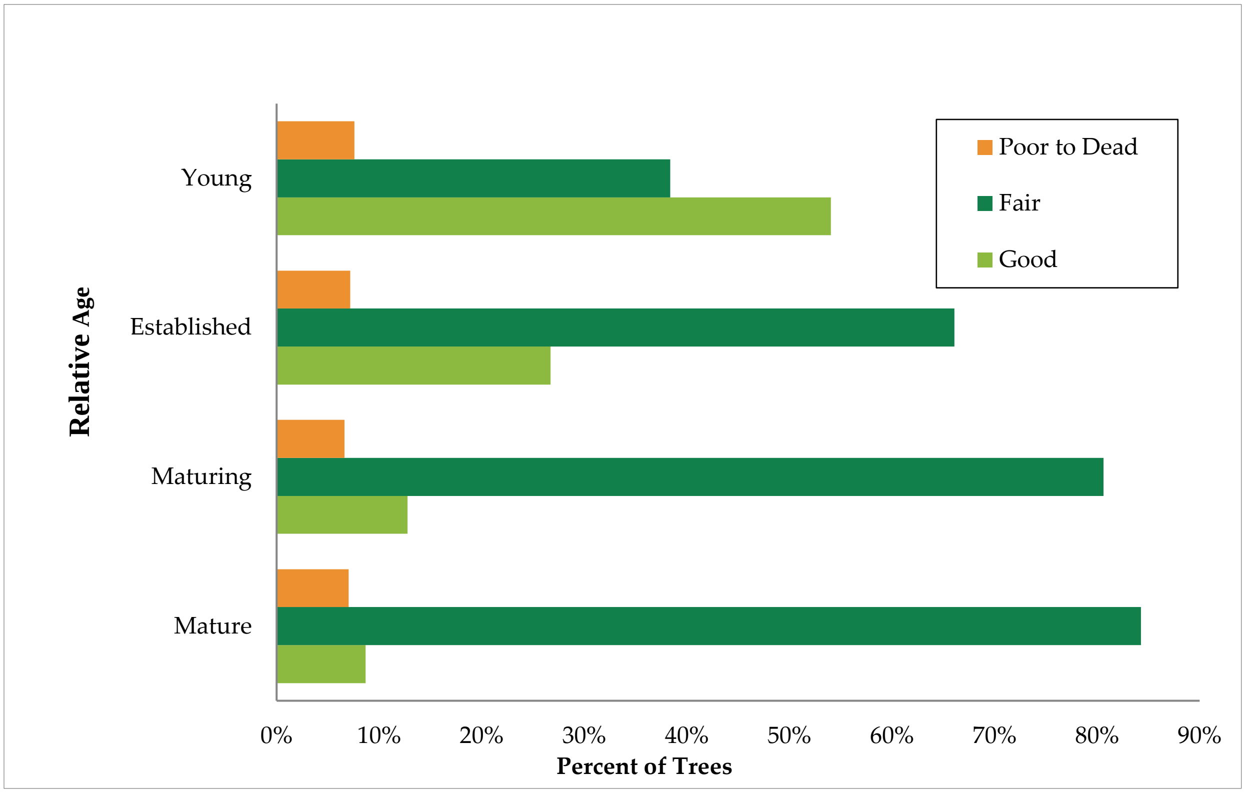


Figure 6. Tree condition by relative age for trees inventoried in Bethlehem, NY.

Defects

The primary defect or structural flaw of each tree was recorded during the inventory. The noted defect was often, although not always, the defect to be corrected by the recommended maintenance procedure. Defects noted in the inventory included broken and/or hanging branches, cracks, dead and dying parts, missing or decayed wood, root problems, tree architecture, weakly attached branches and codominant stems, none, and other.

Table 3 lists the defects identified during the 2019 inventory and the number of trees assigned to each defect. Dead and dying parts was the most observed defect, affecting 48% of the inventoried trees. Other defects, including missing or decayed wood (6%), weakly attached branches and codominant stems (4%), and tree architecture (3%), were much less common. Another 36% of the inventoried trees had no major defect. It is worth mentioning that dead trees were recorded as having no primary defect, as it is assumed that a dead tree has dead parts and requires removal. 1,769 trees recorded as having no defect and 168 were dead. Generally, the defects observed are not concentrated in any particular part of town, but there are some slight differences between hamlet areas. Most hamlet areas have clusters of trees with dead and dying parts. Elsmere has a concentration of trees with missing or decayed wood.

Table 3. Defects recorded in the Bethlehem, NY tree inventory

Defect	Number of Trees	Percent of Inventory
Dead and Dying Parts	2,308	48%
Missing or Decayed Wood	307	6%
Weakly Attached Branches and Codominant Stems	211	4%
Tree Architecture	151	3%
Broken and/or Hanging Branches	70	1%
Root Problems	27	1%
Cracks	6	0%
None	1,601	33%
Dead	168	3%
Total	4,849	100%

Some defects can be readily remedied through corrective maintenance, such as crown cleaning to remove dead limbs. Others, such as a decay column located low in the trunk, cannot be easily rectified; however, maintenance procedures that improve overall tree vitality may help offset such a defect. The costs for treating tree defects should also be considered, as removing and replacing the tree may be the more viable option. And in some cases, a defect may be significant enough that tree removal is required to promote public safety.

Unless slated for removal, trees with missing or decayed wood or root problems should be regularly inspected. Corrective actions should be taken when warranted and if their condition worsens, removal may be required. Trees with dead or dying parts or broken and/or hanging branches should be pruned to remove dead wood and hanging or damaged limbs. Trees with poor tree architecture or weakly attached branches and codominant stems may benefit from pruning to correct structural deficiencies or from other maintenance techniques, such as cabling or bracing, to reinforce weak branch unions. See the Section 3 description of Priority and Proactive maintenance regimes for more detail.

Photograph 3. Ash tree recommended for removal.

Conflicts with Overhead Utilities

In an urban setting, space is limited both above and below ground. Trees in this environment often conflict with infrastructure, such as buildings, sidewalks, and utility wires and pipes, and may pose risks to public health and safety. Existing or possible conflicts between trees and infrastructure recorded during the inventory included conflicts with overhead utilities, such as primary and secondary electrical lines, telecommunication lines, and service drops.

Potential conflict between trees and overhead utilities was recorded with one of three categories: present and conflicting, present and not conflicting, or not present. Present and conflicting was selected if any part of the tree was touching a utility line at the time of inventory or was likely to touch a utility line within the next year of growth. Present and not conflicting was selected when a utility line was present above the tree, but no part of the tree was currently touching or likely to touch the line within the next year of growth. Not present was selected if no overhead utility lines were present in the airspace around the tree.

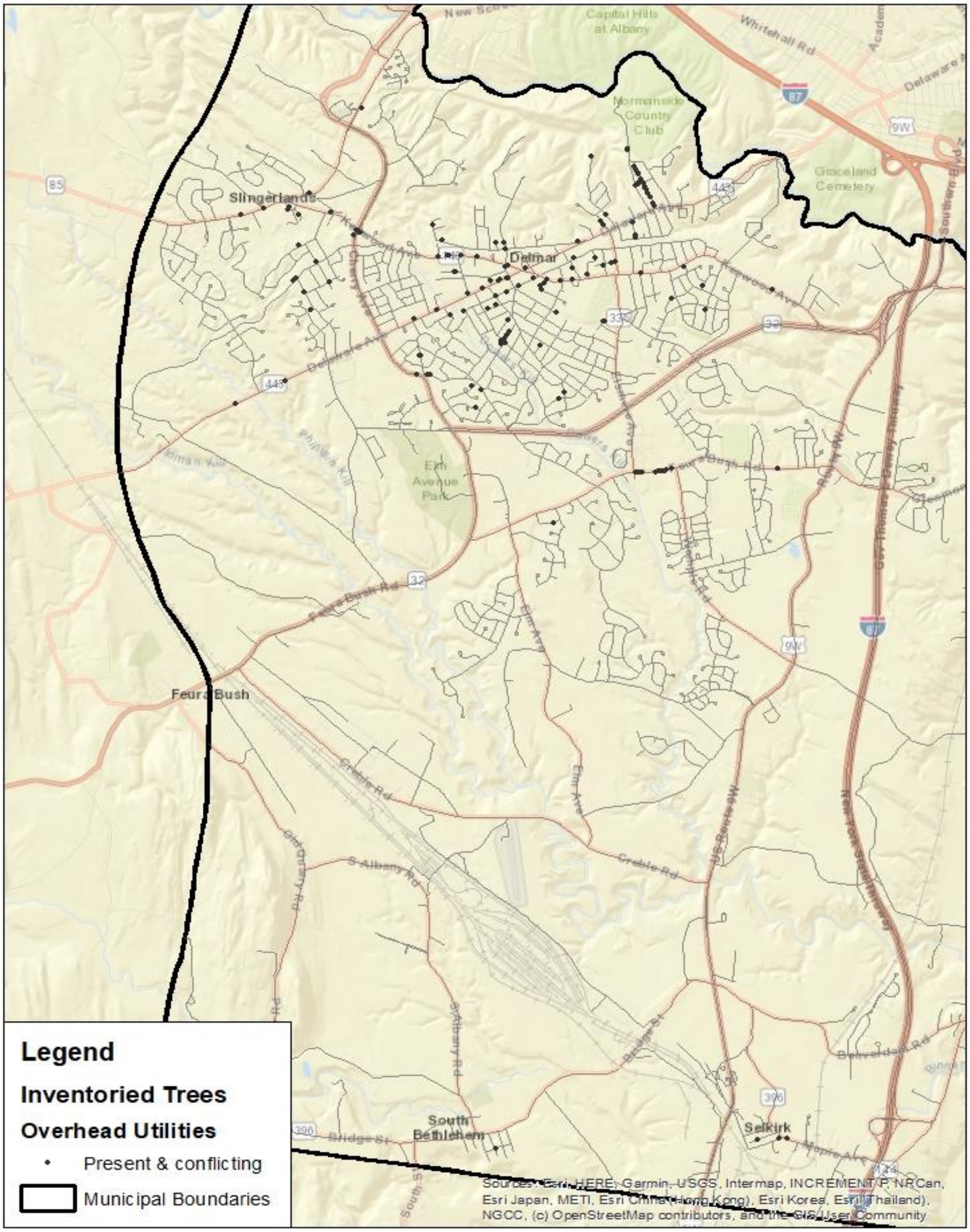
It is important to consider the presence of existing infrastructure like overhead wires when planning pruning or selecting tree species for planting. Table 4 summarizes the presence or absence of overhead utility conflicts in Bethlehem.

Table 4. Tree and overhead utility potential conflict in Bethlehem, NY

Overhead Utility Presence	Number of Trees	Percent of Inventory
Present and Conflicting	148	3%
Present and Not Conflicting	738	15%
Not Present	3,963	82%
Total	4,849	100%

Relatively few trees in the inventoried population were interfering with utility lines as of the 2019 inventory (3%). These present and conflicting trees are dispersed throughout town, but there is a concentration in Elsmere south of the Normanside Country Club (See Map 4). A larger percentage (15%) has the potential to conflict with utility lines in the future, although they were not in conflict with utility lines at the time of the inventory. Generally, these present and not conflicting trees are located along major roadways. Most of the inventoried population (82%) was not underneath any utility lines, indicating that Bethlehem has done a good job in the past of managing their urban forest to prevent conflicts with overhead utility lines.

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


Legend
Inventoried Trees
Overhead Utilities
Present & conflicting
Municipal Boundaries
Slingerlands
Delmar
Feura Bush
South Bethlehem
Selkirk
Normanside Country Club
Graceland Cemetery
Capital Hills at Albany
Elm Avenue Park
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Further Inspection

As part of the assessment of each tree, surveyors indicated whether a particular tree required a more intensive inspection, such as a Level III Risk Assessment (*ANSI A300, Part 9, 2011*), or periodic inspection due to particular conditions that make it be a safety risk and, therefore, hazardous. If further inspection was recommended for a tree, Town staff should investigate as soon as possible to determine corrective actions.

In addition to a Level III Risk Assessment, trees could be recommended for multi-year/annual inspections or for ongoing pest and disease monitoring. Trees that required further inspection with more advanced equipment to determine the severity or extent of a defect were recommended for a Level III Risk Assessment. Trees which showed potential signs of pest or disease damage, but which did not yet require removal, were recommended for insect/ disease monitoring. Trees that had recent damage or which had defects that did not necessitate removal at the time of the inventory, but which could worsen over time and require removal at a later date, were recommended for multi-year/annual inspections.

Although most of Bethlehem's inventoried trees did not require further inspection, surveyors did identify a total of 215 trees for further inspection. Refer to Table 5 for a breakdown of recommended inspection types.

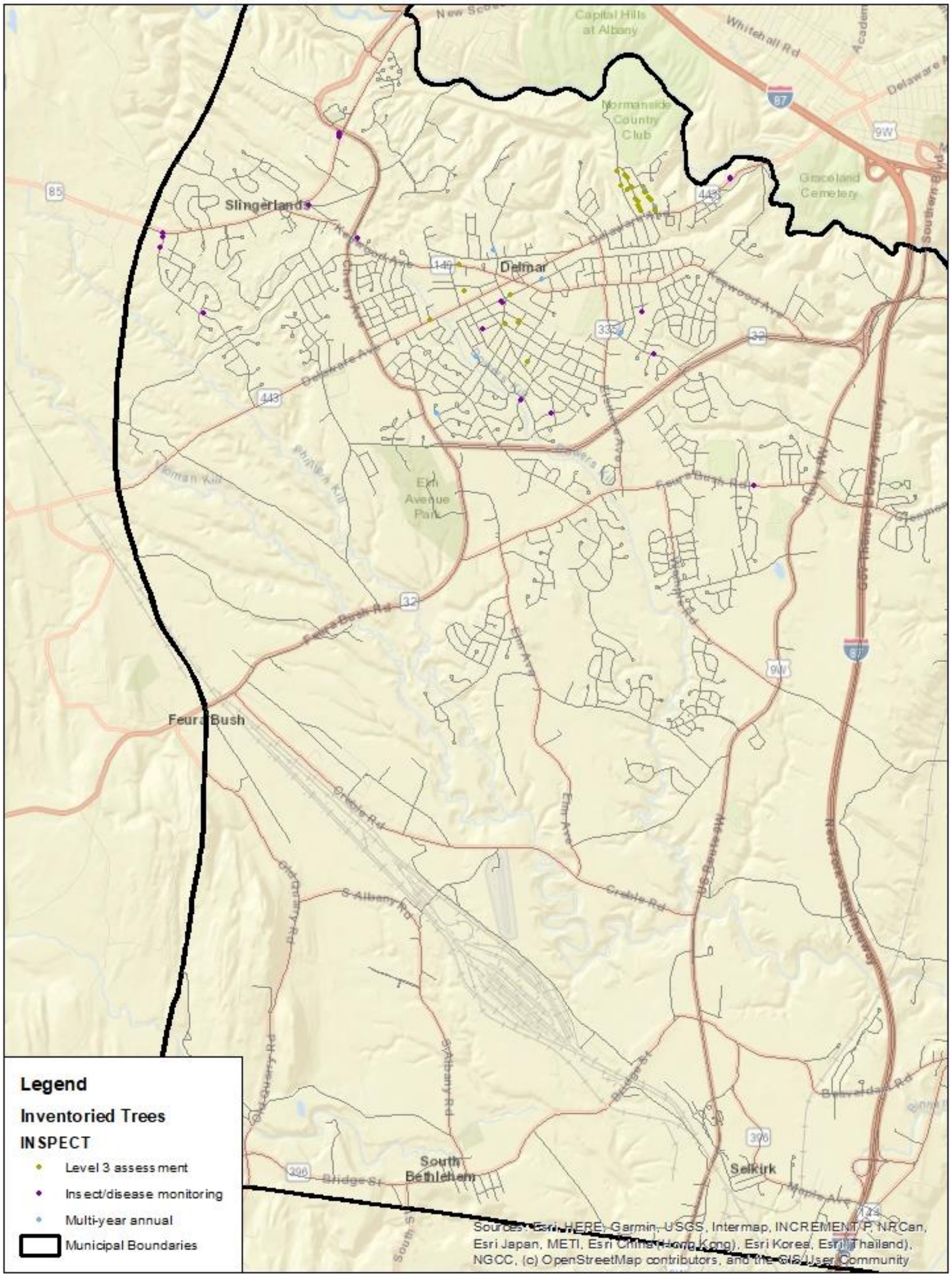
Table 5. Number of trees recommended for further inspection in Bethlehem, NY

Further Inspection	Number of Trees	Percent of Inventory
Level III Assessment	28	0.6%
Insect/ Disease Monitoring	24	0.5%
Multi-Year/ Annual	7	0.1%
None	4,634	95.6%
Total	4,849	100.0%

Twenty four trees (24) were recommended for insect/disease monitoring. These trees were either ash (*Fraxinus* spp.), eastern white hemlock (*Tsuga canadensis*), or oak (*Quercus* spp., specifically in the red oak group), which would be potentially affected by emerald ash borer (EAB) (*Agrilus planipennis*), hemlock wooly adelgid (HWA) (*Adelges tsugae*), or oak wilt (*Bretziella fagacearum*), respectively. See the next subsection on pest and disease risk for more detail.

An ISA Certified Arborist should perform additional inspections of the 28 trees recommended for a Level III Risk Assessment. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

Trees recommended for multi-year/annual inspections should be monitored by the Town for further decline or damage. The defective part(s) should be corrected or removed as necessary to maintain risk at or below the acceptable threshold.



Legend
Inventoried Trees
INSPECT
Level 3 assessment
Insect/disease monitoring
Multi-year annual
Municipal Boundaries
Slingerlands
Delmar
Feura Bush
South Bethlehem
Selkirk
Elm Avenue Park
Normanside Country Club
Capital Hills at Albany
Graceland Cemetery
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Pest and Disease Risk

Pests and diseases pose serious risk to tree health. Awareness and early diagnosis are essential to ensuring the health and longevity of urban trees. Pests and diseases can 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 only presents data collected from the inventory. Many more trees throughout Bethlehem, including those on public and private property, may be susceptible.

There are several pests and diseases that may impact the trees in Bethlehem. Figure 7 summarizes the forest health concerns for the inventoried population. Appendix E provides more information about these forest health threats in New York and includes websites where more detailed information can be found.

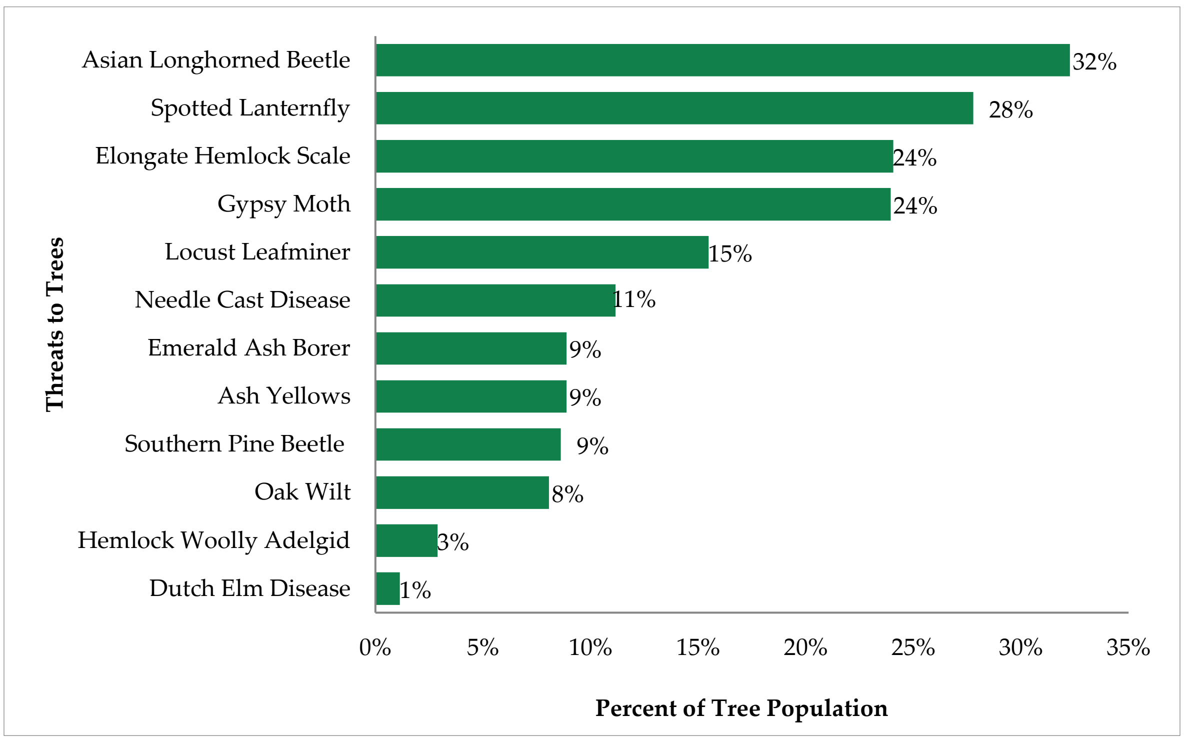


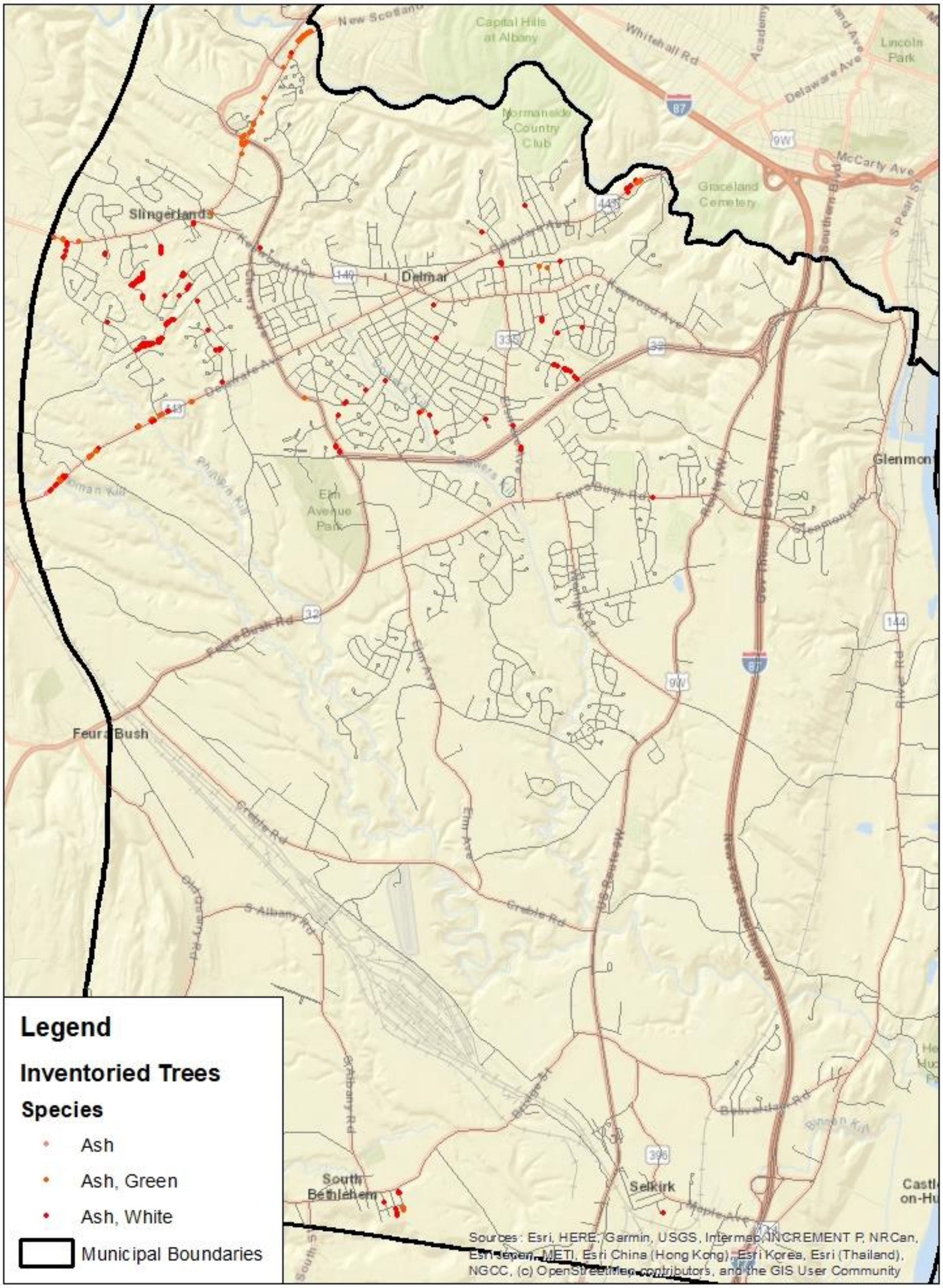
Figure 7. Pest and disease risk for trees inventoried in Bethlehem, NY.

Asian longhorned beetle (ALB, *Anoplophora glabripennis*) has the potential to impact the largest proportion of the trees inventoried in Bethlehem in 2019. If an infestation becomes established, almost one-third of the population would be threatened. Three additional pests could have significant impacts as well: spotted lanternfly (SLF, *Lycorma delicatula*), elongate hemlock scale (EHS, *Fiorinia externa*), and gypsy moth (*Lymantria dispar*). Other pests and diseases to note are locust leafminer (*Odontota dorsalis*), needle cast disease, emerald ash borer (EAB, *Agrilus planipennis*), ash yellow (*Candidatus fraxinii*), southern pine beetle (*Dendroctonus frontalis*), and oak wilt (*Bretziella fagacearum*). Fortunately, none of these pests were detected in Bethlehem during the 2019 inventory except for EAB; however, if these other threats are introduced to the area, there would be severe losses in the tree population.

Of note, emerald ash borer (EAB) was detected in Bethlehem at the CSX railyard and at the airport in 2012. There were 431 ash trees included in the inventoried population (9% of the inventoried population), 17 of which showed symptoms of EAB infestation and require further insect/disease monitoring. Oak wilt has also been detected in Glenville, NY (New York State Department of Environmental Conservation 2018), which is about 40 miles from Bethlehem. This is a serious fungal disease that specifically targets oak trees and is particularly impactful on the red oak group, causing mortality within months of infection. One hundred and ninety-four (194) oak were collected as part of the inventory (8% of the population) and of these oak, 156 fall in the red oak group[2]. These trees should also be regularly monitored for the disease. Maps 4 and 5 show the locations of ash and oak trees in Bethlehem. There are concentrations of ash trees in Slingerlands, along New Scotland Road in North Bethlehem, along western portions of Delaware Avenue, along a section of Bender Lane north of the Bypass, on Delaware Avenue close to the Albany border, and in South Bethlehem. Oak trees are more dispersed throughout town, but there are denser concentrations in Slingerlands and in Delmar.

Bethlehem should be aware of the signs and symptoms of potential infestations and should be prepared to act if a significant threat is observed in its tree population or a nearby community. An integrated pest management plan should be established, which focuses on identifying and monitoring threats, understanding the economic threshold, selecting appropriate treatments, properly timing management strategies, recordkeeping, and evaluating results. Section 4 discusses recommendations for managing the ash tree population and mitigating EAB, as well as other potential forest threats. Larger and/or more prominent ash trees may be better candidates for treatment, as they might provide significant benefits to the community.

[2] Species categorized in the red oak group include northern red oak (*Quercus rubra*), pin oak (*Q. palustris*), black oak (*Q. velutina*), and scarlet oak (*Q. coccinea*).


Legend
Inventoried Trees
Species
Ash
Ash, Green
Ash, White
Municipal Boundaries
Slingerlands
Delmar
Feura Bush
Glenmont
South Bethlehem
Selkirk
Elm Avenue Park
Normanside Country Club
Graceland Cemetery
Capital Hills at Albany
Lincoln Park
Whitehall Rd
Delaware Ave
McCarty Ave
Feura Bush Rd
Elm Ave
Grable Rd
S Albany Rd
River Rd
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

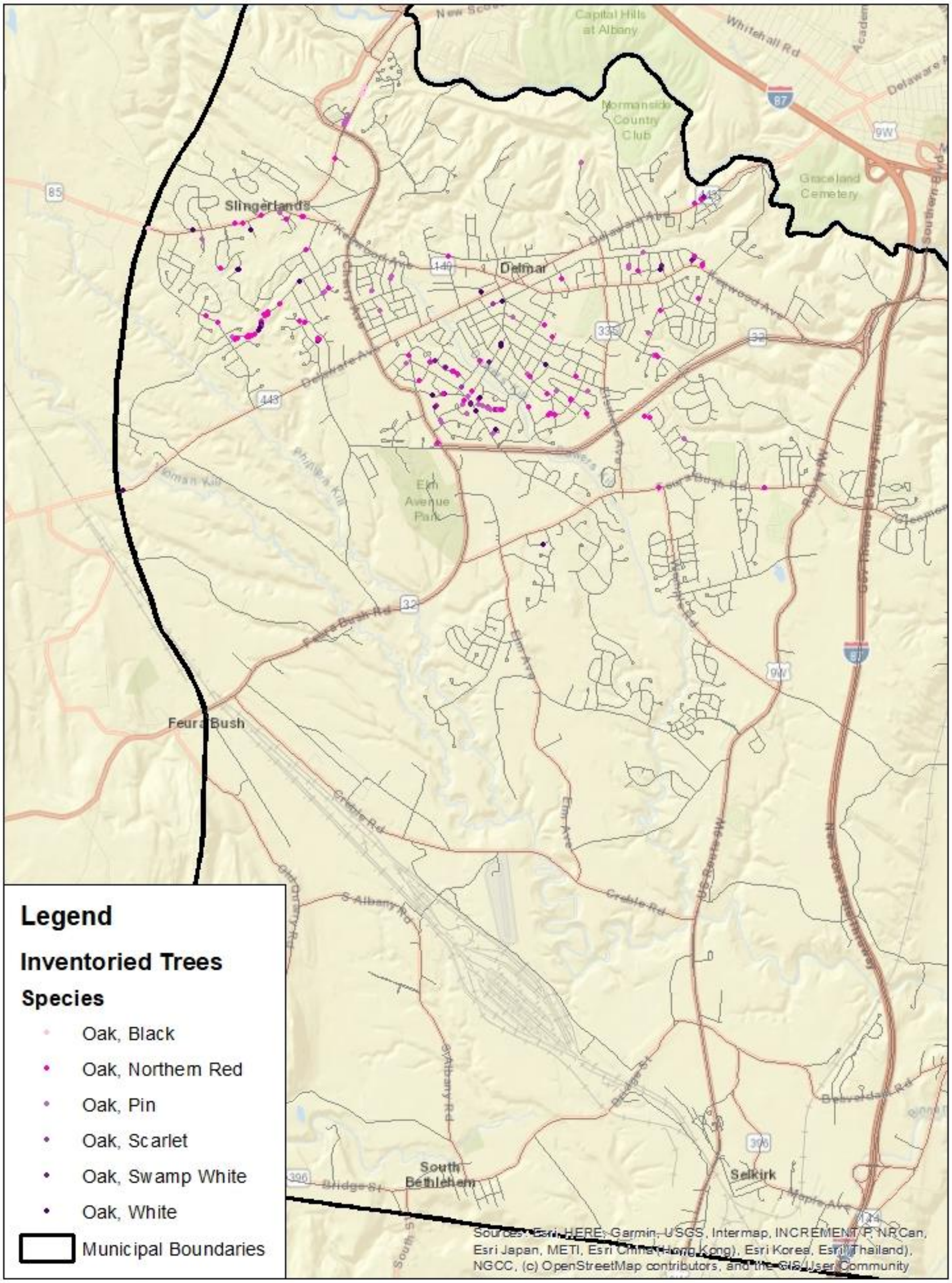

Legend
Inventoried Trees
Species
Oak, Black
Oak, Northern Red
Oak, Pin
Oak, Scarlet
Oak, Swamp White
Oak, White
Municipal Boundaries
Slingerlands
Delmar
Feura Bush
South Bethlehem
Selkirk
Elm Avenue Park
Normanside Country Club
Capital Hills at Albany
Graceland Cemetery
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Table 6. Conclusions

Section 1 Recommendation Summary	
Goals	Recommendation
10-20-30 Rule for Species Diversity	The continued planting of maple should be minimized to help achieve better species diversity.
Richards Size Class Distribution Ideal	Support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy, replace older, declining trees, and maintain the ideal size class distribution.
Further Inspection	As part of the assessment of each tree, surveyors indicated whether a particular tree required a more intensive inspection, such as a Level III Risk Assessment (ANSI A300, Part 9, 2011), or periodic inspection due to particular conditions that make it a safety risk and, therefore, hazardous. If further inspection was recommended, Town staff should investigate as soon as possible to determine corrective actions.
Integrated Pest Management Plan	An integrated pest management plan should be established, which focuses on identifying and monitoring threats, understanding the economic threshold, selecting appropriate treatments, properly timing management strategies, recordkeeping, and evaluating results.

SECTION 2: BENEFITS OF THE INVENTORIED TREE POPULATION

Urban forests play an important role in supporting and improving the quality of life in urban areas. The trees growing along public streets constitute a valuable community resource. Their shade and beauty contribute to a community's quality of life and soften the hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide numerous tangible and intangible environmental (pollution control, stormwater management, wildlife habitat), economic (higher property value, energy reduction), and social benefits (education, aesthetics, human health and safety) that far exceed the time and money invested in planting, pruning, protection, and removal. The following is a list of various examples of the benefits derived from urban trees.

Tree Benefit Analysis

Up until recently, the services and benefits of trees in urban and suburban settings were once considered difficult to quantify. Using extensive scientific studies and practical research, these benefits can now be estimated using tree inventory information. i-Tree, based on peer-reviewed, USDA Forest Service research, is one such tool that is used to quantify the benefits and values of trees. Bethlehem's tree inventory was run through the i-Tree Eco application of i-Tree, which is the model's "flagship tool" used to quantify "the structure of, threats to, and benefits and values provided by forest populations…" (www.itreetools.org/). This analysis was used to provide insight into the overall health of the town's public trees and the management activities needed to maintain and increase the benefits of trees into the future, and the results are summarized in this report.

Environmental Benefits

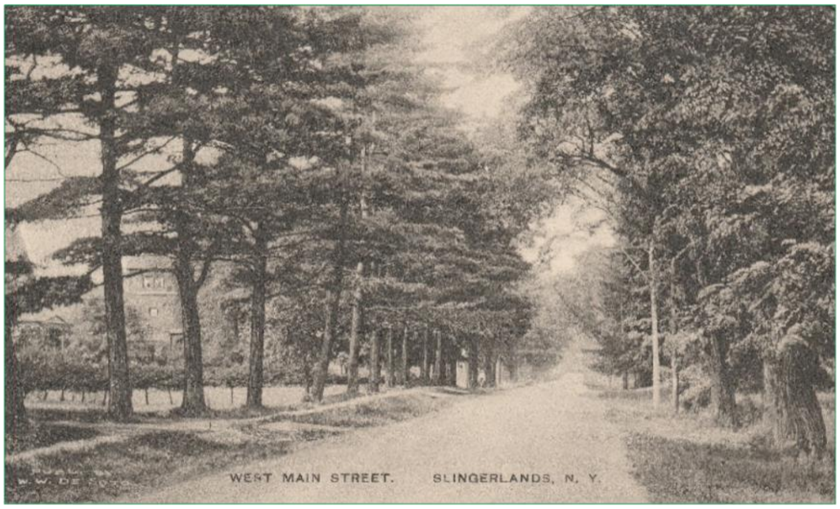
- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. One hundred mature tree crowns intercept roughly 100,000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

Economic Benefits

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

Social Benefits

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



The entire dataset collected during the 2019 inventory was uploaded into the i-Tree Eco tool to produce benefit results. This section will highlight each element of the collective benefits provided by the inventoried trees of the Town of Bethlehem.

It is important to remember that the 2019 Bethlehem tree inventory did not include all public trees nor any trees on private property. The total benefits provided by Bethlehem's entire urban forest are likely to be significantly greater than the benefits estimated for the inventoried tree population alone. It is also important to consider that i-Tree Eco does not provide estimates for all the services that urban trees provide. For example, increases in property values due the aesthetic qualities of trees are not estimated, nor are energy benefits provided by the temperature-moderating properties of the urban canopy. While the information provided by the i-Tree Eco model cannot provide a complete picture of the benefits provided by Bethlehem's inventoried trees, the information it does provide can help form a base from which to advocate for increased funding for urban forestry activities.

i-Tree

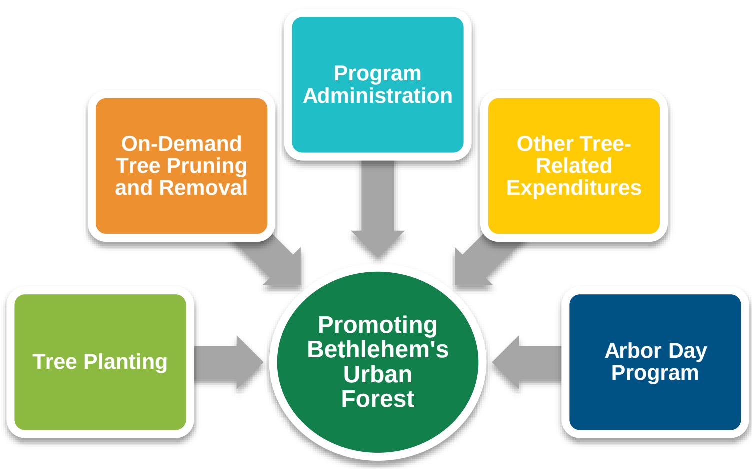
i-Tree Tools software was developed by the U.S. Department of Agriculture, Forest Service (USDA FS) with the help of several industry partners, including The Davey Tree Expert Company. Learn more at www.itreetools.org.

The quantified benefits and the reports generated are described below.

- **Stormwater:** Presents reductions in annual stormwater runoff due to rainfall interception by trees, measured in cubic feet (ft^3).
- **Air Quality:** Quantifies the air pollutants[3] deposited on tree surfaces, and reduced emissions from power plants[4] due to reduced electricity use, both measured in pounds. The potential negative effects of trees on air quality due to biogenic volatile organic compounds (BVOC) emissions is also reported.
- **Carbon Storage:** Tallies all the carbon dioxide (CO_2) stored in the inventoried trees over the life of those trees through sequestration. Carbon stored is measured in pounds and has been translated to tons for this report.
- **Carbon Sequestration:** Presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reductions in energy use. This is measured in pounds and has been translated to tons for this report. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.
- **Structural Value:** The structural value represents the monetary amount it would cost to replace all the trees that were inventoried.

i-Tree Eco Inputs

i-Tree Eco uses data gathered from the inventory, along with regional data and stormwater costs, to generate the environmental benefits trees provide. See Appendix A for specific values used in the i-Tree Eco model.



Annual Benefits Summary

The i-Tree Eco model estimated that the inventoried tree population provides a total annual benefit of **$14,927**. On average, one of Bethlehem's trees provides an annual benefit of **$3.09**.

[3] Specifically, carbon monoxide [CO], ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter less than 2.5 micrometers in diameter [$PM_{2.5}$].

[4] Specifically, NO_2, $PM_{2.5}$, volatile organic compounds [VOCs], SO_2.

The assessment found that of the three annual benefits included in this total (air pollutant removal, avoided stormwater runoff, and carbon sequestration), avoided stormwater runoff comprised the greatest value to the community, at nearly $7,000 annually, almost half of the total annual benefits. In addition to stormwater management, trees also play a major role in carbon sequestration. The town's trees sequester nearly 120 tons of CO_2 equivalent each year, which equates to an annual value of $5,575 (~37% of the annual benefits calculated). Pollution removal accounts for $2,357 annually (~16% of the annual benefits), with 0.92 ton of pollutants removed. Figure 8 summarizes the annual benefits and results from the inventoried population. A breakdown of the benefits provided by the most common species in the inventory is provided in Table 7.

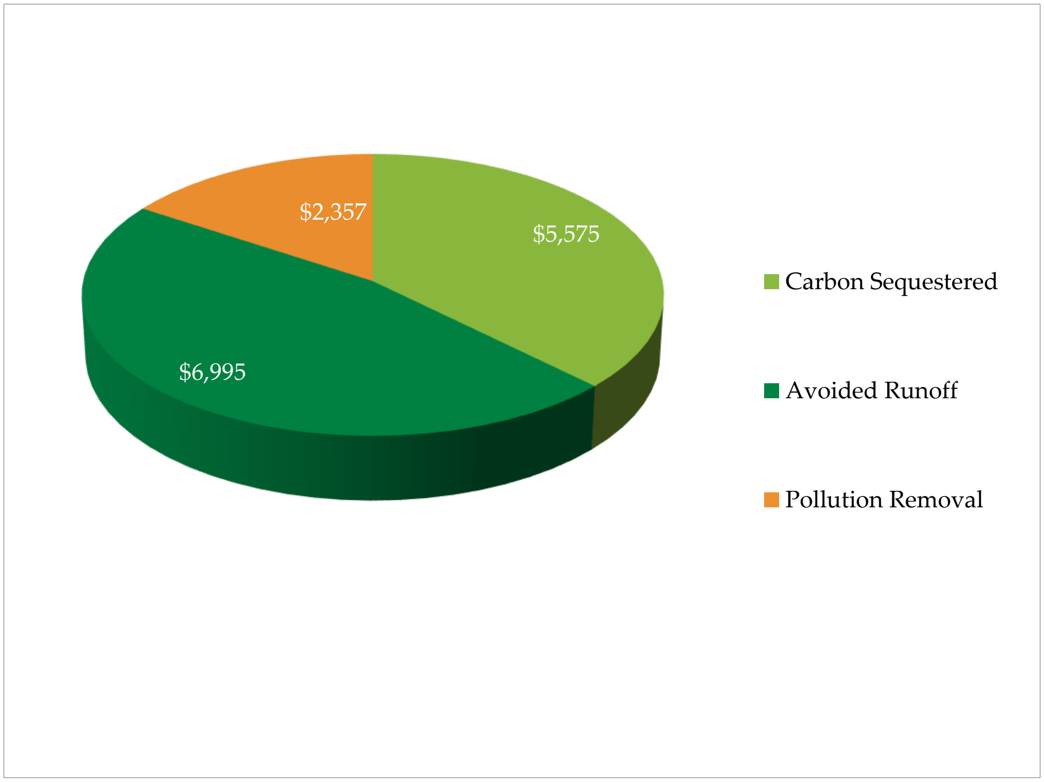


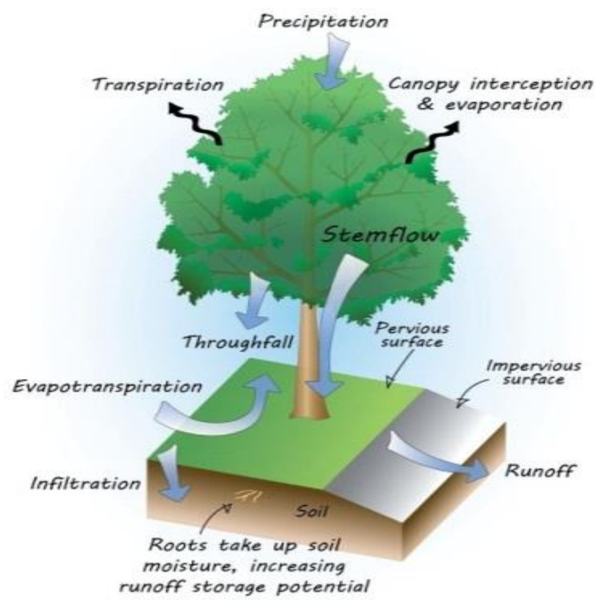
Figure 8. Breakdown of total annual benefits provided by the trees inventoried in Bethlehem, NY.

Table 7. Total benefit data, by species, for trees inventoried in Bethlehem, NY

Most Common Trees Collected During Inventory		Number Trees Inventoried	Percent of Total Trees	Canopy Cover	Carbon Stored	Annual Benefit Provided			Structural Value
						Carbon Sequestered	Avoided Runoff	Pollution Removal	
Common Name	Scientific Name		(%)	(ft²)	$	($/yr)			$
Norway maple	*Acer platanoides*	500	10.4%	241,015	56,312.73	677.42	1,051.37	354.22	858,162.75
silver maple	*Acer saccharinum*	381	7.9%	468,217	183,903.56	1,092.45	1,548.21	521.61	1,452,486.15
eastern white pine	*Pinus strobus*	341	7.1%	134,978	35,060.36	358.93	603.98	203.49	1,082,285.77
white ash	*Fraxinus americana*	329	6.8%	44,216	6,713.53	139.62	132.83	44.75	151,444.90
Norway spruce	*Picea abies*	322	6.7%	93,572	22,771.46	286.43	571.65	192.59	639,388.79
red maple	*Acer rubrum*	303	6.3%	162,406	55,749.05	578.67	597.77	201.39	845,762.58
apple	*Malus* spp.	197	4.1%	36,312	6,354.89	127.57	101.91	34.34	137,373.58
northern white cedar	*Thuja occidentalis*	189	3.9%	6,350	1,129.67	27.27	36.45	12.28	94,944.64
eastern hemlock	*Tsuga canadensis*	140	2.9%	20,761	3,818.17	62.92	126.63	42.66	112,504.84
blue spruce	*Picea pungens*	129	2.7%	12,107	2,902.59	61.03	77.83	26.22	93,451.58
sugar maple	*Acer saccharum*	124	2.6%	61,928	28,052.62	261.56	245.41	82.68	415,309.59
northern red oak	*Quercus rubra*	103	2.1%	82,061	32,056.51	274.65	225.32	75.91	478,085.78
white mulberry	*Morus alba*	102	2.1%	22,195	6,347.66	80.73	71.54	24.10	94,806.39
green ash	*Fraxinus pennsylvanica*	101	2.1%	15,350	1,329.38	27.64	49.43	16.65	50,378.20
other street trees		1,563	32.4%	454,068	126,633.12	1,518.50	1,554.44	523.72	1,912,790.04
Inventory Total		4,824	100.0%	1,855,535	569,135.30	5,575.39	6,994.77	2,356.61	8,419,175.58

Stormwater Runoff

Trees intercept rainfall, helping to lower the costs to manage stormwater runoff. Without trees, precipitation can result in faster supersaturation of the soil, increasing runoff. In i-Tree Eco, the hydrology effects of trees are modeled based on local weather station data and computed rainfall interception to provide an estimate of avoided runoff due to tree-related stormwater interception.



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

The inventoried trees in Bethlehem prevent a total of 104,640 ft^3 of runoff annually. The estimated annual savings for the town in stormwater runoff management based solely on the inventoried population is $6,995. Table 8 provides a summary of annual avoided runoff by species.

Of the species inventoried, silver maple (*Acer saccharinum*) contributed the largest annual stormwater runoff benefits. The population of silver maple (8% of the inventoried population) prevented approximately 23,161 ft^3 of runoff, or 22% of the total runoff avoided annually; a value of nearly $1,550 saved, annually. Norway maple (*A. platanoides*), which comprised 11.5% of the inventoried population, provided the next largest reduction in annual runoff, intercepting 15,728 ft^3 annually (15% of the total runoff avoided annually) and saving a little over $1,000, annually.

Figure 9 compares the prevalence of the most common species in the inventoried population to the percentage of annual runoff each species intercepts. As discussed previously, the two most influential species for avoided stormwater runoff are silver maple and Norway maple—although the two only account for a combined 18% of the inventoried tree population, they provide 37% of the avoided runoff.

On a per tree basis, large trees with leafy canopies provided the most value. Table 9 provides a list of the 25 individual trees which contributed most to reductions in stormwater runoff. The top performer is a 65” DBH silver maple located at 380 Feura Bush Road. This tree alone prevents ~126 ft^3 of runoff annually, a benefit valued at $8.45 per year. The next three top performers are a trio of eastern cottonwood (*Populus deltoides*) with a DBH of 70”, 44”, and 42”. Each prevented ~124 ft^3, valued annually at $8.31.

Table 8. Total annual avoided runoff, by species, for trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		Avoided Runoff		Value
Common Name	Botanical Name	#	(%)	(ft³/yr)	(%)	($/yr)
silver maple	*Acer saccarinum*	381	10%	23,161	22%	1,548.21
Norway maple	*Acer platanoides*	500	8%	15,728	15%	1,051.37
eastern white pine	*Pinus strobus*	341	7%	9,035	9%	603.98
red maple	*Acer rubrum*	303	7%	8,942	9%	597.77
Norway spruce	*Picea abies*	322	7%	8,552	8%	571.65
sugar maple	*Acer saccharum*	124	6%	3,671	4%	245.41
northern red oak	*Quercus rubra*	103	4%	3,371	3%	225.32
'Crimson King' Norway maple	*Acer platanoides 'Crimson King'*	56	4%	2,116	2%	141.47
eastern cottonwood	*Populus deltoides*	31	3%	2,031	2%	135.73
white ash	*Fraxinus americana*	329	3%	1,987	2%	132.83
eastern hemlock	*Tsuga canadensis*	140	3%	1,894	2%	126.63
apple	*Malus* spp.	197	2%	1,525	1%	101.91
pin oak	*Quercus palustris*	46	2%	1,435	1%	95.95
black locust	*Robinia pseudoacacia*	66	2%	1,418	1%	94.78
black walnut	*Juglans nigra*	45	2%	1,185	1%	79.19
blue spruce	*Picea pungens*	129	2%	1,164	1%	77.83
white mulberry	*Morus alba*	102	2%	1,070	1%	71.54
Other inventoried trees		1,609	27%	16,354	16%	1,093.20
Inventory Total		4,824	100%	104,640	100%	6,994.77

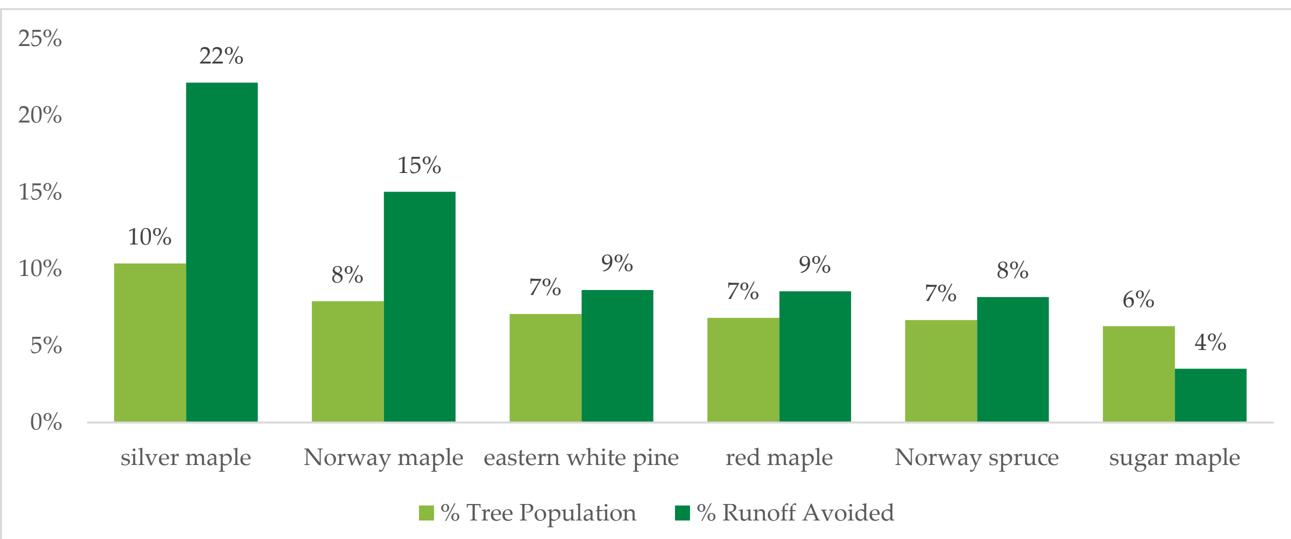


Table 9. The 25 most influential individual trees for stormwater avoidance in Bethlehem, NY

Top 25 Individual Trees Collected		DBH	Avoided Runoff	Value
Common Name	Scientific Name	(in)	(ft3/yr)	($/yr)
silver maple	*Acer saccharinum*	65	126.3	8.45
eastern cottonwood	*Populus deltoides*	70	124.3	8.31
eastern cottonwood	*Populus deltoides*	44	124.3	8.31
eastern cottonwood	*Populus deltoides*	42	124.3	8.31
silver maple	*Acer saccharinum*	49	122.4	8.18
silver maple	*Acer saccharinum*	63	122.0	8.15
silver maple	*Acer saccharinum*	48	119.8	8.01
silver maple	*Acer saccharinum*	59	113.0	7.56
silver maple	*Acer saccharinum*	45	111.4	7.44
silver maple	*Acer saccharinum*	58	110.9	7.42
silver maple	*Acer saccharinum*	58	110.9	7.42
silver maple	*Acer saccharinum*	58	110.9	7.42
tulip tree	*Liriodendron tulipifera*	44	110.6	7.39
eastern cottonwood	*Populus deltoides*	39	109.3	7.31
silver maple	*Acer saccharinum*	57	108.9	7.28
silver maple	*Acer saccharinum*	57	108.9	7.28
silver maple	*Acer saccharinum*	57	108.9	7.28
silver maple	*Acer saccharinum*	57	108.9	7.28
tulip tree	*Liriodendron tulipifera*	31	108.3	7.24
silver maple	*Acer saccharinum*	55	104.8	7.01
eastern cottonwood	*Populus deltoides*	38	103.9	6.95
silver maple	*Acer saccharinum*	42	102.8	6.87
silver maple	*Acer saccharinum*	54	102.4	6.85
silver maple	*Acer saccharinum*	53	100.4	6.71
silver maple	*Acer saccharinum*	53	100.4	6.71

Air Quality

Urban forests impact air quality in several ways, including the removal of pollutants from the air, oxygen production, and the emission of biogenic volatile organic compound (BVOC).

i-Tree Tools

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

The inventoried tree population removes 0.92 ton of air pollutants, annually, including ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], carbon monoxide [CO], and particulate matter through deposition. Figure 10 provides a breakdown of the quantities of each pollutant, measured in pounds, removed by Bethlehem's inventoried trees annually. The value of the pollutant reduction provided by the inventoried population of trees is calculated at ~$2,357 per year. Reductions in ozone, a harmful gas that pollutes the air and damages vegetation, account for the greatest annual pollutant reductions, with 1,656 pounds of ozone removed each year. In addition to removing air pollutants, trees improve air quality by producing oxygen. The town's inventoried trees produce ~87.2 tons of oxygen every year.

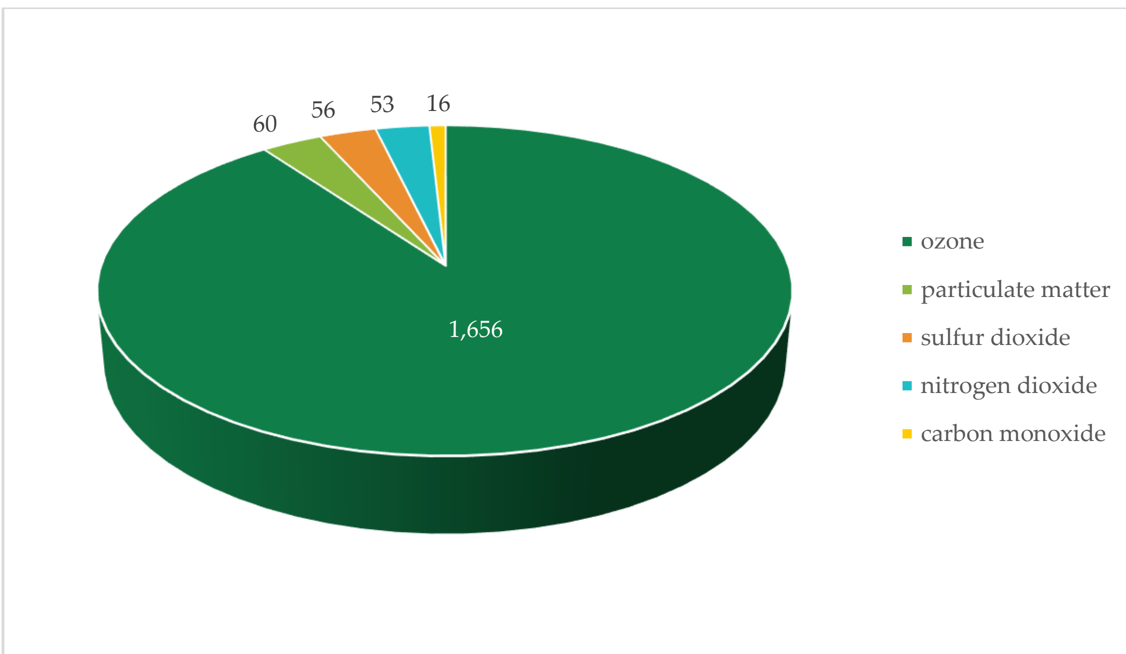


Figure 10. Quantity of air pollutants (in lbs.) removed by trees inventoried in Bethlehem, NY.

Table 10 provides a summary of the species which contribute most to pollutant removal annually. The species which contributed most included silver maple (*Acer saccharinum*) (0.2 ton/year, $521.61/year) and Norway maple (*A. platanoides*) (0.14 ton/year, $354.22/year). On a per tree basis, silver maple and eastern cottonwood (*Populus deltoides*) removed the largest quantities of air pollutants each year. Table 10 lists the 25 individual trees that contribute the most to reductions in air pollution in Bethlehem.

Table 10. Total annual air pollutant removal, by species, for trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		Pollution Removed		Value
Common Name	Scientific Name	#	(%)	(ton/yr)	(%)	($/yr)
silver maple	*Acer saccharinum*	381	8%	0.20	22%	521.61
Norway maple	*Acer platanoides*	500	10%	0.14	15%	354.22
eastern white pine	*Pinus strobus*	341	7%	0.08	9%	203.49
red maple	*Acer rubrum*	303	6%	0.08	9%	201.39
Norway spruce	*Picea abies*	322	7%	0.08	9%	192.59
sugar maple	*Acer saccharium*	124	3%	0.03	3%	82.68
Northern red oak	*Quercus rubra*	103	2%	0.03	3%	75.91
'Crimson King' Norway maple	*Acer platanoides 'Crimson King'*	56	1%	0.02	2%	47.66
eastern cottonwood	*Populus deltoides*	31	1%	0.02	2%	45.73
white ash	*Fraxinus americana*	329	7%	0.02	2%	44.75
eastern hemlock	*Tsuga canadensis*	140	3%	0.02	2%	42.66
apple	*Malus* spp.	197	4%	0.01	1%	34.34
pin oak	*Quercus palustris*	46	1%	0.01	1%	32.33
black locust	*Robinia pseudoacacia*	66	1%	0.01	1%	31.93
black walnut	*Juglans nigra*	45	1%	0.01	1%	26.68
blue spruce	*Picea pungens*	129	3%	0.01	1%	26.22
white mulberry	*Morus alba*	102	2%	0.01	1%	24.10
white oak	*Quercus alba*	26	1%	0.01	1%	20.96
Other inventoried trees		1,583	33%	0.13	14%	347.36
Inventory Total		4,824	100%	0.92	100%	2,356.61

Table 11. The 25 most influential trees for air pollution removal in Bethlehem, NY

Top 25 Individual Trees Collected		DBH	Pollution Removed						Value
			CO	O_3	NO_2	SO_2	$PM_{2.5}$	Total	
Common Name	Scientific Name	(in)	(oz/yr)						($/yr)
silver maple	*Acer saccharinum*	65	0.4	32.0	1.0	1.1	1.2	35.6	2.85
eastern cottonwood	*Populus deltoides*	70	0.4	31.5	1.0	1.1	1.1	35.0	2.80
eastern cottonwood	*Populus deltoides*	44	0.4	31.5	1.0	1.1	1.1	35.0	2.80
eastern cottonwood	*Populus deltoides*	42	0.4	31.5	1.0	1.1	1.1	35.0	2.80
silver maple	*Acer saccharinum*	49	0.3	31.0	1.0	1.0	1.1	34.5	2.76
silver maple	*Acer saccharinum*	63	0.3	30.9	1.0	1.0	1.1	34.4	2.75
silver maple	*Acer saccharinum*	48	0.3	30.3	1.0	1.0	1.1	33.8	2.70
silver maple	*Acer saccharinum*	59	0.3	28.6	0.9	1.0	1.0	31.9	2.55
silver maple	*Acer saccharinum*	45	0.3	28.2	0.9	1.0	1.0	31.4	2.51
silver maple	*Acer saccharinum*	58	0.3	28.1	0.9	1.0	1.0	31.3	2.50
silver maple	*Acer saccharinum*	58	0.3	28.1	0.9	1.0	1.0	31.3	2.50
silver maple	*Acer saccharinum*	58	0.3	28.1	0.9	1.0	1.0	31.3	2.50
tulip tree	*Liriodendron tulipifera*	44	0.3	28.0	0.9	0.9	1.0	31.2	2.49
silver maple	*Acer saccharinum*	39	0.3	27.6	0.9	0.9	1.0	30.8	2.46
silver maple	*Acer saccharinum*	57	0.3	27.6	0.9	0.9	1.0	30.7	2.45
silver maple	*Acer saccharinum*	57	0.3	27.6	0.9	0.9	1.0	30.7	2.45
silver maple	*Acer saccharinum*	57	0.3	27.6	0.9	0.9	1.0	30.7	2.45
eastern cottonwood	*Populus deltoides*	57	0.3	27.7	0.9	0.9	1.0	30.7	2.45
tulip tree	*Liriodendron tulipifera*	31	0.3	27.4	0.9	0.9	1.0	30.5	2.44
silver maple	*Acer saccharinum*	55	0.3	26.5	0.9	0.9	1.0	29.5	2.36
eastern cottonwood	*Populus deltoides*	38	0.3	26.3	0.8	0.9	1.0	29.3	2.34
silver maple	*Acer saccharinum*	42	0.3	26.0	0.8	0.9	0.9	29.0	2.32
silver maple	*Acer saccharinum*	54	0.3	25.9	0.8	0.9	0.9	28.9	2.31
silver maple	*Acer saccharinum*	53	0.3	25.4	0.8	0.9	0.9	28.3	2.26
silver maple	*Acer saccharinum*	53	0.3	25.4	0.8	0.9	0.9	28.3	2.26

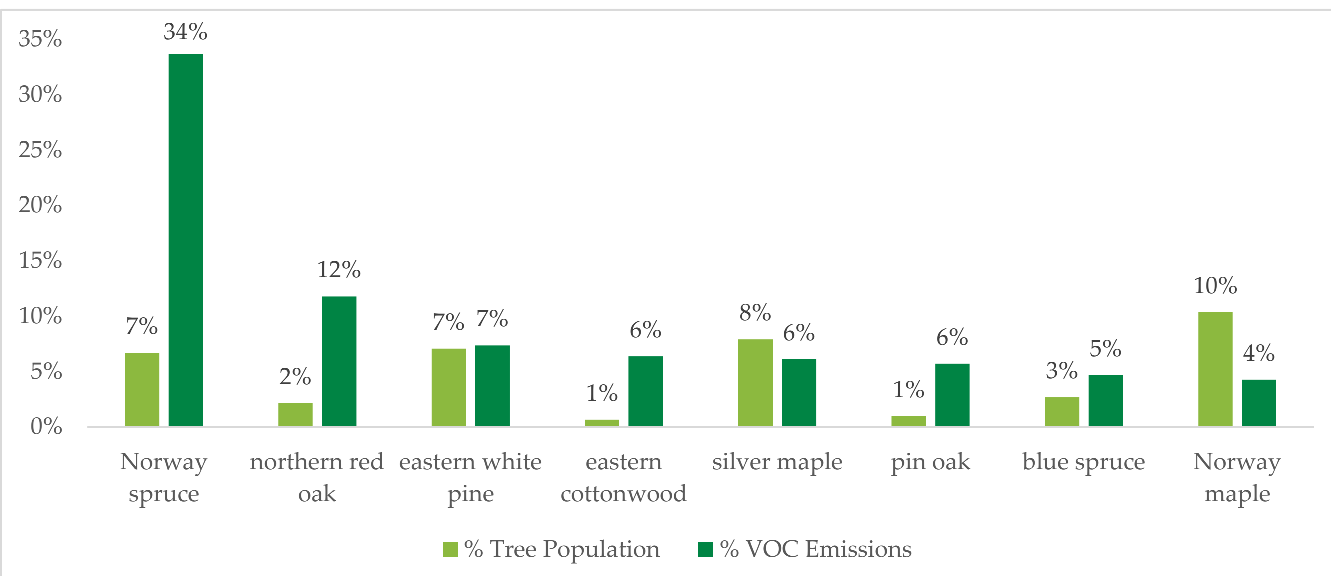
While trees do a great deal to improve air quality, they can also contribute negatively to air quality. Trees emit various biogenic volatile organic compounds (BVOCs), such as isoprenes and monoterpenes, which can contribute to the formation of ozone. Table 12 summarizes the contribution of BVOCs emitted by the trees inventoried; the top 14 species are highlighted. In total, the trees inventoried release ~918 lbs. of BVOCs annually. The primary contributor to BVOC emissions was the population of Norway maple (*Picea abies*), which emitted ~309 lbs. of BVOCs per year (34% of the total annual BVOC emissions) despite comprising only 7% of the inventoried trees. Northern red oak (*Quercus rubra*) was the second largest contributor to BVOC emissions, emitting ~108 lbs. per year, mostly in the form of isoprenes (~107 lbs./year).

Figure 11 compares the quantity of BVOCs released by a species to the prevalence of that species in the inventoried population. In general, only 9% of the population is contributing nearly half of the BVOC's emitted by this population.

Overall, the inventoried trees removed more pollutants (0.92 ton or 1,840 lbs. removed annually) than they emitted (~918 lbs. emitted annually), resulting in a positive economic value.

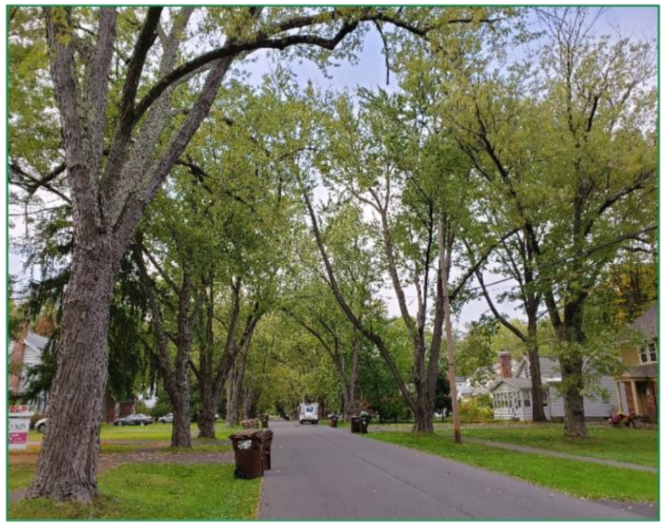
Table 62. Total BVOC's emitted annually, by species, by trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		BVOCs Emitted			
				Monoterpene	Isoprene	Total	
Common Name	Scientific Name	#	(%)	(lb/yr)			(%)
Norway spruce	*Picea abies*	322	7%	164.5	144.4	308.9	34%
northern red oak	*Quercus rubra*	103	2%	1.5	106.6	108.1	12%
eastern white pine	*Pinus strobus*	341	7%	67.0	0.4	67.5	7%
eastern cottonwood	*Populus deltoides*	31	1%	0.4	58.1	58.5	6%
silver maple	*Acer saccharinum*	381	8%	55.2	0.7	55.9	6%
pin oak	*Quercus palustris*	46	1%	0.7	51.5	52.3	6%
blue spruce	*Picea pungens*	129	3%	22.8	20.0	42.8	5%
Norway maple	*Acer platanoides*	500	10%	38.4	0.5	38.9	4%
red maple	*Acer rubrum*	303	6%	27.3	0.3	27.6	3%
white oak	*Quercus alba*	26	1%	0.4	26.9	27.3	3%
white spruce	*Picea glauca*	90	2%	14.2	12.5	26.7	3%
red pine	*Pinus resinosa*	61	1%	12.8	0.1	12.9	1%
swamp white oak	*Quercus bicolor*	12	0%	0.2	12.6	12.8	1%
sugar maple	*Acer saccharum*	124	3%	10.0	0.1	10.1	1%
Other inventoried trees		2,355	49%	45.3	22.1	67.2	7%
Inventory Total		4,824	100%	460.7	456.8	917.5	100%



Carbon Storage and Carbon Sequestration

Trees act as a reservoir for carbon dioxide (CO_2), storing carbon over their lifetimes. This prevents CO_2 from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. Trees also sequester some CO_2 during growth (Nowak et al. 2013), adding to the stored carbon they contain every year. The i-Tree Eco model calculates carbon storage as a single value over the lifespan of each tree and calculates carbon sequestration for each tree on a per year basis.



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, and provide shelter to animals and recreational areas for people.

Table 12 summarizes the carbon storage and carbon sequestration of the trees inventoried. The top 16 performers by species are highlighted. Bethlehem's inventoried trees store 12,237 tons of carbon (measured in CO_2 equivalents). This amount reflects the amount of carbon they have amassed during their lifetimes. Three species accounted for more than 50% of the total carbon storage capacity of the town's trees: silver maple (*Acer saccharinum*) (8% of the inventoried population, 32% of the carbon storage capacity), Norway maple (*A. platanoides*) (11.5% of the inventoried population, 10% of the carbon storage capacity), and red maple (*A. rubrum*) (6% of the inventoried population, 10% of the carbon storage capacity). The total value of the carbon storage provided by inventoried trees in the town is $569,135.30.

Table 13 lists the 25 individual trees which store the most carbon in Bethlehem. On an individual basis, white oak (*Quercus alba*), northern red oak (*Q. rubra*), silver maple (*A. saccharinum*), sugar maple (*A. saccharum*), and eastern cottonwood (*Populus deltoides*) stored the most carbon (16,534.7 lbs. each, $1,410 each).

Figure 12 compares the carbon storage capacity of the top performing species to the prevalence of that species in the inventoried population. Silver maple (*A. saccharinum*) represents 8% of the collected population yet stores 32% of the inventory's carbon.

Table 13. Total carbon storage, by species, by trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		Carbon Storage			
				Carbon		CO_2 Equivalent	Value
Common Name	Scientific Name	#	(%)	(tons)	(%)	(tons)	($)
silver maple	*Acer saccharinum*	381	8%	1,078.3	32%	3954.1	183,903.56
Norway maple	*Acer platanoides*	500	10%	330.2	10%	1210.8	56,312.73
red maple	*Acer rubrum*	303	6%	326.9	10%	1198.7	55,749.05
eastern white pine	*Pinus strobus*	341	7%	205.6	6%	753.8	35,060.36
northern red oak	*Quercus rubra*	103	2%	188.0	6%	689.2	32,056.51
sugar maple	*Acer saccharum*	124	3%	164.5	5%	603.2	28,052.62
Norway spruce	*Picea abies*	322	7%	133.5	4%	489.6	22,771.46
pin oak	*Quercus palustris*	46	1%	89.9	3%	329.7	15,336.10
black locust	*Robinia pseudoacacia*	66	1%	84.3	3%	309.1	14,376.90
common honey locust	*Gleditsia triacanthos inermis*	74	2%	63.4	2%	232.4	10,808.20
eastern cottonwood	*Populus deltoides*	31	1%	62.5	2%	229.3	10,664.92
white oak	*Quercus alba*	26	1%	60.1	2%	220.2	10,243.63
'Crimson King' Norway maple	*Acer platanoides 'Crimson King'*	56	1%	41.2	1%	151.1	7,027.87
white ash	*Fraxinus americana*	329	7%	39.4	1%	144.3	6,713.53
apple	*Malus* spp.	197	4%	37.3	1%	136.6	6,354.89
white mulberry	*Morus alba*	102	2%	37.2	1%	136.5	6,347.66
Other inventoried trees		1,823	38%	394.7	12%	1,448.3	67,355.31
Inventory Total		4,824	100%	3,337.0	100%	12,236.9	569,135.30

Table 74. The 25 most influential trees for carbon storage in Bethlehem, NY

Top 25 Individual Trees Collected		DBH	Carbon Storage	Value
Common Name	Scientific Name	(in)	(lbs)	($)
white oak	*Quercus alba*	58	16,534.7	$ 1,410.00
silver maple	*Acer saccharinum*	55	16,534.7	$ 1,410.00
sugar maple	*Acer saccharum*	50	16,534.7	$ 1,410.00
silver maple	*Acer saccharinum*	50	16,534.7	$ 1,410.00
northern red oak	*Quercus rubra*	65	16,534.7	$ 1,410.00
northern red oak	*Quercus rubra*	63	16,534.7	$ 1,410.00
silver maple	*Acer saccharinum*	59	16,534.7	$ 1,410.00
eastern cottonwood	*Populus deltoides*	70	16,534.7	$ 1,410.00
silver maple	*Acer saccharinum*	58	16,257.0	$ 1,386.32
silver maple	*Acer saccharinum*	58	16,257.0	$ 1,386.32
silver maple	*Acer saccharinum*	58	16,257.0	$ 1,386.32
weeping willow	*Salix babylonica*	60	16,072.7	$ 1,370.61
northern red oak	*Quercus rubra*	47	15,989.3	$ 1,363.49
black locust	*Robinia pseudoacacia*	57	15,766.4	$ 1,344.48
silver maple	*Acer saccharinum*	57	15,675.3	$ 1,336.72
silver maple	*Acer saccharinum*	57	15,675.3	$ 1,336.72
silver maple	*Acer saccharinum*	57	15,675.3	$ 1,336.72
silver maple	*Acer saccharinum*	57	15,675.3	$ 1,336.72
sugar maple	*Acer saccharum*	46	14,905.5	$ 1,271.07
pin oak	*Quercus palustris*	44	14,898.3	$ 1,270.46
white mulberry	*Morus alba*	51	14,700.7	$ 1,253.61
silver maple	*Acer saccharinum*	55	14,548.1	$ 1,240.60
pin oak	*Quercus palustris*	43	14,479.7	$ 1,234.76
northern red oak	*Quercus rubra*	45	14,386.2	$ 1,226.79
red maple	*Acer rubrum*	47	14,339.2	$ 1,222.78

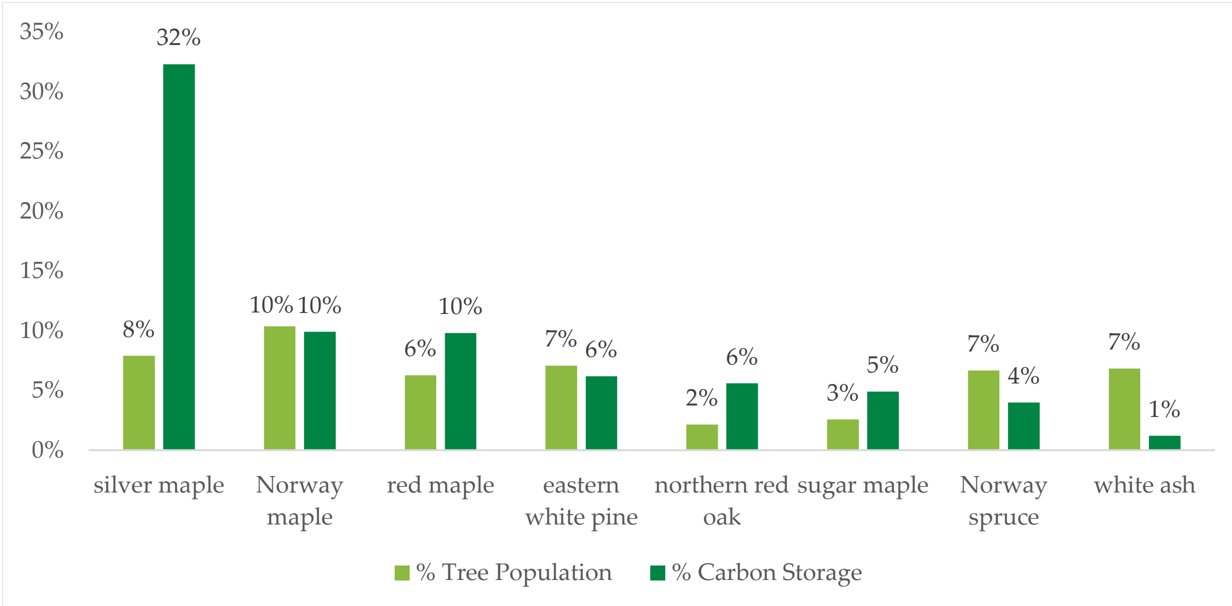


Figure 12. Percent of inventoried tree population compared to percentage of total carbon stored, by species, in Bethlehem, NY.

Through carbon sequestration and avoidance, almost 120 tons of CO_2 (measured in CO_2 equivalents) are removed from the environment by the inventoried trees each year. Silver maple, Norway maple, and red maple are the largest contributors to annual carbon sequestration, removing 23, 15, and 12 lbs. of CO_2 equivalent per year, respectively. The annual carbon sequestration benefits provided by the inventoried trees in Bethlehem are valued at $5,576. The individual trees which sequestered the most carbon annually were composed of a variety of species of oak, including pin oak (*Quercus palustris*), white oak (*Q. alba*), and northern red oak (*Q. rubra*). See Table 15 for a list of the top performing tree species in the inventory. See Table 15 for a list of the top 25 performing individual trees.

Table 85. Total carbon sequestration, by species, annually for trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		Carbon Sequestration			
				Carbon		CO_2 Equivalent	Value
Common Name	Scientific Name	#	(%)	(tons/yr)	(%)	(tons/yr)	($/yr)
silver maple	*Acer saccharinum*	381	8%	6.41	20%	23.49	$1,092.45
Norway maple	*Acer platanoides*	500	10%	3.97	12%	14.57	$677.42
red maple	*Acer rubrum*	303	6%	3.39	10%	12.44	$578.67
eastern white pine	*Pinus strobus*	341	7%	2.10	6%	7.72	$358.93
Norway spruce	*Picea abies*	322	7%	1.68	5%	6.16	$286.43
northern red oak	*Quercus rubra*	103	2%	1.61	5%	5.91	$274.65
sugar maple	*Acer saccharum*	124	3%	1.53	5%	5.62	$261.56
pin oak	*Quercus palustris*	46	1%	0.84	3%	3.07	$142.75
white ash	*Fraxinus americana*	329	7%	0.82	3%	3.00	$139.62
common honey locust	*Gleditsia triacanthos inermis*	74	2%	0.76	2%	2.78	$129.08
black locust	*Robinia pseudoacacia*	66	1%	0.76	2%	2.80	$130.03
apple	*Malus* spp.	197	4%	0.75	2%	2.74	$127.57
'Crimson King' Norway maple	*Acer platanoides 'Crimson King'*	56	1%	0.57	2%	2.09	$97.29
white oak	*Quercus alba*	26	1%	0.53	2%	1.93	$89.63
eastern cottonwood	*Populus deltoides*	31	1%	0.50	2%	1.85	$86.12
Other inventoried trees		1,925	40%	6.47	20%	23.71	$1,103
Inventory Total		4,824	100%	32.69	100%	119.88	$5,576

Table 96. The 25 most influential trees for carbon sequestration in Bethlehem, NY

Top 25 Individual Trees Collected		DBH	Carbon Sequestration	Value
Common Name	Botanical Name	(in)	(lbs/yr)	($/yr)
pin oak	*Quercus palustris*	36	96.0	$8.18
northern red oak	*Quercus rubra*	47	89.3	$7.61
white oak	*Quercus alba*	42	85.5	$7.29
northern red oak	*Quercus rubra*	45	83.9	$7.16
northern catalpa	*Catalpa speciosa*	42	83.5	$7.12
sugar maple	*Acer saccharum*	46	80.7	$6.88
white oak	*Quercus alba*	33	79.4	$6.77
sugar maple	*Acer saccharum*	45	78.4	$6.68
scarlet oak	*Quercus coccinea*	40	78.3	$6.67
white oak	*Quercus alba*	32	75.8	$6.46
black cherry	*Prunus serotina*	38	75.8	$6.47
northern red oak	*Quercus rubra*	41	73.5	$6.27
pin oak	*Quercus palustris*	41	73.1	$6.23
white ash	*Fraxinus americana*	42	72.3	$6.16
swamp white oak	*Quercus bicolor*	30	71.9	$6.14
red maple	*Acer rubrum*	44	71.2	$6.08
red maple	*Acer rubrum*	44	71.2	$6.08
northern red oak	*Quercus rubra*	40	70.9	$6.05
silver maple	*Acer saccharinum*	49	70.0	$5.97
sugar maple	*Acer saccharum*	33	69.8	$5.95
northern red oak	*Quercus rubra*	39	68.4	$5.83
northern red oak	*Quercus rubra*	39	68.4	$5.83
northern red oak	*Quercus rubra*	39	68.4	$5.83
silver maple	*Acer saccharinum*	48	68.3	$5.82
sugar maple	*Acer saccharum*	40	67.2	$5.73

Structural Value

The most straightforward way to establish a monetary value for a forest is by establishing a structural value (SV). The SV calculated by i-Tree Eco represents the amount it would cost to replace all the inventoried trees.

The total SV of Bethlehem's inventoried tree population is $8,419,178, with an average SV of $1,745 per tree. The population of silver maple (*Acer saccharinum*) was the most valuable species population, with a total SV of $1,452,486, followed by eastern white pine (*Pinus strobus*) (SV= $1,082,286). Table 16 lists the structural value for each species in the inventory.

The individual tree with the highest structural value in the inventory was a 58" DBH white oak (*Quercus alba*) (SV=$17,594) located at 1075 Delaware Ave. Despite having the highest per species SV, no individual silver maple was among the 25 individual trees with the highest SVs.

Instead, oak, eastern white pine (*Pinus strobus*), and sugar maple (*Acer saccharum*) were the highest individually valued trees. See Table 17 for the 25 highest valued individual trees in the inventoried population.

Table 17. Total structural value, by species, of trees inventoried in Bethlehem, NY

Top Species Collected		Inventoried Trees		Structural Value
Common Name	Scientific Name	#	(%)	($)
silver maple	*Acer saccharinum*	381	8%	1,452,486
eastern white pine	*Pinus strobus*	341	7%	1,082,286
Norway maple	*Acer platanoides*	500	10%	858,163
red maple	*Acer rubrum*	303	6%	845,763
Norway spruce	*Picea abies*	322	7%	639,389
northern red oak	*Quercus rubra*	103	2%	478,086
sugar maple	*Acer saccharum*	124	3%	415,310
pin oak	*Quercus palustris*	46	1%	205,848
common honey locust	*Gleditsia triacanthos inermis*	74	2%	173,683
white ash	*Fraxinus americana*	329	7%	151,445
white oak	*Quercus alba*	26	1%	150,651
black locust	*Robinia pseudoacacia*	66	1%	147,625
apple	*Malus* spp.	197	4%	137,374
eastern hemlock	*Tsuga canadensis*	140	3%	112,505
'Crimson King' Norway maple	*Acer platanoides 'Crimson King'*	56	1%	109,036
Other inventoried trees		1,816	38%	1,459,528
Inventory Total		4,824	100%	8,419,178

Table 18. The 25 most structurally valuable trees in Bethlehem, NY

Top 25 Individual Trees Collected		DBH	Structural Value
Common Name	Scientific Name	(in)	($)
white oak	*Quercus alba*	58	$17,594.15
northern red oak	*Quercus rubra*	55	$16,686.76
northern red oak	*Quercus rubra*	50	$15,045.56
eastern white pine	*Pinus strobus*	44	$14,516.59
northern red oak	*Quercus rubra*	47	$13,983.51
sugar maple	*Acer saccharum*	46	$13,616.60
sugar maple	*Acer saccharum*	45	$13,243.25
northern red oak	*Quercus rubra*	45	$13,243.25
little leaf linden	*Tilia cordata*	37	$12,686.91
pin oak	*Quercus palustris*	44	$12,204.78
Norway spruce	*Picea abies*	36	$12,142.04
Norway spruce	*Picea abies*	36	$12,142.04
pin oak	*Quercus palustris*	36	$12,142.04
eastern white pine	*Pinus strobus*	48	$12,134.20
eastern white pine	*Pinus strobus*	48	$12,134.20
white oak	*Quercus alba*	42	$12,084.53
pin oak	*Quercus palustris*	43	$11,838.87
eastern white pine	*Pinus strobus*	47	$11,830.65
northern red oak	*Quercus rubra*	41	$11,685.40
Norway spruce	*Picea abies*	35	$11,589.04
sugar maple	*Acer saccharum*	40	$11,279.82
northern red oak	*Quercus rubra*	40	$11,279.82
sugar maple	*Acer saccharum*	40	$11,279.82
pin oak	*Quercus palustris*	41	$11,088.73
sugar maple	*Acer saccharum*	33	$11,013.80

Conclusions

The i-Tree Eco analysis found that Bethlehem's inventoried trees provide environmental and economic benefits to the community valued at $14,927 annually. Currently, the greatest annual benefits are derived from the runoff reduction capacity of the town's trees. The 4,824 inventoried trees divert 104,640 ft^3 of runoff annually, a service valued at $6,995. Trees also sequester carbon—in Bethlehem, the inventoried trees sequester 120 tons annually valued at $5,575. Pollution removal accounted for the smallest annual benefit at only $2,357, with 0.92 ton of pollutants removed each year. The total carbon storage capacity of Bethlehem's inventoried tree population is valued at over $569,135, and the structural value of those trees is $8,419,176.

Across the range of benefits analyzed by the i-Tree Eco model, the populations of silver maple (*Acer saccharinum*), Norway maple (*A. platanoides*), eastern white pine (*Pinus strobus*), and red maple (*A. rubrum*) were consistently the largest contributors of benefits. If Bethlehem's maple were lost to Asian longhorned beetle or other threats, the loss would be felt beyond just the visual impact of this loss. The Town should consider planting other genera to decrease the impact a pest or disease could have on the town's urban forest. To increase the benefits the urban forest provides, the Town should plant large-statured tree species that are low emitters of BVOCs wherever possible. Leafy, large-stature trees consistently created the most environmental and economic benefits. A list of large broadleaf trees recommended for the local climate of Bethlehem can be found in Appendix C.

Table 19. Conclusions

Section 2 Recommendation Summary	
Goals	Recommendation
Protecting species diversity and maximizing environmental and economic benefits	To increase the benefits the urban forest provides, the town should plant large-statured tree species that are low emitters of BVOCs wherever possible. A list of large broadleaf trees recommended for the local climate of Bethlehem can be found in Appendix C.

SECTION 3: TREE MANAGEMENT PROGRAM

A tree management program is an ongoing process and tree work that reduces public safety risks must always be prioritized. Work identified during the inventory should be completed based on the assigned risk rating (see below chart); however, it is essential to routinely monitor the tree population to identify and systematically address other Extreme or High Risk trees. While regular pruning cycles and tree planting are important, priority work (especially for Extreme or High Risk trees) must take precedence to ensure that risk is expediently managed.

Extreme Risk
- Perform tree maintenance immediately to reduce hazards
- Includes tree removal and pruning
- Mostly high-use areas

High Risk
- Perform tree maintenance immediately to reduce hazards and improve tree health
- Includes tree removal and pruning
- Generally high-use areas

Moderate Risk
- Perform tree maintenance as soon as possible to improve tree health
- Includes tree removal and pruning
- May be high- or low-use areas

Low Risk
- Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees and stumps
- Includes tree removals and pruning
- Mostly low-use areas but may be high-use areas as well

Routine Pruning
- Perform tree maintenance when convenient or as funding allows to improve aesthetics and improve tree health and structure

Training Prune
- Perform corrective pruning to young trees to increase structural integrity and develop a strong architecture of branches before serious problems develop

The tree management program developed to uphold Bethlehem's comprehensive vision for preserving its urban forest is a five-year program. It is designed to reduce risk through prioritized tree removal and pruning and to improve tree health and structure through proactive pruning cycles. Additional components of the program include tree planting to mitigate the negative effects of removals and increase canopy cover and public outreach, including stewardship and education. The five-plan is summarized on the next page, dividing the work between Priority Maintenance and Proactive Maintenance.

Year 1 **$428,721**

PRIORITY MAINTENANCE:

- High Risk tree removals: 3 trees
- Post-storm windshield inspections
- Newly found priority tree work (removal or pruning): costs TBD

PROACTIVE MAINTENANCE:

- Annual Routine Inspections
- Moderate or Low Risk tree removals: 162 trees
- Young Tree Training: 331 trees
- Routing Pruning Program: 1/5 of public trees
- Stump removal: 44 stumps
- New and replacement plantings, including follow-up care: 331 trees

Year 2 **$421,547**

PRIORITY MAINTENANCE:

- Post-storm windshield inspections
- Newly found priority tree work (removal or pruning): costs TBD

PROACTIVE MAINTENANCE:

- Low Risk tree removal: 162 trees
- Stump removal: 49 stumps
- Young Tree Training: 331 trees
- Routine Pruning Program: 1/5 of public trees
- New plantings, including follow-up care: 331 trees

Year 3 **$294,507**

PRIORITY MAINTENANCE:

- Post-storm windshield inspections
- Newly found priority tree work (removal or pruning): costs TBD

PROACTIVE MAINTENANCE:

- Stump removal: 50 stumps
- Young Tree Training: 332 trees
- Routine Pruning Program: 1/5 of public trees
- New plantings, including follow-up care: 331 trees

Year 4 **$266,987**

PRIORITY MAINTENANCE:

- Post-storm windshield inspections
- Newly found priority tree work (removal or pruning): costs TBD

PROACTIVE MAINTENANCE:

- Young Tree Training: 331 trees
- Routine Pruning Program: 1/5 of public trees
- New plantings, including follow-up care: 331 trees

PRIORITY MAINTENANCE:

- Post-storm windshield inspections
- Newly found priority tree work (removal or pruning): costs TBD

PROACTIVE MAINTENANCE:

- Young Tree Training: 331 trees
- Routine Pruning Program: 1/5 of public trees
- New plantings, including follow-up care: 331 trees

Priority Maintenance

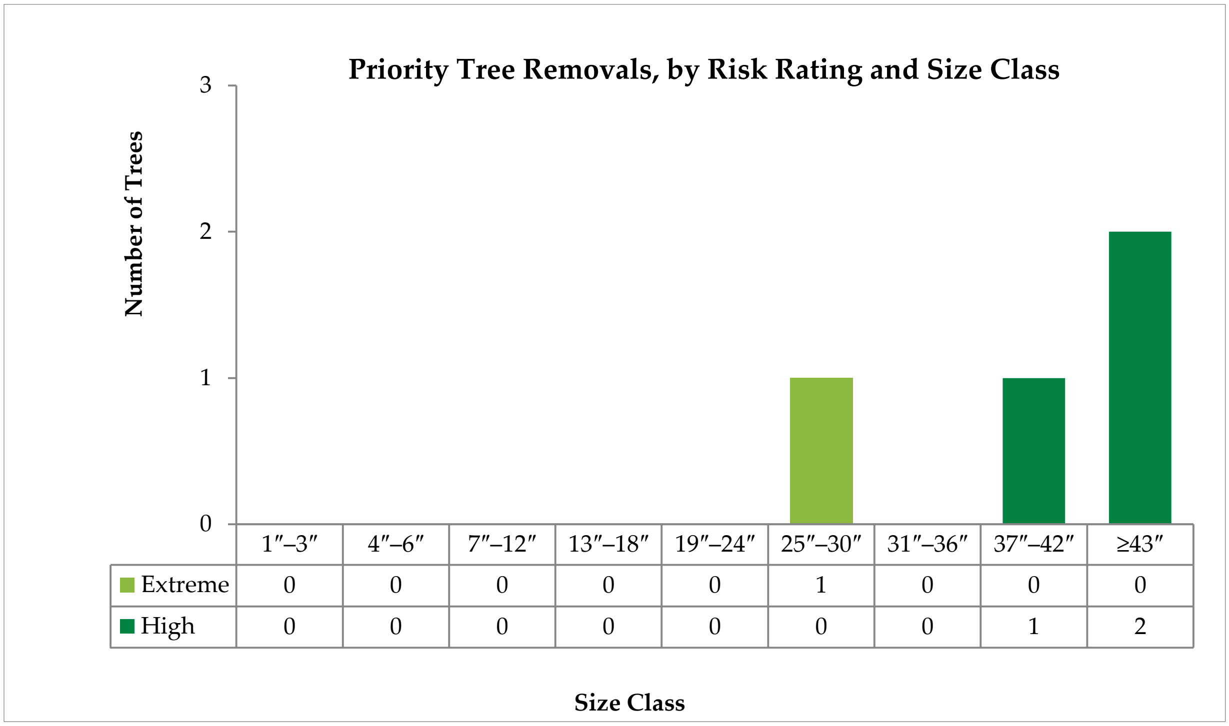
Priority maintenance includes tree removals and pruning of trees with an assessed risk rating of High or Extreme. Such trees are likely to fail more immediately and cause significant damage to people or property, and the removal of these trees or defective parts of these trees can significantly reduce the risk to public safety. Trees and tree parts may fail from natural causes, such as diseases, insects, and weather conditions, or from physical injury due to vehicles, vandalism, and root disturbances.

Extreme and High Risk Tree Removal

While tree removal is usually considered a last resort and may create a negative reaction from the community, it is important to understand that even trees with apparently healthy, or at least live, canopies can be hazardous. For example, a tree with a severely compromised root system due to nearby construction may look healthy for some time while still being at an elevated risk of failure. Such a tree, if in a location where its failure is likely to cause serious damage to structures, vehicles, or people, may warrant immediate removal despite having a full canopy and appearing to be healthy. Conversely, a tree with significant dieback located in a seldom-visited area of a public park may not necessitate immediate removal, despite the likelihood of tree failure. For a better understanding of the risk rating system used in this inventory, please see Appendix B. Ultimately, it is up to the discretion of the Town to determine acceptable levels of risk and whether the benefits of leaving a tree in declining health outweighs the risks to nearby people and property.

Trees should be removed when corrective pruning will not adequately eliminate the hazards associated with them or when correcting problems would be cost-prohibitive. Trees that cause obstructions, that interfere with power lines or other infrastructure, or that are diseased should be removed when their defects cannot be corrected through pruning or other maintenance practices. Nuisance trees may also warrant removal. Addressing Extreme and High Risk trees in a timely and proactive manner often requires significant resources to be secured and allocated. However, performing this work expediently will mitigate risk, improve public safety, and reduce long-term costs.

Figure 13 presents the recommended priority tree removals by risk rating and size class – surveyors identified two Extreme Risk trees and three High Risk trees. The size classes for the High Risk trees ranged between 37–42” DBH and >43” DBH. One Extreme Risk tree was removed immediately while the other was determined by NYSDOT to be located on private property. The High Risk trees should be removed as soon as possible due to their failed health and potential to cause extensive harm to people or property in their vicinity. Extreme and High Risk removals and pruning can be performed concurrently.



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Extreme	0	0	0	0	0	1	0	0	0
High	0	0	0	0	0	0	0	1	2

Figure 13. Priority tree removals, by risk rating and size class, in Bethlehem, NY. Note: Extreme risk tree found to be on private property

Extreme and High Risk Tree Pruning

Extreme and High Risk trees should be pruned immediately based on assigned risk rating, which generally requires removing defects such as dead and dying parts, broken and/or hanging branches, and missing or decayed wood that may be present in tree crowns, even when most of the tree is sound. In these cases, pruning the defective branch(es) can correct the problem and promote healthy growth and the risk associated with the tree is reduced.

No Extreme or High Risk trees recommended for priority pruning were identified during the inventory. Moderate and Low Risk trees found in need of pruning can be included in the routine pruning cycle, which is discussed in the Proactive Maintenance section.

Proactive Maintenance

Proactive tree maintenance includes individual pruning or removal of trees with a risk rating of Moderate or Low, as well as routine pruning of both mature and young trees. Tree planting, inspections, and community outreach are also considered proactive maintenance.

Moderate and Low Risk Tree Removal

Trees recommended for removal with an assigned risk rating of Moderate or Low were generally trees with smaller defective parts or were small, dead, invasive, or poorly formed trees that need to be removed. Eliminating these trees will reduce breeding site locations for pests and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or healthy, undesirable species are also included in this category. Moderate Risk trees should be addressed first, and Low Risk trees should be removed when convenient or when funding allows after all higher risk pruning and removals have been completed. Moderate and Low risk removals can be completed concurrently with Moderate and Low risk pruning.

As noted earlier, tree removal can be a sensitive subject in a community. Removing trees which are apparently healthy may seem counterintuitive and cause a reaction from the public. However, invasive, poorly formed, poorly located, and diseased/infested trees may not be worth the cost, whether monetary or otherwise, of maintaining. For example, allowing highly invasive trees, such as tree-of-heaven (*Ailanthus altissima*), to remain in the landscape helps these species to spread, and retaining trees with known diseases or insect infestations may allow those pests and pathogens to spread and affect other trees. A small tree growing in a poor location, such as too close to a utility, may not appear to be a concern, but can become costly to maintain or destructive to surrounding utilities as it grows. Again, the Town of Bethlehem, with advice from the Tree Committee, the Highway Department, and other tree-care professionals, will need to determine what level of risk is acceptable and whether the benefits of retaining a poorly formed, poorly located, diseased, or invasive tree outweigh the management cost.

The 2019 inventory identified 36 Moderate Risk trees and 288 Low Risk trees that are recommended for removal (Figure 14). The Moderate Risk trees ranged between 4–6" DBH and >43 inches DBH in size. These trees should be removed after all Extreme and High Risk removals and pruning have been completed. These removals can be completed concurrently with Moderate risk pruning. All Low Risk trees should be removed when convenient after all Extreme, High and Moderate Risk removals and pruning have been completed.

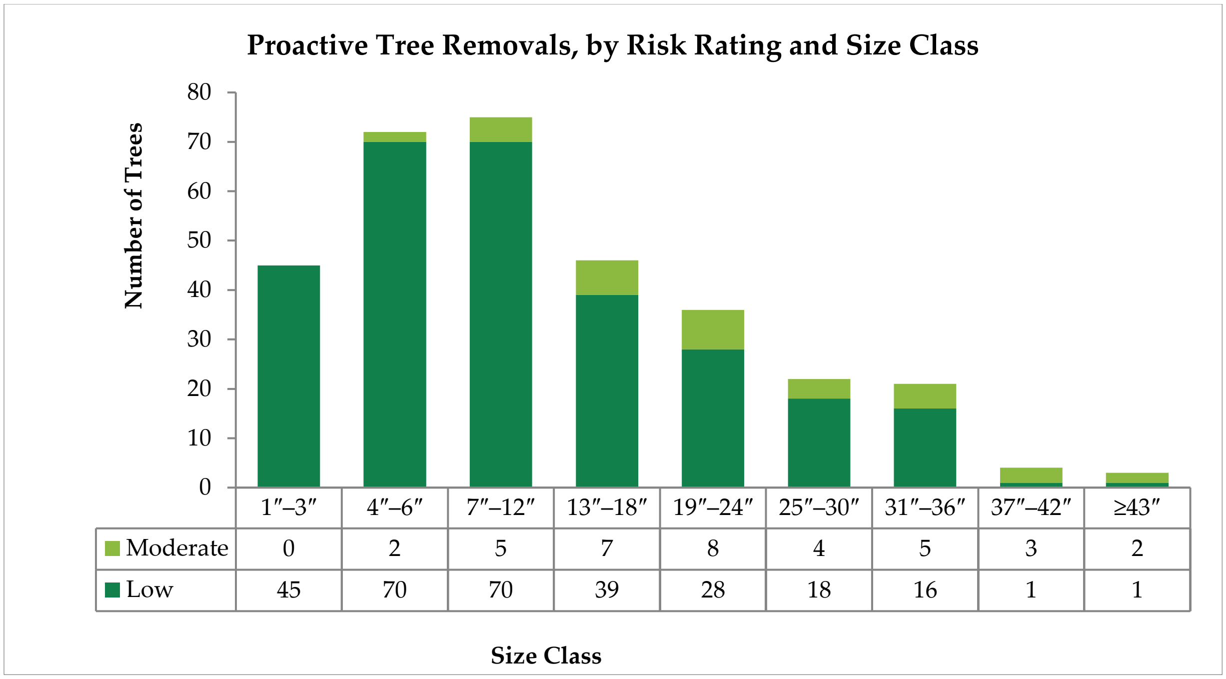


Figure 14. Proactive tree removal recommendations, by risk rating and size class, in Bethlehem, NY.

Routine Inspections

Routine inspections are essential to identifying major and minor tree issues. Inspections should be performed by a qualified arborist who is knowledgeable about the needs of trees and is trained and equipped to provide proper care. Qualified arborists hold credentials issued by the professional organizations in the field, such as ISA's (International Society of Arboriculture) Arborist Certification or ISA's Tree Risk Assessment Qualification (TRAQ) credentials.

All trees along the street ROW should be regularly inspected and addressed based on the inspection findings. Trees that need additional or new work should be added to the maintenance schedule and budgeted as appropriate. Use the data files provided as part of this tree inventory to update inventory data and work records. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Bethlehem has a large population of trees that are susceptible to pests and diseases, such as maple, ash, and oak, making routine inspections imperative to discovering an issue as early as possible. Study area 3A (pg. 14) has a relatively large number of mature trees that would especially benefit from routine inspections. In addition, Area 3F (pg. 14) has a relatively high population of oak and ash trees which would make it an important area for continued invasive pest and disease monitoring.

Street tree maintenance is currently addressed by Bethlehem's Highway Department; however, this department does not currently have a trained and credentialed arborist on staff. **Bethlehem should provide training in best practices for tree care to Highway Department employees and consider adding a trained arborist to their Highway Department staff. The Highway Department should perform routine inspections of inventoried trees and other public trees via windshield survey (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* annually and after all severe weather events**, to identify defects with heightened risk, signs of pest activity, and symptoms of disease.

Proactive Pruning Cycles

Pruning cycles are used to visit, assess, and prune trees on a regular schedule with a goal to improve health and reduce risk. Due to the long-term benefits of pruning (refer to Figure 15), the cycles should be implemented as soon as all Extreme and High Risk trees are corrected through removal or pruning. To ensure that all trees receive the type of pruning they need to mature with better structure and lower associated risk, two pruning cycles are recommended, which differ in the type of pruning, the general age of the target tree, and the length of the cycle:

- Young Tree Training Cycle
- Routine Pruning Cycle

The number of trees addressed in the pruning cycles will need to be adjusted to reflect changes in the tree population as trees are planted, age, and die. Newly planted trees should enter the young tree training cycle once they become established, and, as these young trees reach maturity, they should be shifted into the routine pruning cycle. When a tree reaches the end of its useful life, it should be removed and eliminated from the routine pruning cycle.

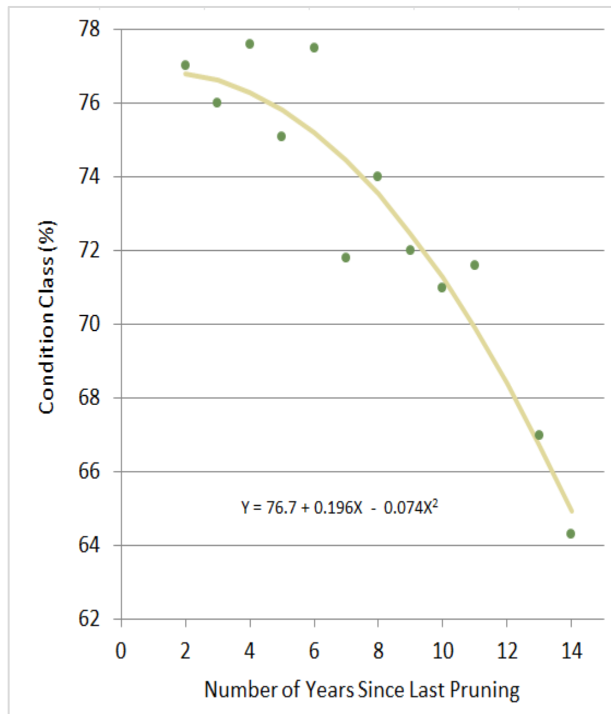


Figure 15. Relationship between average tree condition and the number of years since pruning (adapted from Miller and Sylvester, 1981).

Why Prune Trees on a Cycle?

Miller and Sylvester (1981) examined the frequency of pruning for 40,000 street and boulevard trees in Milwaukee, Wisconsin. They documented a decline in tree health as the length of the pruning cycle increased. When pruning was not completed for more than 10 years, the average tree condition was rated 10% lower than when trees had been pruned within the last several years (Figure 15). Miller and Sylvester suggested that a pruning cycle of five years is optimal for urban trees.

For many communities, a proactive tree management program is challenging. An on-demand response to urgent situations is commonplace. Research has shown that a proactive program that includes a routine pruning cycle will improve the overall health of a tree population (Miller & Sylvester 1981). Proactive tree maintenance has many advantages over on-demand maintenance, the most significant of which is reduced risk. In a proactive program, trees are regularly assessed and pruned, which helps detect and eliminate most defects before they escalate to a hazardous situation with an unacceptable level of risk. Area 3A (pg.14) has many large trees (50+DBH) that would benefit from proactive pruning. Other advantages of a proactive program include longer lifespan, increased environmental and economic benefits from trees, more predictable budgets and projectable workloads, and reduced long-term tree maintenance costs.

Young Tree Training Cycle

Young tree training is performed to improve tree form or structure by pruning for one dominant leader or other desired structure. The young tree training cycle differs from the routine pruning cycle in that these trees can typically be pruned from the ground with a pole pruner or pruning shear (routine pruning often requires a bucket truck or climbing arborist). Trees included in the young tree training cycle are generally less than 8 inches DBH. These younger trees sometimes have undesirable branch structures, such as codominant leaders or crossing limbs that can lead to potential problems as the tree ages. If these problems are not corrected, they may worsen as the tree grows, increasing risk and creating potential liability. The recommended length of a young tree training cycle is three years because young trees tend to grow at faster rates (on average) than more mature trees.

Young tree training is species-specific since many trees such as river birch (*Betula nigra*) may naturally have more than one leader. For such trees, young tree training is performed to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

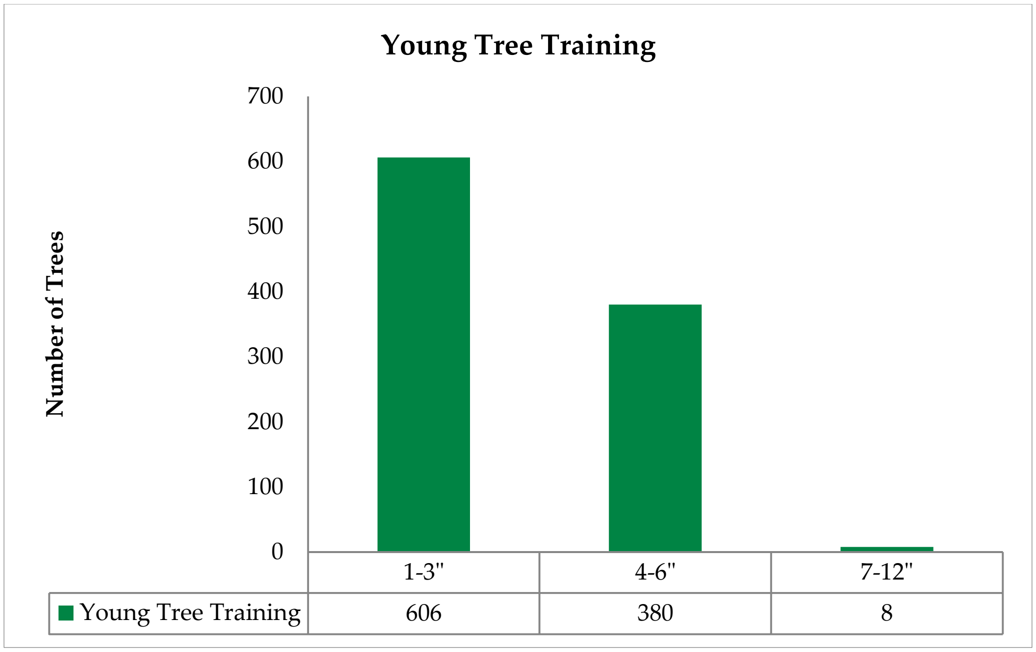


Figure 16. Number of trees recommended for young tree training, by size class, in Bethlehem, NY.

Figure 16 breaks down the trees recommended for young tree training by size class. A total of 994 trees fall into this program. The majority of the young trees (606) inventoried in Bethlehem were under 3” DBH, while a smaller number (380) were 4–6” DBH. A few larger diameter trees (7–12”) were also included in this program (8 trees). Conifer species are not included in the young tree training program, as they typically do not require intervention to develop good structure.

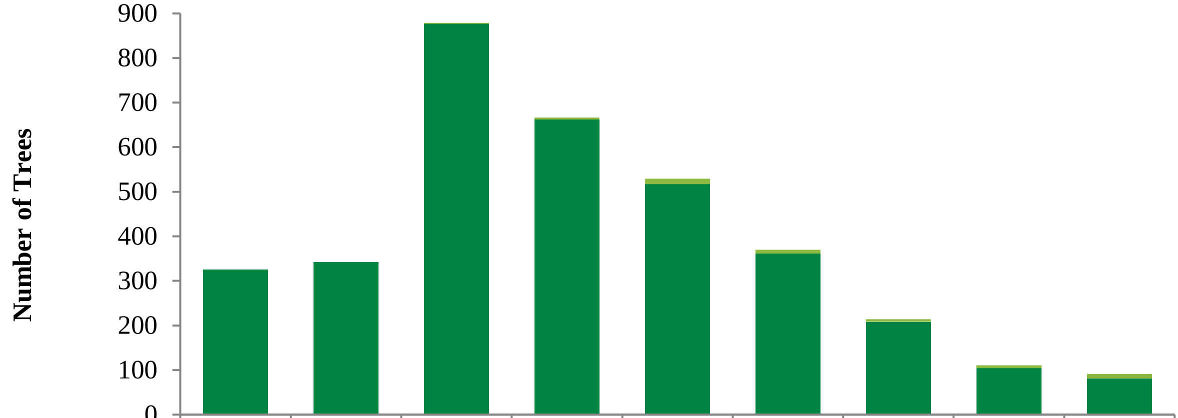
As described above, Bethlehem should implement a three-year young tree training cycle to begin after all Extreme and High Risk trees are removed. Since the number of existing young trees is relatively small, and the benefit of beginning young tree training is substantial, **it is recommended that the Town structurally prune an average of 331 trees each year over a three-year period**, beginning in Year One of the management program. A majority of trees recommended for the Young Tree Training cycle are in study areas 2 and 3D.

If trees are planted, they will need to enter the young tree training cycle after establishment, typically a few years after planting. In future years, the number of trees in this cycle will be based on tree planting efforts and growth rates of young trees. In future years, t**he Town should strive to continue to prune approximately one-third of its young trees each year.**

Routine Pruning Cycle

The routine pruning cycle includes established, maturing, and mature trees (mostly greater than 8” DBH) that need strategic pruning to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance, minimize instances of elevated risk, and provide the basis for a more defensible risk management program. Included in this cycle are Moderate and Low Risk trees that require pruning and pose some risk—these trees have smaller defects and/or a lower potential to impact a target. The defects found within these trees can usually be remediated with routine pruning.

The length of the routine pruning 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 routine pruning cycle length is generally five years but may extend to seven years if the street tree population is large.**



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Moderate	0	0	2	4	12	9	6	7	10
Low	325	342	877	662	517	361	208	104	81

Figure 17. Number of trees recommended for routine pruning, by size class, in Bethlehem, NY.

The 2019 tree inventory identified approximately 3,527 trees that should be pruned through a five-year routine pruning cycle (Figure 17 shows the number and size class of these trees). Small diameter trees included in this cycle include young conifer, which generally do not require pruning to correct structural deficiencies, and young broad-leaf trees that are located in unmaintained areas and are unlikely to pose significant risks to the community as they grow. Most of the trees in this cycle were classified as Low Risk (3,477), with a smaller number classified with Moderate Risk (50). Most trees in the routine pruning cycle were between 7” DBH and 30” DBH.

The town should establish a five-year routine pruning cycle in which approximately one-fifth of the tree population is to be pruned each year. An average of 705 trees should be pruned each year over the course of the cycle, starting in Year One with Moderate Risk trees followed by Low Risk trees. The routine pruning cycle should begin in Year One of this five-year plan, after all Extreme and High Risk pruning has been addressed.

Tree Planting and Stump Removal

Planting new trees in areas where there is sparse canopy, poor canopy continuity, or gaps in the existing canopy is an essential goal of a systematic tree planting program. While Bethlehem receives value from the ecosystem services provided by the public tree resource, such benefits tend to be distributed unevenly.

The "Right Tree, Right Place" mantra for tree planting is 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. **Before selecting a tree for planting, make sure it is the right tree for the right location**—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right site 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 and hardscape as it grows taller, wider, and deeper. If the tree at maturity will reach overhead lines, or conflict with sidewalks and curbs, it is best to choose another species or a different location.

The Town currently installs less than 25 new trees each year, and while increasing this number could provide many benefits, it will also require inputs of labor and capital. Residents of Bethlehem have requested expansion of the current tree planting program. Bethlehem should work toward a consistent and sustainable tree-planting program to fill existing canopy gaps and to replace trees that must be removed due to age, EAB, other pests or diseases, or damage due to weather or human error. Bethlehem should look into the planting programs of other towns to see if current practices in other areas are a good fit for the Town's level of resources.

When considering whether a location was suitable for planting, surveying arborists assessed the overall size of the vacant site as well as the presence of any overhead or underground utilities that could conflict with a tree. A total of 1,657 vacant sites[6] were collected along county routes, including 344 large vacant sites, 186 medium vacant sites, and 1,127 small vacant sites. Additionally, 328 trees and 143 stumps were identified for removal, which have or will cause gaps in the existing tree canopy. In total, there are a little over 2,100 planting opportunities in Bethlehem's forest over the management horizon of this plan.

The cost of filling all inventoried vacant sites and filling gaps in the existing tree canopy was estimated assuming that an equal number of new plantings would occur annually over five years and that tree and stump removals would be replanted in the same year as removal. Using 2.5" caliper, balled and burlapped trees and including aftercare for the trees, the estimated budget is a little over $1,000,000 over the next five years. The cost of planting bare-root trees is significantly less. DRG recommends that the bare-root tree planting method developed by the Cornell University Urban Horticulture Institute (in collaboration with the City of Ithaca Parks and Forestry Section) become the primary way that the Town of Bethlehem plants public trees. More information on bare-root tree planting appears in Appendix C.

The Town should carefully consider how to best allocate the planting funds they currently have while advocating for more funding from both the Town and various outside granting agencies.

There are also several ways to reduce the cost to the Town:

- Expanded beyond this five-year term to lessen the cost burden.
- Volunteer groups participating in tree planting.
- Private property owners given the option of paying for the tree and choosing the tree they want from a list of recommended species.
- Grants for reforestation.

[6] During the 2019 inventory vacant sites suitable for planting were only collected along state and county road ROWs. See Appendix A for the specific characteristics required for a small, medium, or large vacant site to be recorded during the inventory.

With ample sites available, a matrix can be designed to pick the very best spot in the town to plant a tree. Ask the question, "Where is the best place to plant a tree?" Some municipal arborists coined the phrase, "purposeful planting" or "planting with a purpose." As discussed earlier, there are many purposes which trees can be beneficial—air pollution control, aesthetics, stormwater attenuation, central business district streetscapes, etc. Consider creating a table, listing the best possible sites in the town to plant a tree, and begin planting. Create this table with the help of the internal and external stakeholders who can aid in priority setting. The Town should consider equity in distribution of street tree canopy in when evaluating possible planting sites and use available demographic data to support decision-making.

Consider palettes or themed plantings for various geographies (e.g., neighborhoods/wards), typically 3–5 genera of trees per block. A list of suggested tree species is provided in Appendix C. These tree species are specifically selected for the climate of Bethlehem. This list is not exhaustive but can be used as a guideline for species that meet community objectives and to enhance any existing list of approved species.

On the municipal side, take the necessary steps to ensure the new plantings have a chance to grow in the space they are provided. Soil enhancements, watering regimes, and young tree training are vital to the future success of newly planted trees. Efforts should be made to prudently select healthy tree species from nurseries and do not settle for poor nursery stock simply for the fact of planting a tree. The urban environment is hostile to trees, it is not the forest and as such, this artificial environment requires human intervention for the trees to maximize their benefits to the community.

Creating larger growing sites for trees in the municipal ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts, as the trees can be planted further from curbs and sidewalks. Depending on the site, there are several methods available to create and/or increase the growing space for newly planted trees:

- Install or enlarge tree wells/pits in existing sidewalks of sufficient width. Ideally, the minimum growing space of a small-sized tree is 32 square feet. Where Bethlehem has sidewalks of a sufficient width and length, the Town could install tree pits with enough space remaining for the sidewalk to still comply with American Disability Act (ADA) standards.
- Planting trees 4 feet behind a curb without a sidewalk, or 4 feet behind an existing sidewalk, can be a low-cost alternative to more construction-intensive methods. This can result in less damage to the sidewalk and give tree roots room to grow into the open soil.
- Re-routing the sidewalk around an area to create designated large tree sites is a relatively cost-effective method to increase growing spaces and preserve large trees. This method can also be applied to existing tree sites, where roots are already conflicting with the sidewalk.
- A landscape bump-out/curb extension is a vegetative area that protrudes into the parking lane of a street to provide a growing space for plants or trees. These spaces can be used quite effectively by municipalities to beautify a streetscape and provide greater storm water retention, along with the added benefit of slowing car speeds at the bump-out location.

Maintenance Schedule and Budget

Utilizing data from the 2019 Town of Bethlehem tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. Budget projections were made using industry knowledge and public bid tabulations in the region. The pricing provided in the budget table (Table 20) is based on hiring outside contractors to complete all tree management tasks and as such will overestimate the costs of using in-house personnel and equipment. A summary of the maintenance schedule is provided in the Executive Summary at the beginning of this report, and a complete table of estimated costs for Bethlehem's five-year tree management program follows.

The schedule provides a framework for completing the inventory maintenance recommendations over the next five years. Following this schedule can shift tree care activities from an on-demand system to a more proactive tree care program. Due to the COVID-19 pandemic and resulting economic challenges, the Town faces a period of resource uncertainty. The schedule may need to be adapted in consideration of other needs.

To implement the maintenance schedule, the Town's tree maintenance budget should be no less than $428,721 for the first year of implementation, no less than $421,547 for the second year, no less than $294,507 for the third year, and no less than $266,987 for the final two years of the maintenance schedule, representing a $1.68M budget over the five-year management plan. Annual budget funds are needed to ensure that High Risk trees are remediated, and that crucial younger tree training and routine pruning cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Table 20. Estimated budget for five-year urban forestry management program in Bethlehem, NY. Please note, this table reflects both the average per tree cost for each activity (Ave. Cost/ Tree column) as well as the total cost of the activity factoring in the actual size of each tree to be managed (Total Cost).

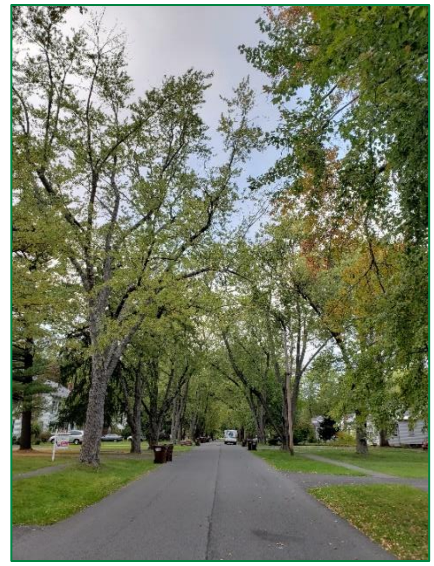
			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Maintenance Type	Activity	Ave. Cost/ Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
PRIORITY MAINTENANCE	Extreme and High Risk Removals	$726	3	$4,785	0	$0	0	$0	0	$0	0	$0	$6,380
	High Risk Pruning	$213	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	Total Cost		**$4,785**		$0		$0		$0		$0		**$6,380**
PROACTIVE MAINTENANCE	Moderate and Low Risk Removals	$726	162	$53,913	162	$50,118	0	$0	0	$0	0	$0	$104,031
	Stump Removals	$94	44	$3,526	49	$3,902	50	$4,230	0	$0	0	$0	$11,657
	Young Tree Training (3-year cycle)	$25	331	$7,910	331	$7,910	332	$7,940	331	$7,910	331	$7,910	$39,580
	Routine Pruning (5-year cycle)	$213	702	$98,715	705	$99,265	705	$99,265	708	$100,005	707	$99,675	$496,925
	Total Cost		**$164,064**		**$161,195**		**$111,435**		**$107,915**		**$107,585**		**$652,193**
PLANTING	Procurement	$170	331	$56,270	331	$56,270	331	$56,270	332	$56,440	332	$56,440	$281,690
	Planting	$110	331	$36,410	331	$36,410	331	$36,410	332	$36,520	332	$36,520	$182,270
	Mulching	$100	331	$33,100	331	$33,100	331	$33,100	332	$33,200	332	$33,200	$165,700
	Watering	$100	331	$33,100	331	$33,100	331	$33,100	332	$33,200	332	$33,200	$165,700
	Total Cost		**$259,872**		**$260,352**		**$183,072**		**$159,072**		**$159,072**		**$1,021,440**
Maintenance Cost Grand Total			$428,721		$421,547		$294,507		$266,987		$266,657		$1,680,013

Table 21. Implementation steps for Bethlehem, NY

Implementation Step	Responsible Department(s)
Update inventory database to reflect trees removed to date	Economic Development and Planning Department and Highway Department
Verify ROW for any remaining High Risk Trees	Department of Public Works
Perform Maintenance on High Risk Trees	Highway Department
Capture Tree Removals in Database Update	Economic Development and Planning Department
Verify ROW for Moderate Risk Trees	Department of Public Works
Perform Level III Risk Assessments	Highway Department
Perform Maintenance on Moderate Risk Trees	Highway Department
Discuss and decide a Town EAB strategy	Highway Department and Economic Development and Planning Department
Capture Tree Removals in Database Update	Economic Development and Planning Department
Closely Monitor and/or Inspect All Trees Recommended for Further Inspection	Highway Department
Verify ROW for Low Risk Removals	Department of Public Works
Remove Low Risk Trees	Highway Department
Capture Tree Removals for Database Update	Economic Development and Planning Department
Begin 5 Year Routine Pruning Cycle	Highway Department
Begin 3 Year Young Tree Training Cycle	Highway Department
Verify ROW for Stumps	Department of Public Works
Remove Stumps	Highway Department

Verify ROW for Identified Planting Sites as Trees are Planted	Department of Public Works and Highway Department
Expand Planting Program	Supervisor's Office

Inventory and Management Updates



Photograph 12. A street well stocked with trees provides economic, environmental, and social benefits, including temperature moderation, reduction of air pollutants, energy conservation, and increased property values.

The inventory should be routinely updated using an appropriate computer software program so that the Town can sustain its program and accurately project future program and budget needs. The following management activities should be performed and tracked in the inventory when completed:

- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help Town staff stay apprised of changing conditions. Schedule and prioritize work based on risk.
- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Update the inventory database as work is performed on a seasonal basis. Town Highway staff will record tree removal and pruning data and provide Planning staff with the updated information via spreadsheet. New tree work will be added to the schedule when work is identified through inspections or a citizen call process. New trees will be added to the inventory after plantings occur as part of the Street Tree Planting Program or from the Planning Board approval process.
- Modify maintenance schedules and budgets accordingly if recommended work cannot be addressed on time.
- Re-inventory the street ROW and update all data fields in five years, or a portion of the population (1/5) every year over the course of five years.
- Revise the Tree Management Plan after five years when the re-inventory has been completed.

Conclusion

When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. At this time, the town's inventoried trees provide an annual benefit of $14,927, a carbon storage value of $569,135, and have a replacement value (or structural value) of $8,419,176. By following the maintenance recommendation outlined in this section, these benefits are sure to grow.

The management program outlined here is ambitious and is a challenge to complete in five years but becomes easier after all high priority tree maintenance is completed. This *Standard Inventory Analysis and Management Plan* could potentially help the Town advocate for an increased urban forestry budget to fund the recommended maintenance activities. Getting started is the most difficult part because of the expensive maintenance in the first year, which represents the transition from reactive maintenance to proactive maintenance. Significant investment early on can reduce tree maintenance costs over time.

Table 22. Implementation steps for Bethlehem, NY

Section 3 Recommendations Summary	
Maintenance Needs	Recommendation
Priority Maintenance	Priority maintenance includes tree removals and pruning of trees with an assessed risk rating of High or Extreme. Such trees are likely to fail more immediately and cause significant damage to people or property, and the removal of these trees or defective parts of these trees can significantly reduce the risk to public safety.
Proactive Maintenance: Routine Inspections	Routine inspections are essential to identifying major and minor tree issues. Inspections should be performed by a qualified arborist who is knowledgeable about the needs of trees and is trained and equipped to provide proper care.
Tree Planting	The cost of planting bare-root trees is significantly less. DRG recommends that the bare-root tree planting method developed by the Cornell University Urban Horticulture Institute (in collaboration with the City of Ithaca Parks and Forestry Section) become the primary way that the Town of Bethlehem plants public trees.

Section 3 Recommendations Summary	
Maintenance Needs	Recommendation
Proactive Maintenance: Pruning cycles	Pruning cycles are used to visit, assess, and prune trees on a regular schedule with a goal to improve health and reduce risk. Due to the long-term benefits of pruning, the cycles should be implemented as soon as all Extreme and High Risk trees are corrected through removal or pruning. To ensure that all trees receive the type of pruning they need to mature with better structure and lower associated risk, two pruning cycles are recommended, which differ in the type of pruning, the general age of the target tree, and the length of the cycle—Young Tree Training Cycle and Routine Pruning Cycle. The Town should establish a five-year routine pruning cycle and a three-year young tree training cycle in which approximately one-fifth and one-third of the tree population is to be pruned each year, respectively.
Tree Planting and Stump Removals	Planting new trees in areas where there is sparse canopy, poor canopy continuity, or gaps in the existing canopy is an essential goal of a systematic tree planting program. Stumps and trees identified for removal should be removed and replanted to avoid gaps in the existing canopy. Before selecting a tree for planting, make sure it is the right tree for the right location—know how tall, wide, and deep it will be at maturity.
Expanding The Current Tree Planting Program	DRG recommends that Bethlehem explore expanding its current street tree planting program so that they can capture their resident's recommendation. Bethlehem should look into the planting programs of other towns to see if current practices in other areas would be a good fit for the Town and its level of resources.

SECTION 4: FOREST PEST AND DISEASE DETECTION AND MANAGEMENT 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 native trees and shrubs do not have appropriate defense mechanisms to fight them off. Mortality from pests or diseases can occur within two weeks, such as with oak wilt (*Bretziella fagacearum*), to at least seven years, as with emerald ash borer (EAB) (*Agrilus planipennis*). An integral part of tree management is maintaining awareness of invasive insects and diseases in the area and knowing how to best manage them.

This section discusses some of the insects and diseases of concern in Bethlehem and provides a framework for pest management, offering EAB as a case study. Appendix E contains additional reference materials concerning a variety of pests found in and around New York State.

Pests and Diseases and Bethlehem's Trees

Many pests and diseases are threatening forests in New York State. However, not all forests are equally vulnerable. All pests and diseases have a range of host tree species on which they live, breed, and feed, and forests with higher concentrations of these preferred host species are at a higher risk of an outbreak. In urban settings, monocultures of a few tree species can create both a highly suitable habitat for pests and diseases and can create higher stakes for the community should a forest health issue threaten a large portion of the urban tree population.

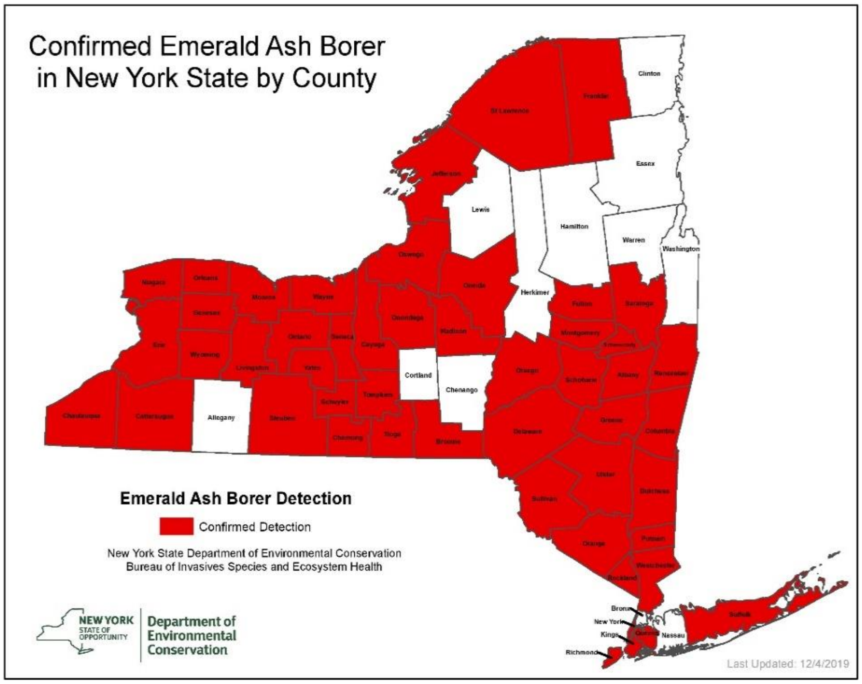
Bethlehem has a wide variety of tree genera and species present in the urban landscape (~52 genera and ~110 species). However, as discussed in Section 1, maple (*Acer* spp.) make up 31% of the inventoried population. The prevalence of maple in Bethlehem's urban forest makes the forest more susceptible to pests and diseases that count maple among their host species, making a large portion of the urban canopy vulnerable should any arrive in the town. Not only would such a loss cost the Town large amounts of money in hazard tree mitigation, but the losses in ecosystem services provided by the trees would be massive.

Based on the composition of Bethlehem's inventoried tree population, **Asian longhorned beetle (ALB) (*Anaplophora glabripennis*), spotted lanternfly (SLF) (*Lycorma delicatula*), elongate hemlock scale (EHS) (*Fiorinia externa*), and gypsy moth (*Lymantria dispar*) are the pest species with the potential to impact the greatest portions of the inventoried trees.** Thirty-two percent of the inventoried population is susceptible to ALB, 28% is susceptible to SLF, 24% is susceptible to EHS, and 24% is susceptible to gypsy moth.

Although, invasive pests like Asian longhorned beetle and spotted lanternfly are generalizers and have the potential to impact a larger portion of the inventoried trees if an infestation establishes, emerald ash borer (EAB) is more of an immediate concern due to its known activity in the town. This makes the following a valuable case study on pest management strategies.

Case Study: Emerald Ash Borer

Emerald ash borer (EAB) (*Agrilus planipennis*) is native to Asia. In North America, the insect 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.



Map 7. New York counties with confirmed EAB presence as of December 2019.

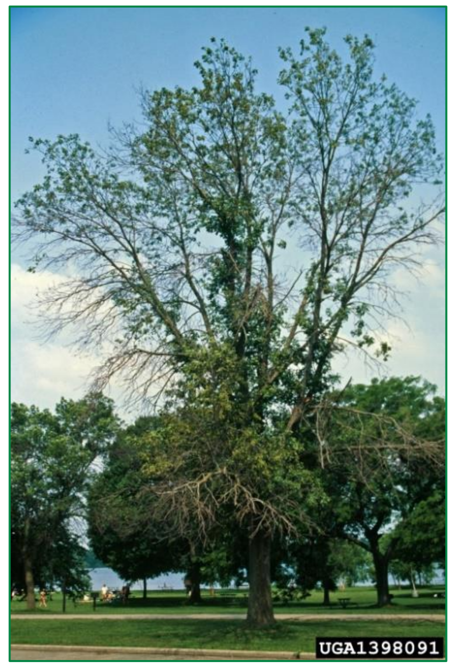
EAB is thought to have been introduced into the United States and Canada in the 1990s; however, it was not positively identified in North America until 2002 in Canton, Michigan. The presence of EAB has been confirmed in 35 states as of July 2020. EAB has killed at least 50–100 million ash trees and threatens another 7.5 billion ash trees throughout North America. It was first found in New York in Cattaraugus County in 2009 and has since spread to more than 40 counties in New York, including Albany County, where Bethlehem is located. Map 2 shows the New York counties in which EAB has been confirmed. EAB is a serious pest that threatens the health of all ash tree species in the state. Nine percent of Bethlehem's inventoried tree population is comprised of ash trees, making EAB a significant concern for the town.

EAB Identification

The adult beetle is elongate, metallic green, and 3⁄8 to 5⁄8 inches long. They emerge from their host tree beginning in late May through 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 roughly a week, the eggs hatch into larvae, which then bore into the tree. Larvae are creamy white in color, can grow up to an inch long, and are found underneath the bark of the trees. The larvae tunnel and feed on the inner bark and phloem, creating winding galleries as they feed, which cut off the flow of the water and nutrients to the tree, causing dieback and eventual tree death.

EAB can be very difficult to detect. Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting and can often mimic those associated with ash yellow. The entire canopy may die 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, and can appear as "blonding" where the freshly stripped bark shows as a lighter color than the remaining bark.

The 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 throughout the tree, from upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole that is about 1/8 inch in diameter. The loss of water and nutrients from the intense larvae tunneling can cause trees to lose between 30% and 50% of their canopies during the first year of infestation, and trees often die within two years of infestation.



EAB State and Federal Response

The New York State Department of Environmental Conservation (NYS DEC) is the leading agency responsible for control of invasive pests in New York. The Federal agency USDA-APHIS (United States Department of Agriculture – Animal and Plant Health Inspection Service) assists with regulatory and control action of invasive pests. EAB is listed as a prohibited invasive species by 6 NYCRR Part 575. Under this regulation, no person shall sell, import, purchase, transport, introduce, or propagate, or have the intent to take any of these actions on the regulated species, unless issued a permit by DEC for research, education, or other approved activity. The entirety of New York State has been quarantined to limit the spread of EAB beyond the borders of the state, and the DEC has instituted regulations to restrict the movement of firewood beyond 50 miles of the point of origin for the same purpose within the state. They are also working cooperatively with other groups and agencies to identify potentially resistant ash trees and to conserve ash seed for future restoration efforts (see: https://www.dec.ny.gov/animals/7253.html).

Photograph 8. NYS DEC emerald ash borer identification tag.

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*, an endoparasitoid; *Oobius agrili*, a solitary, parthenogenic egg parasitoid; and *Spathius agrili*, an 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, and more recently New York (New York City).

Ash Population in Bethlehem

With the threat of EAB, it is crucial that the Town have an action plan. Some of the most important questions to answer will include:

- How many ash trees are in the population?
- Where are they located?
- What actions should be taken?

To answer these questions, Bethlehem needs to maintain an up-to-date inventory, know what resources are available, and understand the Town's priorities. 431 ash trees were identified during the 2019 inventory; however, it is important to note that the inventory focused on street ROWs and was limited to only certain portions of the Town. The actual number of ash trees within Bethlehem's town limits is certainly much higher. Of the inventoried ash trees, 83 (19%) were recommended for removal based on health or safety concerns identified during the inventory. Most of the ash population was in Good or Fair condition (39% and 40%, respectively), with a significantly smaller percentage in Poor or Dead condition (6% and 14%, respectively). Table 23 shows the condition of each ash tree by size class. Of the ash trees inventoried, seven were recorded with potential signs and symptoms of EAB. However, assessing trees for EAB damage was not the focus of this inventory and many more ash trees may have signs and symptoms of EAB that were either not observed or not recorded during the inventory.

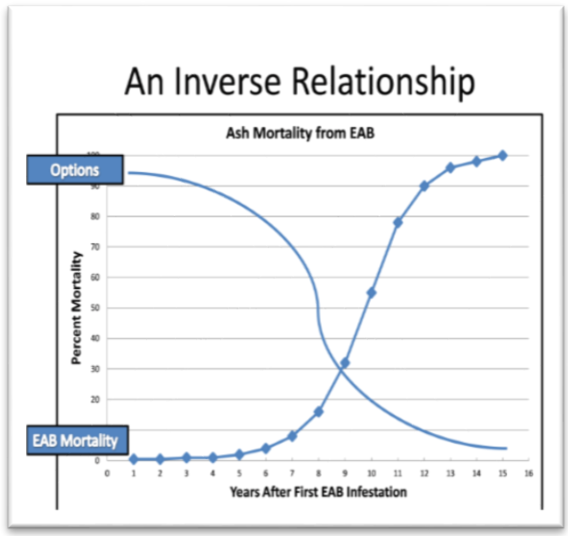
Table 23. Ash tree condition by size class (in inches) for trees inventoried in Bethlehem, NY

Condition	1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
Good	74	72	23	1	0	0	0	0	0	170
Fair	21	87	47	10	7	0	0	1	0	173
Poor	2	9	7	6	1	0	1	0	0	26
Dead	12	25	21	3	1	0	0	0	0	62
Total	109	193	98	20	9	0	1	1	0	431

EAB Management Options

Ash trees may not exhibit outright symptoms of infestation until a critical mass of tissue destruction has occurred. In a recent study, the United States Forest Service found that 100% mortality occurred in stands of ash after 6 years of infestation (tree diameter >1”). Decline was very slow, then accelerates as borer population increases over time.

As time passes since the first EAB infestation, fewer management options are available. Figure 18 presents a unique visual tool for a town when deciding on viable management options for varying levels of EAB infestations. With no current strategy or budget in place to prepare for the infestation of EAB, Bethlehem 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 strategies. The following are current strategies for managing EAB and their associated costs.



Options for management of EAB decrease as the time since infestation increases. Graph courtesy of Emerald Ash Borer University (www.emeraldashborer.info).

Photograph 9. The results of a Do Nothing strategy. The ash trees pictured here became infested with EAB and eventually died. They have now become a public safety issue.

EAB Strategy 1: Do Nothing

The Do Nothing strategy entails letting EAB run its course and implementing no management methods for dealing with EAB. This strategy includes not removing and not treating any ash trees and is economical in the beginning of an infestation because it does not cost the Town any money until dead trees become hazardous and require removal. This strategy leads to an extreme public safety issue within a few years and, in general, it is not a recommended management strategy.

EAB Strategy 2: Remove and Replace All Ash

Using the Remove and Replace strategy, forest managers remove all ash trees on a systematic basis over a specific time period and then replace those trees with non-ash species. This strategy would benefit public safety from the EAB infestation and lay the groundwork to rebuild environmental benefits lost from these ash trees.

Incorporating this strategy into the five-year management plan, Bethlehem would remove and replace all inventoried ash trees by 2024. If deemed necessary, tree removals should occur as quickly as possible to reduce the spread to neighboring ash populations once EAB is detected within the town and to reduce the risk to the public related to a standing dead ash.

Although this strategy would improve public safety around these trees if they were to become infested, there would be both a significant environmental and economic cost. Removing mature ash trees in Good and Fair condition would eliminate the benefits that these trees provide to the town and would significantly reduce or eliminate canopy cover in the areas with higher densities of ash trees. Replacing the removed trees as soon as possible would be essential to regain lost economic benefits of the urban forest. Table 24 summarizes the total approximate cost for this strategy, which would be almost $263,000 (the same approximate costs used to create the budget table from Section 3 of this management plan were used to estimate these costs).

Table 104. Total five-year cost to implement a Remove and Replace EAB management strategy for trees inventoried in Bethlehem, NY.

Management Action	# of Trees/ Stumps	Average Cost per Tree/ Stump	Five-Year Cost
Tree Removal	431	$726	$42,025
Stump Removal	431	$94	$14,262
Replacement	431	$480	$206,880
Total			$262,791

EAB Strategy 3: Treat all Ash

A third management strategy would be to treat all living ash trees and remove dead trees. Trees that do not show signs of infestation would be considered for treatment rather than removal. There are four types of EAB treatment options: soil injection, trunk injection, bark spray, and canopy spray. The most common are soil injections and trunk injections, which deliver treatment into the tree's tissues. Costs of injections vary depending on the method and the size of the tree to be treated.

Treating all of Bethlehem's ash trees to prevent EAB infestation could reduce the annual mortality rate, stabilize removals, and would be less expensive than removing and replacing all ash trees. These trees would continue providing the town with the multitude of ecosystem services and economic benefits that trees offer. However, some of these ash trees are in Fair or Poor condition and are more likely to become infested with EAB and some are in undesirable locations—these trees may not be the best candidates to retain in the long term.

On average, the cost to treat one tree in Bethlehem is about $133, or $6 per diameter inch. Based on a two-year treatment cycle, the five-year cost to treat all living ash trees would be approximately $33,000. Table 25 summarizes the total cost ($39,583) to implement this strategy over five years[7]. It is important to note that this is a recurring strategy that would mean future costs for the Town.

Table 115. Total five-year cost to implement a Tree All Ash EAB management strategy for trees inventoried in Bethlehem, NY

Management Action	# of Trees	Average Cost per Tree	Five-Year Cost
Treat	369	$133	$33,383
Tree Removal	62	$726	$6,201
Total			$39,583

EAB Strategy 4: Combination of Removals and Treatment

The fourth recommended strategy uses a combination of treatment, removals, and replacement to manage an EAB infestation. This strategy is intended to give the Town options to stabilize annual removals, annual budgets, and prolong the life of ash trees in Good and Fair condition, thus prolonging the benefits derived from these trees. Depending on the evaluation of each ash tree, the condition and risk should meet a threshold of treatment rather than removal. Table 26 summarizes the number of trees that should be considered for treatment or removal.

Table 126. Recommended EAB management using Strategy 4 for ash trees inventoried in Bethlehem, NY. Green indicates high priority treatment, yellow low-moderate priority treatment, and red remove and replacement

Condition	Size Class									Total
	1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	
Good	74	72	23	1	0	0	0	0	0	170
Fair	21	87	47	10	7	0	0	1	0	173
Poor	2	9	7	6	1	0	1	0	0	26
Dead	12	25	21	3	1	0	0	0	0	62

[7] Although the management plan has a five-year horizon, it is recommended to complete a full two-year treatment cycle for each tree. The sixth year would cost an additional $6,700.

Total	109	193	98	20	9	0	1	1	0	431

High Priority Treatment: 24 trees

- High-priority treatment trees are high quality specimens due to their condition and their size. These trees have significant environmental value.
- Candidates for treatment should be in Good condition, have no more than 30% dieback, and be larger than 7 inches DBH. Such trees should also be growing in an appropriate site (i.e., not under overhead utilities).

Low-Moderate Priority of Treatment: 18 trees

- Low-moderate priority candidates are trees that should be treated only to defer removal and minimize short-term budgets.
- Candidates for low-moderate priority treatment are trees in Fair condition larger than 13 inches DBH.

Remove and Replace: 389 trees

- Trees slated for removal are those that are more susceptible to infestation if EAB spreads more widely in Bethlehem or are small enough that the cost to remove and replace them is more economical than retaining and treatments them.
- Candidates for removal are trees in the Poor and Dead condition class, Fair condition trees under 12 inches DBH, and Good condition trees less than six inches DBH.
    - The 88 trees in Poor and Dead condition are more likely to create a public safety issue if infested and not removed immediately, especially the larger they are. They should be replaced upon removal.
    - The remaining 301 smaller trees in Fair and Good condition do not provide as many benefits to the community compared to mature ash trees. It would be in the best interest of the town to remove these trees and replace them with a more diversified mix of trees.

In this strategy, costs are derived from treating all 42 candidate ash trees, regardless of priority, and removing and replacing the remaining 389 trees. Immediately following removals, the associated stump should be removed, and a new tree should be planted. The estimated cost to complete the recommended five-year management plan is a little more than $236,000 (see Table 27).

Table 137. Total five-year cost to implement a combination Treatment and Remove/Replace EAB management strategy for tree inventoried in Bethlehem, NY

Management Action	# of Trees/ Stumps	Average Cost per Tree/ Stump	Five-Year Cost
Treat	42	$133	$8,685
Tree Removal	389	$726	$29,484
Stump Removal	389	$94	$11,483
Replacement	389	$480	$186,720

Total			$236,372

EAB Management Recommendations

Public Tree Management

The Town of Bethlehem should follow the EAB Strategy that maintains the highest environmental benefits and species diversity, mitigates risk and maintains public safety, and is the most cost-effective to implement. Table 28 compares the estimated cost to implement each of the four EAB management strategies outlined above and the number of ash trees retained after five years of management.

- Strategy 1 does not align with the vision set forth by the Town of Bethlehem nor with the best management practices for EAB management. Although the economic impact to use this strategy is low, the loss in benefits and the increase in risk to public safety far outweigh the apparent management savings.
- Strategy 2 is the costliest budget-wise, eliminates an entire genus from the town's species diversity, and immediately reduces canopy and the environmental benefits derived from the removed trees. However, replanting the removed trees does set the town up to reap environmental benefits in the future and the removal of these trees does reduce risk, improving public safety.
- Strategy 3 aims to maintain the current ash inventory for as long as financially possible. This strategy has the second lowest cost over a five-year management horizon and does maintain species diversity; however, it also retains undesirable trees that may become safety issues in the future and does not replace removed trees as they die. In general, a municipality should begin treatments when a known infestation is within 15 miles. Neighboring Albany had an initial detection in 2014. Given that EAB was detected in Bethlehem in 2012 and the aggressive advance of the typical infestation, treatments should begin as soon as possible.
- Strategy 4 combines the previous strategies and is the more holistic approach to EAB management – this is the recommended strategy. While this is only slightly lower than the cost to remove all ash trees, this option means that many beautiful shady trees will be saved. Additionally, addressing dead and undesirable trees reduces risk and improves public safety. After six years, treatment costs will be less than $6,000 every two years, depending on ash tree mortality. It is worth noting that most of the ash trees recorded in the 2019 inventory were in woodlots along state and county routes. While this strategy includes removing 389 trees, the Town may want to consider whether it is worthwhile to treat or replace ash trees located in unmaintained areas. If the Town were to choose not to treat or replace these trees, EAB management costs would be reduced significantly.

Table 148. Cost comparison of four EAB management strategies for trees inventoried in Bethlehem, NY.

EAB Strategy	Estimated Five-Year Cost	Ash Trees Retained
1: Do Nothing	$0	0
2: Remove and Replace All Ash Trees	$262,791	0
3: Treat All Ash	$39,583	369
4: Treat, Remove, Replace Ash	$236,372	42

Private Trees

In addition to ash trees located on public property, EAB will impact trees located on private property. The number of private ash trees is unknown but could be equal to or greater than the ash trees located on public property. During the inventory, the arborists observed an abundance of ash trees located on private properties. The cost to remove ash trees will be higher on private property due to accessibility limitations. It is crucial that the Town promotes public education about EAB so that it can reduce the potential of regulating tree removals on private properties.

Photograph 10. Hangers will help make private homeowners aware of the management options available for EAB.

Dying and infested ash trees on private property will pose a threat to public safety. Bethlehem should consider adding or amending a town tree/landscape ordinance so that EAB is specifically acknowledged as a public hazard and treated in similar fashion as Dutch elm disease and other insect pests or plant diseases. Such an ordinance would help provide Town officials with the authority to address EAB-infested trees on private, as well as public, property, and would serve to demonstrate to the citizens of Bethlehem that EAB is a serious threat to the local tree population.

Public Education

It is crucial for Bethlehem 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 reforestation should occur after removals of infested ash trees are complete. The Town should inform the public that EAB has been discovered in Albany County, and if EAB should be identified in Bethlehem, the public must be immediately informed. A well-informed community is more likely to cooperate with the Town's requests. The Town should inform the public in the following ways:

- News release
- Town newsletter articles
- Radio programs
- Post information about EAB on the Town's website

Photograph 11. Posting information about EAB on ash trees around the town could encourage private homeowners to become more proactive in managing their ash trees.

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

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

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

Table 159. EAB Management Recommendation Summary

Section 4 Recommendation Summary	
Management	Recommendation
EAB Strategy	Strategically use a combination of treatment, removals, and replacement to manage Bethlehem's EAB response.
Public Education and Outreach	In addition to ash trees located on public property, EAB will impact trees located on private property. It is crucial for Bethlehem 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 reforestation should occur after removals of infested ash trees are complete.

SECTION 5: THE ROAD TO TREE CITY USA

Since 1976, the Arbor Day Foundation (ADF) and the National Association of State Foresters (NASF) have been working together to sponsor the Tree City USA designation. Tree City USA membership is a prestigious accomplishment that loudly proclaims the commitment of a municipality to fostering a healthy urban forest, both today and in the future. The program provides direction and assistance in addition to national recognition to participating communities by setting a framework for a sustainable urban forestry program.

Tree City USA Membership Requirements

The ADF and NASF have established four standards that must be met by a municipality to qualify for Tree City USA membership. These standards were instituted to ensure that all Tree City USA members have a viable tree management program in place.

Standard 1: A Tree Board or Department

It is important that someone be legally responsible for the care of trees on publicly owned property. Establishing who is responsible for tree care allows maintenance to proceed smoothly, budgets to be drawn up accurately, and lets the public know who is making decisions that affect their urban forest. Some municipalities have entire departments dedicated to tree care, while others rely on a citizen-lead tree board to direct tree care decisions.

Bethlehem does not currently have a dedicated urban forester or Town arborist, and most tree maintenance work is carried out by the Highway Department. However, the Town has recently created a Street Tree Advisory Committee (STAC). While such a committee cannot replace the expert guidance provided by a tree-care professional, it may be sufficient to meet Standard 1 requirements for Tree City USA membership.

Standard 2: A Tree Care Ordinance

A tree care ordinance is essential to an effective tree care program, as it provides the opportunity to set in place good policies and back those policies with the force of law. Qualifying ordinances should:

- Establish a tree board and/or forestry department and assign the responsibility for public tree care to one of these groups.
- Assign a person or group the task of making and carrying out a plan or work and documenting annual tree care activities.
- Provide clear guidance for planting, maintaining, and removing trees from streets, parks, and public spaces.
- Provide clear guidance of any tree-related activities that are required or prohibited.

A bulletin on how to write a municipal tree ordinance is available from the ADF for a small fee (https://shop.arborday.org/product.aspx?zpid=687) and could provide good guidance on writing a comprehensive tree care ordinance for the Town of Bethlehem. The town may also want to consider reviewing tree care ordinances from neighboring communities which are already members of the Tree City USA program, such as Albany, to provide an outline of what should be included in an ADF approved ordinance.

Standard 3: A Community Forestry Program with an Annual Budget of at Least $2 Per Capita

The ADF requires that Tree City USA communities spend at least $2 per capita annually on tree care. This requirement is in place to demonstrate Tree City USA members commitment to maintaining healthy urban forests and growing the benefits that urban forests can provide. As of July 2018, Bethlehem had 35,093 residents; thus, a dedicated annual tree care budget of at least $70,186 is needed to satisfy Standard 3. When considering the costs of annual tree removal, planting, and post-storm debris removal, the Town likely already spends more than this each year on tree care.

Standard 4: An Arbor Day Observance and Proclamation

The final standard that must be met for a municipality to qualify for Tree City USA status is the observance of Arbor Day and an official Arbor Day proclamation. This is typically the easiest standard to meet, as such observances can take many forms, from a short ceremony or single tree planting to a full week of celebration. Arbor Day can be an excellent opportunity to provide public education on the benefits provided by the urban forest, ways that private landowners can care for trees on their properties, insect and disease threats to the urban forest, and many other topics. It can also be worked into tree-planting plans – many communities rely on volunteers to plant new trees, and tree planting pushes organized around Arbor Day can provide citizens an opportunity to improve their community while participating in the observance of the holiday.

Table 30. Arbor Day Observance and Proclamation Recommendation Summary

Section 5 Recommendation Summary	
Goal	Recommendation
Meet the four standards established by the Arbor Day Foundation and the National Association of State Foresters	Bethlehem must establish a tree board or department, a tree care ordinance, a community forestry program with an annual budget of $2 per capita, and an Arbor Day observance and proclamation.

CONCLUSIONS

The public trees in Bethlehem are continuously supporting and improving the quality of life for its residents and visitors. The town's inventoried trees provide an annual benefit of $14,927, a carbon storage value of $569,135, and have a replacement value (or structural value) of $8,419,176. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Managing trees in urban areas is often complicated. Navigating the recommendations of experts, the needs of residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge.

The Town 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 town's trees, Bethlehem is well positioned to thrive. If this management program is successfully implemented, the health and safety of Bethlehem's trees and citizens will be maintained for years to come.

TOWN PROGRAMS AND KNOWLEDGE RESOURCES

Street Tree Planting Program

The Town's Street Tree Planting Program has allowed trees to be replaced or added to streets in neighborhoods and along main roadways throughout the town. The program was initially supported by funds the Town received from NY State government efficiency grant award. Over 60 trees have been planted since the program began in 2014. Residents pay for about half of the tree cost and maintain the tree after planting and initial watering. The labor to plant the tree and some follow-up watering by the Highway Department is free. The table below identifies the tree plantings to date.

Table 31. Location of Annual Tree Plantings

	Street Tree Planting Program – Location of Annual Tree Plantings		
	Number	Street	Notes/Quantity (if available)
2014	111	Delaware	
	203	Delaware	
	384	Delaware	
	482	Kenwood	
	488	Kenwood	
	490	Kenwood	
2015	393*	Delaware	Removed by new owner in 2017
	17	Elsmere	
	29	Elsmere	
	2	Herber	
	319	Kenwood	
	331	Kenwood	
	518	Kenwood	
	616	Kenwood	
	638	Kenwood	
	384 & 388	Kenwood	
	466-468/470	Kenwood	
2016	196	Delaware	
	414	Delaware	
	415	Delaware	
	594	Delaware	
	457/459	Kenwood	
	5	Union	3
	55	Delmar	1

	Street Tree Planting Program – Location of Annual Tree Plantings		
	Number	Street	Notes/Quantity (if available)
2017	213	Delaware	1
	502	Delaware	1
	59	Delmar	2
	75	Delmar	2
	116	Elsmere	1
	34	Elsmere	1
	37	Elsmere	1
	621	Kenwood	1
	410	Kenwood	1
	77	Fernbank	1
	20	Cherry	1
	268	Kenwood	1
	53	Louise	2
	1578	New Scotland	2
	1672	New Scotland	2
2018	71	Cherry	1
	78	Cherry	1
	150	Kenwood	1
	212	Kenwood	1
	262	Kenwood	1
	1740	New Scotland	2
	445	Delaware	1 white or pink dogwood, replace Dr. Little memorial tree
2019	678	Kenwood	1
	32	Hudson	1
	54	Hudson	1

Annually near the beginning of the year, the Program Coordinator (currently located in the Supervisor's office) contacts property owners on primarily main roadways where street trees would provide a public benefit and gauges interest in the program. The property owner submits street tree program application and there is no fee to apply.

The program coordinator provides the Town Department of Public Works (DPW) with a list of applicant addresses to identify underground utilities, which are marked on site. The coordinator then contacts the property owner and arranges for the Highway Superintendent or designee and a local landscape architect (volunteer) to visit the planting location, meet with property owner, and determine appropriateness for planting. If the location is a good spot for a tree planting, the Town Highway Department provides a planting plan. Town Highway Department staff select appropriate species based on site conditions including soil type, topography, and presence of utilities. Staff utilize the *Manual of Woody Landscape Plants* by Michael A. Dirr.

The Highway Department then contacts nurseries to get quotes early springtime for tree plantings for a season. In the past, staff has sourced trees from Northern Nursery and Island Park Nursery. The Program Coordinator then contacts the property owner to confirm the Highway Department's planting plan and requests a co-pay of about 50% the cost of each tree, which can range between $150 and $300 depending on species and availability of smaller caliper trees. After the co-pay is received, the Program Coordinator advises the Highway Department to purchase tree(s) and schedule planting.

The Highway Department purchases ball and burlap trees 1 ½"-2" caliper in size from local nurseries based on the winning bid. At times, the Highway Department may purchase trees up to 3" caliper if smaller trees are hard to find but transporting and planting trees of this size has been difficult due to the size and weight. Staff use Arbor Ties to secure the tree in place, but staff do not tie tightly, as minimal movement does help strengthen the root system. After planting, the Program Coordinator sends a tree maintenance letter to property owners who received trees. Town Highway Department staff monitor each tree's health for the first year, and the resident cares for the tree thereafter. DRG recommends using bare-root trees.

Highway Department Pruning and Maintenance

The current tree maintenance performed by the Town Highway Department includes annual pruning and removal, with approximately 75 trees addressed per year. Areas with older dieback are pruned on a five-year cycle versus total removal where applicable. A Town pruning crew is made up of an average of five Highway Department staff. The Highway staff who perform tree work also work on stormwater management and beautification. The Town has a 28' bucket truck, power pruner, hand saws, clip truck, a chipper, and flagging equipment. The Town will hire a contractor to assist with work requiring a larger bucket truck. Most storm-related tree work can be done in-house. The size of the bucket truck is a factor that determines when a contractor is hired to assist the Town.

Routine Maintenance is determined by resident requests and foreman observations which are turned into work orders. Work orders are normally looked at within a few days. The work is performed primarily in winter months as there is more availability for tree contractors and Town crew members. All requests are triaged as to severity of hazard. The Town Highway Department does not treat for disease or pests due to the town's pesticide-free policy.

Tree removals are performed by Town Highway Department staff and often begin with a joint site visit by the town Department of Public Works staff and Highway Department staff to determine the location of a tree on town ROW. Staff use the documented width of the ROW and measure the distance from the tree to roadway and against any present survey markers.

A town Highway Foreman trains pruning staff on a semi-annual basis covering topics such as saw and chipper safety, tree hazards, exposure hazards, and proper arborist practices. The Highway Department stated that it is often difficult to find the time to schedule training due to staff workload.

The Town Highway Department has indicated it lacks some equipment that could help staff work faster, more efficiently, and avoid hiring outside help. These items include: a larger bucket truck with 45' extension, a prentice loader, a 2–3' auger for planting trees, and a dingo. Additional staff would also help the town Highway Department accommodate the amount of work to be done.

Planting List by Context

Table 32. Recommended Street Tree Planting List

Botanical Name	Common Name	Cultivar	Native	Drought Tolerance	Soil Drainage Tolerance	Soil Salt Tolerance	Salt Spray Tolerance	Soil pH	Pest Resistance	Shape	Mature Spread (feet)	Mature Height (feet)	Growth Rate	Growspace < 3.5'	Growspace 3.5 - 4.5'	Growspace > 4.5'	Overhead Wires
Aesculus × carnea	Red Horsechestnut	Briotti; Ft. McNair	Hybrid	Mod	Moist to Well Drained	Poor	Mod	Acidic to Alkaline	No Serious Pests	Upright/Oval	30 to 40	60 to 80	Mod		•		
Amelanchier × grandifloria	Serviceberry or Juneberry	Autumn Brilliance; Princess Diana	Hybrid	Low to Mod	Well Drained	Low	Low	Acidic to Neutral	No Serious Pests	Rounded	10 to 15	10 to 25	Mod	•			•
Betula nigra	River Birch		Yes	High	Extended Flooding to Moist	Low	Mod	Acidic	No Serious Pests	Upright/Oval	30 to 40	40 to 60	Fast		•		
Carpinus betulus	European Hornbeam	Fastigiata; Various	No	Mod	Well Drained	Low	Low	Acidic	No Serious Pests	Oval	20 to 30	10 to 30	Mod	•			•
Carpinus caroliniana	American Hornbeam		Yes	Mod	Moist to Well Drained	Low	Low	Acidic	No Serious Pests	Upright	20 to 30	20 to 30	Mod	•			•
Celtis occidentalis	Eastern Hackberry		Yes	Mod	Occassionally Wet to Well Drained	Mod	Mod	Acidic	No Serious Pests	Rounded	40 to 50	60 to 70	Fast			•	
Cercis canadensis	Redbud	Various	Yes	Mod	Moist to Well Drained	Low	Low	Neutral to Alkaline	No Serious Pests	Rounded	15 to 25	15 to 30	Mod	•			•
Cladrastis kentukea	American Yellowwood		No	Mod	Well Drained	Low	Low	Acidic to Alkaline	Resistant	Rounded/Vase	20 to 50	40 to 50	Slow		•		
Crataegus crusgalli var Inermis	Cockspur Thornless Hawthorn	Various	Yes	High	Occassionally Wet to Well Drained	Mod	High	Acidic to Alkaline	Somewhat Sensitive	Rounded	10 to 25	10 to 15	Mod	•			•
Gleditsia triacanthos var inermis	Thornless Honeylocust	Various	Yes	High	Moist to Well Drained	High	High	Acidic to Alkaline	No Serious Pests	Rounded	30 to 70	30 to 70	Fast			•	
Gymnocladus diocius	Kentucky Coffeetree		No	High	Moist to Well Drained	Mod	High	Acidic to Alkaline	No Serious Pests	Upright to Rounded	40 to 70	50 to 70	Fast		•		
Koelreuteria paniculata	Golden Raintree		No		Moist to Well Drained	High	High	Acidic to Neutral	No Serious Pests	Rounded	30 to 40	30 to 40	Fast		•		
Liquidambar styraciflua	Sweetgum		Yes	Mod	Extended Floodig, Well-Drained	Low	Mod	Acidic to Slightly Alkaline	Resistant	Pyramidal/Oval	35 to 50	60 to 75	Mod			•	
Liriodendron tulipifera	Tuliptree		Yes	Low	Moist to Well Drained	Low	Low	Acidic to Neutral	No Serious Pests	Pyramidal/Oval	35 to 50	70 to 90	Fast			•	
Malus spp.	Crabapple	Sugar Tyme; Prairie Fire; Various	No	High	Moist to Well Drained	Low	Low	Acidic to Alkaline	Somewhat Sensitive	Rounded	20 to 25	20 to 25	Mod	•			•
Metasequoia glyptostroboides	Dawn Redwood		No	Low	Occassionally wet to Moist.	Low	Low	Acidic to Neutral	Resistant	Upright Pyramidal	20 to 30	60 to 80	Fast			•	
Nyssa sylvatica	Blackgum		No	Low	Extended Floodingto Well-Drained	Low	High	Acidic	No Serious Pests	Pyrmadial / Oval	25 to 35	65 to 75	Slow			•	

Botanical Name	Common Name	Cultivar	Native	Drought Tolerance	Soil Drainage Tolerance	Soil Salt Tolerance	Salt Spray Tolerance	Soil pH	Pest Resistance	Shape	Mature Spread (feet)	Mature Height (feet)	Growth Rate	Growspace < 3.5'	Growspace 3.5 - 4.5'	Growspace > 4.5'	Overhead Wires
Platanus × acerifolia	London Planetree	Bloodgood; Various	No	Mod	Extended flooding to Well-Drained	Mod	Mod	Acidic to Alkaline	Resistant	Pyramidal / Rounded	50 to 70	75 to 90	Mod			•	
Platanus occidentalis	Sycamore		Yes	Mod	Extended Flooding to Well-Drained	Mod	Mod	Acidic to Alkaline	Sensitive	Pyramidal / Rounded	50 to 70	75 to 90	Fast			•	
Quercus bicolor	Swamp White Oak		Yes	High	Extended flooding to Well Drained	Mod	Mod	Acidic to Slightly Alkaline	Resistant	Upright Oval / Rounded	50 to 60	50 to 70	Mod			•	
Quercus macrocarpa	Bur Oak		Yes	High	Moist to Well Drained	High	High	Acidic to Alkaline	Resistant	Upright Oval / Spreading	40 to 60	60 to 70	Slow			•	
Quercus palustris	Pin Oak		Yes	High	Moist	Low	High	Acidic	Resistant	Upright Pyramidal / Oval	40 to 50	60 to 80	Fast			•	
Quercus rubra	Northern Red Oak		Yes	High	Moist to Well Drained	High	Low	Acidic to Slightly Alkaline	Resistant	Rounded	60 to 80	50 to 60	Fast			•	
Syringia reticulata	Japanese Tree Lilac	Ivory Silk	No	High	Moist to Well Drained	High	High	Acidic to Alkaline	Resistant	Oval to Rounded	15 to 20	20 to 30	Mod		•		•
Taxodium distichum	Bald Cypress		No	High	Extended Flooding to Well-Drained	High	High	Acidic to Slightly Alkaline	Resistant	Pyramidal	25 to 35	60 to 80	Fast			•	
Tilia americana	American Linden		Yes	Mod	Moist to Moderately Well Drained	Low	Low	Slightly Acidic to Alkaline	No Serious Pests	Rounded	30 to 50	50 to 80	Mod			•	
Tilia cordata	Little-leaf Linden	Greenspire	No	Mod	Moist to Moderately Well Drained	Low	Low	Slightly Acidic to Alkaline	No Serious Pests	Pyramidal to Rounded	30 to 40	40 to 60	Mod		•		
Tilia tomentosa	Silver Linden		No	High	Moist to Moderately Well Drained	Low	Low	Acidic to Alkaline	Resistant	Broad Columnar	30 to 50	50 to 70	Mod			•	
Ulmus americana	American Elm	Valley Forge; Princeton	Yes	Mod	Extended Flooding to Well-Drained	High	Mod	Acidic to Alkaline	Resistant	Vase	50 to 70	70 to 90	Fast			•	
Ulmus X	Hybrid Elm	Patriot; Triumph; Accolade	No	High	Extended Flooding to Well-Drained	High	High	Acidic to Alkaline	Resistant	Vase	30 to 45	40 to 60	Fast			•	
Zelkova serrata	Zelkova	Green Vase; Village Green	No	Mod	Moist to Moderately Well Drained	Low	Low	Acidic to Slightly Alkaline	No Serious Pests	Vase	40 to 50	60 to 80	Mod			•	

**The tree species and cultivars on this list should not be used exclusively for replacement planting or reforestation of large areas. The diversity of all tree species on individual streets, in neighborhoods, and in the entire community should be taken into consideration. Monocultures should be avoided. The tree species and cultivars on this list are not the only suitable trees for planting in Milford. This list is merely intended to be used as a starting point. There are many more excellent native and non-native shade and ornamental trees that can be planted. Please contact your local Michigan State University Extension office or Natural Resource Conservation Service for additional recommendations.*

DAVEY Resource Group

Guidance for Planting Trees in Residential and Commercial Development

Background

Street trees improve walkability, provide a positive aesthetic experience, reduce the urban heat island effect, and provide stormwater benefits. Neighborhood streets such as those in Slingerlands, Delmar, Elsmere, Selkirk, and South Bethlehem are older established neighborhoods and were developed at a time when trees were permitted to be planted in the street right-of-way. Over time (about 1980), development design standards in the town changed restricting the planting of trees in the street right-of-way due to concern for conflicts with underground public water, sanitary sewer, and stormwater infrastructure; as well as private electric and internet infrastructure. The result of this policy change is apparent in the environment of residential neighborhoods south of the Delmar By-pass (generally known as Glenmont area), where street trees are absent from the street right-of-way and set back within front yards, at least 23 feet from the edge of pavement. In some areas of town, the private utility easement is 15 feet wide instead of 10 feet, pushing trees 28 feet from the edge of pavement.

The Bender Farms subdivision, located off of Bender Lane, is an example of this policy. The street trees along Madeleine Lane will not create a sense of enclosure of the street, will not provide shade for walking or biking along the street, will not calm traffic, and will not provide shaded parking for vehicles since the trees are planted 28 feet from the road. The opportunity cost of these trees being set back so far from the edge of pavement is difficult to quantify, but it would likely represent the value of a neighborhood that is more physically and socially active over the long term.

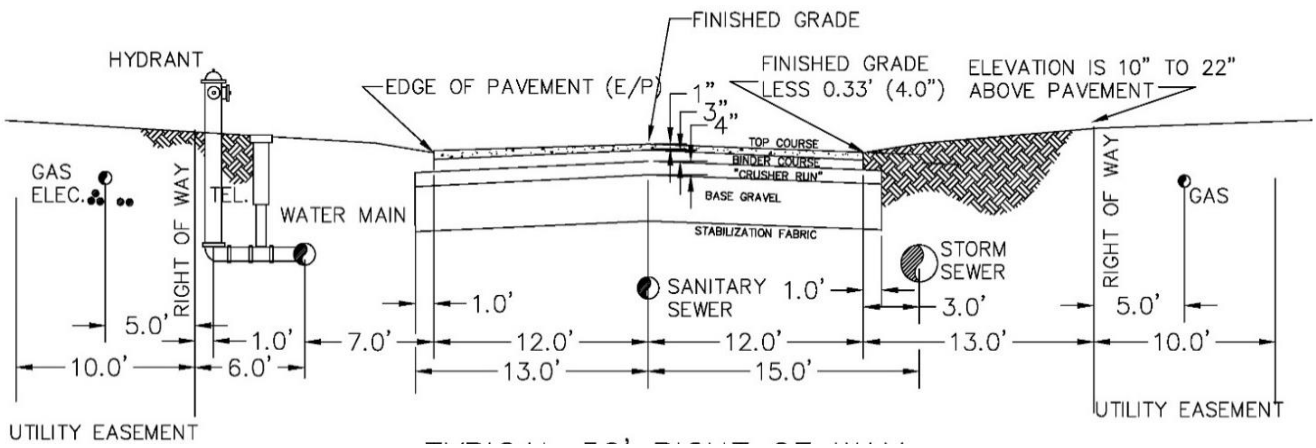


Figure 18. Town Road Cross-Section showing location of underground utility infrastructure.

Figure 18 above provides the Town standard cross-section for the construction of new roadways. The standard town roadway width is 24 feet, located within a 50-foot right-of-way (ROW). Sanitary sewer is located underneath the roadway while public water is located on one side of the road within the center of the ROW, and storm sewer infrastructure is located on the other side of the road 3 feet from the edge of pavement/road. On either side of the ROW are private utility easements for underground gas, electric, and internet lines, which are established at 10 feet in width. Based on these design standards to accommodate utility infrastructure placement and maintenance, space adjacent to the roadway becomes limited for street tree plantings that serve the benefit, as discussed above.

Photograph 13. Street trees set back 28 feet from edge of pavement.

The Town currently avoids planting trees near or over water mains. Water main failure on new pipes is typically a rare occurrence, so the frequency where trees will require removal during water main repair is low.

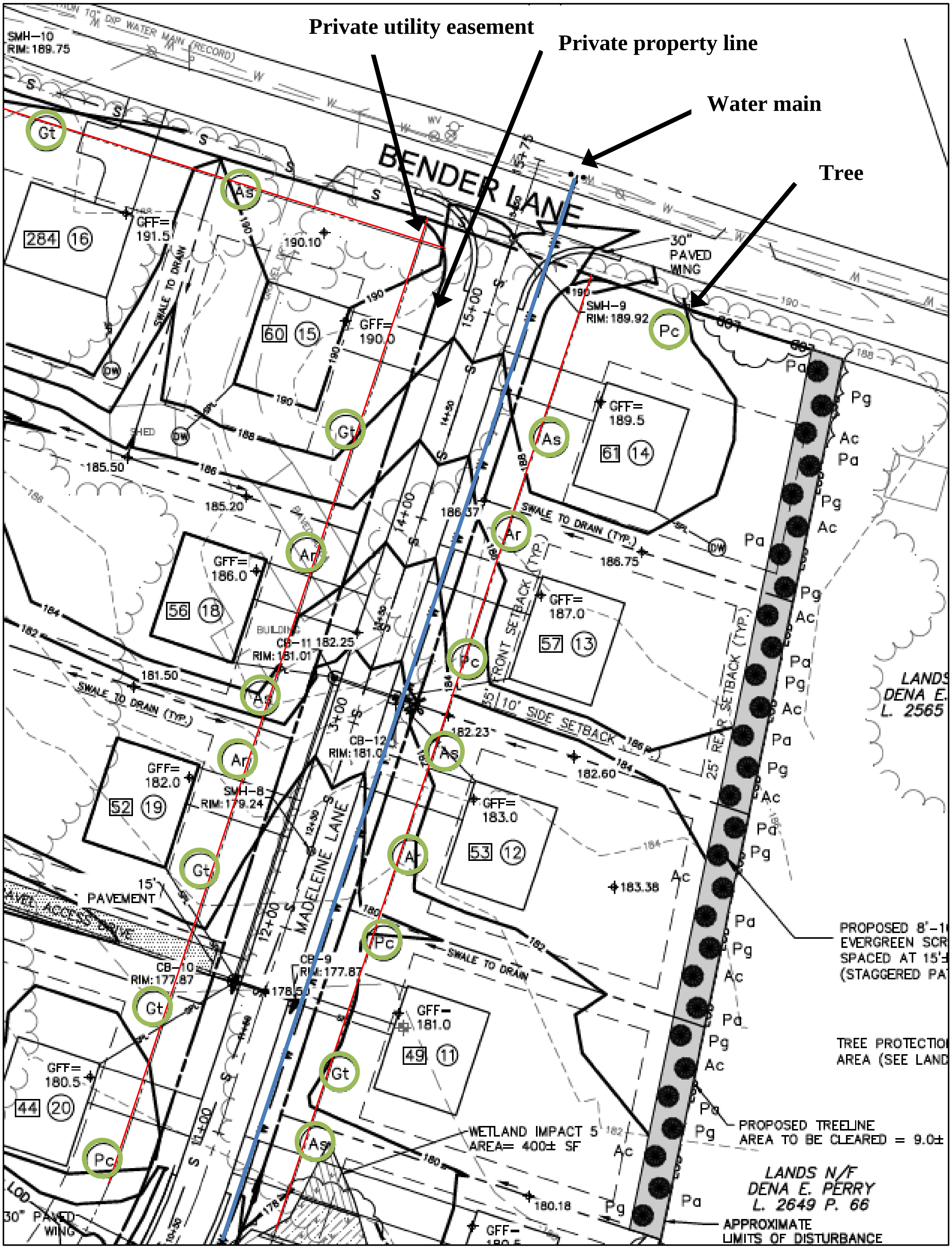


Figure 19. Bender Farms Development, Madeleine Lane. Trees located too far from roadway

RESIDENTIAL

In new residential subdivisions, street trees should be included along the property frontage to provide shade and aesthetic appeal to the edge of the ROW:

a. To minimize impacts of planting street trees adjacent to underground utilities as shown in the Town roadway standard cross-section above, it is recommended that trees should be planted 15 feet from the roadway edge of pavement or approximately 2 feet onto the private property, encroaching slightly into the private utility easement on both sides of the roadway. This creates 8 feet of separation between the water main and the centerline of the street tree. This planting location provides a balance between creating a street tree canopy/quality of life benefits and maintenance of underground utilities. The long-term social, environmental, and economic benefit and value of street trees is worth the relatively low cost of replacing street trees on an infrequent basis due to utility maintenance. Mature trees do not need to be replaced with mature trees. Pursuant to Chapter 124 of the Town Code, street trees shall not be planted within 5 feet of a fire hydrant.
b. Street trees should be provided along roadways within the private utility easement (see discussion above) at least 20 feet apart for small trees, 30 feet apart for medium trees, and 40 feet for large trees.
c. Street trees should be placed outside of the sight distance triangle as determined by roadway geometry/10 feet from directional sign, 20 feet from stop/yield signs.
d. Street trees should be included in cul-de-sac landscaping islands but adhere to restrictions relating to underground utilities as outlined above.

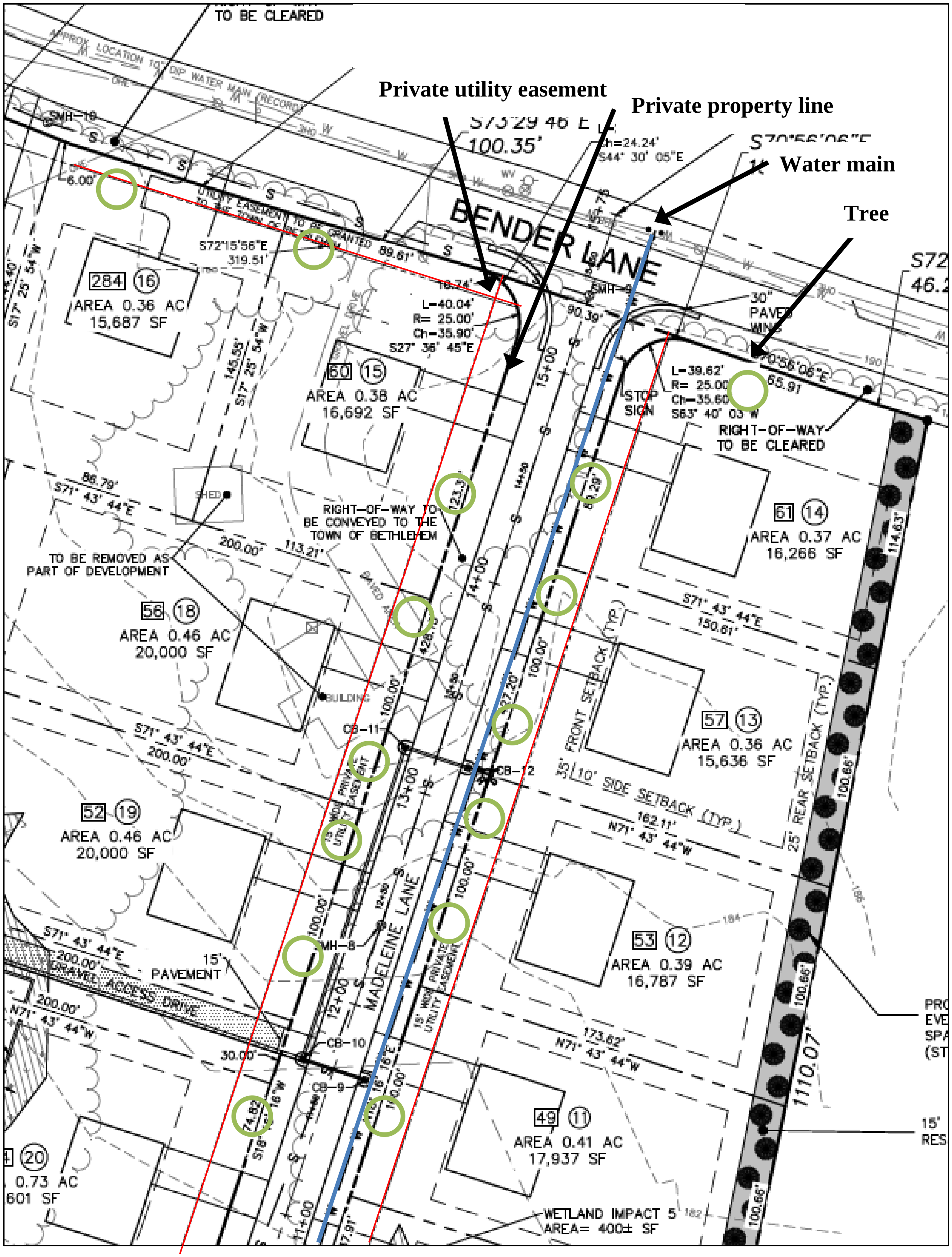


Figure 20. Bender Farms Development, Madeleine Lane. Appropriate location for street trees.

COMMERCIAL

In New Commercial Developments, street trees should be included along sidewalks and in parking lots:

a. Planting Location
   i. With Sidewalk: Street trees should be located within the furnishings zone of the sidewalk ROW area. Two cubic feet of soil volume per each square foot of crown projection is recommended. The furnishings zone is typically around 5 feet in width and begins at 6 inches to 1.5-feet from the curb, depending on context.
   ii. Without Sidewalk or along frontage: Street trees should be located at least 5 feet from existing or proposed utility lines.
   iii. Avoid placing in snow storage areas.
b. Planting Medium/Soil Requirements
   i. Structural soils are used when soil compaction is required. If planting a sapling near pavement, it is best to utilize structural soils; this will help prevent pavement lifting, as well as damage to the tree from root pruning. It will also allow the tree to spread its roots, which will assist in prevention of total tree failure during high wind events. Due to cost it is best to use structural soil around high-use areas.
   ii. Suspended pavement and silva cells facilitate growth of healthy trees in urban settings by creating space for the roots of the trees to grow. This is similar to the use of structural soil, but this is more modular and can be used to create a retaining space for storm water runoff. This system is recommended most around high use areas, but most specifically where vehicles and trees coexist. Best for parking lots and around high pedestrian traffic where a tree pit alone will not provide enough soil for a tree to grow.

Planning Board Development Application Review Guidance

Since 2015, the Town Planning Board has used the following document, Guiding Principles for Street Trees in the Site Planning Process in their review of development applications. The recommendations in the document below may still be valid for some development projects; however, the recommendations and guidance provided in this management plan should be considered a more up-to-date resource for guiding street tree plantings.

Street Tree Types and Species Selection

1. Plantings along streets should consist primarily of large-growing deciduous trees. Evergreen trees and shrub masses, unless used for screening, are undesirable because of security and sight distance concerns. Evergreens can be used as accent elements, especially in large open areas.
2. A variety of species should be planted along street corridors to offset the loss of a large percentage of trees if an invasive species is introduced and affects a monoculture.
3. Tree species considered invasive by NYSDEC should not be used. Some trees have excellent ornamental characteristics, but are beginning to escape and naturalize, or are becoming more susceptible to pests and disease (see list below). These trees should be used sparingly where the need for their ornamental characteristics outweigh their limitations.

Street Tree Sizes

1. Street tree size at planting should be at least 3" caliper. Smaller caliper trees along roadways are often susceptible to damage and vandalism. Low-hanging branches on smaller caliper trees often interfere with pedestrians on adjacent sidewalks and will require routine pruning of lower branches.
2. Planting beneath or in the vicinity of utility lines requires a careful selection of species. Smaller trees are often compatible with overhead lines. However, the lower branches can conflict with adjacent pedestrian use of sidewalks and smaller trees can also create sight distance problems.

Street Tree Locations

1. Greater shading and traffic calming benefits of street trees can be achieved by planting trees closer to the roadway. Sufficient sized utility strips aka planting strips (space between roadway and sidewalk) on local roads provide enough space for new trees. Greater setback from higher volume and higher speed roadways should be considered.
2. Spacing of street trees is a function of the mature size of the trees being planted. Trees should be spaced so that they will have maximum canopy cover but without having their root systems and branches interfere with each other.
3. Greater setback from overhead electric utilities is necessary.
4. Root intrusion in sewer lines is an important consideration in older developments and streets. Sewer mains are usually placed beneath roadways where tree roots generally will not grow. However, sewer laterals servicing adjacent properties can be vulnerable, especially older clay or concrete lateral pipes with gasket connections. Newer sewer systems with plastic pipe and solvent welded connections that are properly installed to prevent movement and damage will generally eliminate the risk of root intrusion.
5. Conflicts with water lines and underground electric lines are generally not a problem. However, sufficient setback from these utilities should be considered to avoid construction accidents and extensive damage to trees if the utility replacement is necessary.

Street Tree Planting Techniques

1. Oversized planting pits should be used where native soil has been disturbed by prior construction.
2. Structural soil should be used for planting shade trees in or adjacent to paved areas such as narrow utility strips or parking lots. Information for structural soils can be found at the Cornell Urban Horticulture Institute.

Location Guidelines for Street Trees

The following is a table of dimensions of setbacks and clearances for the location of street trees:

Table 33. Local Guidelines For Street Trees

Item	Preferred (ft.)	Minimum (ft.)	Maximum (ft.)
Tree Spacing – Med. to Large (>30′ at maturity)	35	30	40
Tree Spacing - Small (<30′ at maturity)	30	25	35
Setback from corner of intersecting streets	25	20	n/a
Setback from stop sign	35	30	n/a
Setback from hydrants	10	7	n/a
Setback from utility or street light pole	25	15	n/a
Setback from driveway	10	7	n/a
Setback from sidewalk or roadway	6	4	n/a
Distance between sidewalk and roadway	8	4	n/a
Setback from overhead electric – Med. Trees (20 - 40′)	25	15	n/a
Distance between plant pit and water or gas line	6	2	n/a
Setback from sewer line/lateral (not under road	10	6	n/a

Popular Plants That Are Invasive

This is a partial list of plants that have often been specified on planting plans and should not or cannot be used. See the NYDEC website for a complete list.

Table 34. Popular Plants That Are Invasive

Botanical Name	Common Name	NYSDEC List	Plant Type
Acer pseudoplatanus	Sycamore Maple	Prohibited	Tree
Berberis thunbergii	Japanese Barberry	Prohibited	Shrub
Celastrus orbiculatus	Oriental Bittersweet	Prohibited	Vine
Elaeagnus umbellata	Autumn Olive	Prohibited	Shrub
Ligustrum obtusifolium	Border Privit	Prohibited	Shrub
Lonicera japonica	Japanese Honeysuckle	Prohibited	Shrub
Lonicera maackii	Amur Honeysuckle	Prohibited	Shrub
Lonicera tatarica	Tatarian Honeysuckle	Prohibited	Shrub
Phellodendron amurense	Amur Cork Tree	Prohibited	Tree
Acer platanoides	Norway Maple	Regulated	Tree
Euonymus alatus	Burning Bush	Regulated	Shrub
Euonymus fortunei	Winter Creeper	Regulated	Ground cover

Popular Plants That Should Be Avoided or Used Sparingly

These trees have some serious limitations or have been overused and are now susceptible to disease and pests. If used for their ornamental value, they should be located as specimen trees and used sparingly.

Table 35. Popular Plants That Should Be Avoided Or Used Sparingly

Botanical Name	Common Name	Limitations
Gleditsia tricanthos	Honeylocust	Overused. Susceptible to numerous pests, diseases, and cankers. Use for light shade and paved areas.
Fraxinus sp.	Ash	Being attacked by the emerald ash borer that has been found close by. May become extinct someday similar to the American elm.
Pyrus calleryana	Callery Pear	Overused because of ornamental attributes. Weak wooded. Holds leaves late into winter. Susceptible to ice storms. Use as specimen.

The guide also lists recommended plants.

Town Code Review

Discussions with the Street Tree Advisory Committee regarding Town or developer planting and maintenance of trees in the street right-of-way resulted in a review of potential regulations found in the Town Code that may prohibit or provide guidance for street trees. Note that some current regulations below apply generally to trees on a site, not just potential or existing street trees. The recommendations are limited to street trees and do not attempt to suggest new regulations for private property owners related to private trees in the interior of a property, unless those trees could reasonably become street trees in the future as development occurs.

While some regulations could be revised to better support the vision of the Street Tree Management Plan, some regulations do not need changes at this time. The following table summarizes the various code provisions that relate to street trees in various articles and chapters of the Town Code. Provisions (in italics) address trees within existing or potential Town highway right-of-way. Recommendations for potential changes to the code follow each provision.

Table 36. Code Provisions That Relate to Street Trees in Various Articles and Chapters of the Town Code

Town Code Review Summary			
Chapter	Article	Section	Change
Chapter 100 Streets and Sidewalks	Article IX Unlawful Obstructions	§ 100-38 Planting trees, shrubs, or fences in highway right-of-way.	Specify this is applicable to private property owners. Town is permitted to plant.
		§ 100-39 Maintaining trees, shrubs, or fences in highway right-of-way.	Specify this is applicable to private property owners. Town is permitted to plant.
Chapter 103 Subdivision Regulations	Article IV General Requirements and Design Standards	§ 103-16 Required public improvements. Street trees are required public improvements.	None

Town Code Review Summary			
Chapter	Article	Section	Change
		§ 103-26 Layout of Streets and Roads, Items B-G	B. Update DPW guidelines date of revision; F. Preserve trees for future roadways. Add provisions to address tree preservation, avoidance of critical root zones, and pre-construction barriers and pruning.
		§ 103-35 Major Sub application and preliminary plat data. Street trees must be shown on site plans.	None
Chapter 124 Water	Article VI Hydrant Regulations	§ 124-19 Hydrant location and access requirements A-C. No trees permitted within 5 feet of a hydrant. Trees placed within 5 feet of a hydrant may be removed by town.	None
Chapter 128 Zoning	Article IV Word Usage and Definitions	§ 128-22 Definitions	Caliper, Tree – Change to dBH;
	Article V District Regulations	§ 128-25 through 41; Zoning District Specific Regulations. Street trees included in zoning district character, trees should be preserved where possible	Consolidate standards into one new section that applies to multiple districts. Consider applying these standards to additional zoning districts.
	Article VI Supplementary Regulations	§ 128-67 Route 9W Corridor Design Guidelines	None.
	Article VII Special Use Permit and Site Plan Review	§ 128-70 Preapplication conference and conceptual site plan review	Add language for street trees to require applicants to show street trees if applicable based on zoning district or other requirement.
	Article VII Special Use Permit and Site Plan Review	§ 128-71 Site plan review and approval.	Add provisions to address tree preservation, avoidance of critical root zones, and pre-construction barriers and pruning.

CHAPTER 103: SUBDIVISION REGULATIONS

The Subdivision Regulation chapter provides guidelines and standards for the development of new residential neighborhoods and commercial sites including the layout of streets and roads.

§ 100-38 Planting trees, shrubs, or fences in highway right-of-way.

It shall be unlawful to plant any tree, shrub, or plant or to erect any fence, wall, or berm within the right-of-way of any town highway, or in any other way encroach upon any public street, parkway or right-of-way, or other public place.

This code language is intended to prevent issues that arise from private property owners planting vegetation within the right-of-way, but it shouldn't prohibit the Town from implementing a street tree planting program. It is recommended the Town modify this section so that it specifically applies to property owners. Alternatively, language could be added to except the Town and members of the public who have received permission from the Commissioner of Public Works. This language could read: "It shall be unlawful for any private property owner to plant any tree, shrub, or plant or to erect any fence, wall, or berm within the right-of-way of any town highway, or in any other way encroach upon any public street, parkway, or right-of-way or other public place."

Additionally, fences aren't planted, they are installed. The title should be revised accordingly.

§ 100-39 Maintaining trees, shrubs, or fences in highway right-of-way.

[Amended 5-22-1991 by L.L. No. 2-1991]

It shall be unlawful to maintain any tree, shrub, plant, fence, wall, berm, or other obstruction within the town highway right-of-way which creates a hazardous condition for vehicular or pedestrian traffic or that interferes with the proper maintenance of any town highway.

This section should be modified similar to the previous section, either specifying it applies to property owners or excepting the Town and those who have received permission from the Commissioner of Public Works to planting a tree or shrub or installing a fence. This language could read: "It shall be unlawful for any private property owner to maintain any tree, shrub, plant, fence, wall, berm, or other obstruction within the town highway right-of-way which creates a hazardous condition for vehicular or pedestrian traffic or that interferes with the proper maintenance of any town highway."

103-26 Layout of Streets and Roads

B. Streets. Streets shall be graded and improved with pavement, street signs, sidewalks, streetlighting, curbs, gutters, trees, water mains, sanitary sewers, storm drains and fire hydrants in accordance with the Town of Bethlehem Department of Public Works Guidelines for Final Subdivision Plans, dated August 25, 1997, as amended, and the State Highway Law, as amended. The Planning Board may waive, subject to appropriate conditions and upon the recommendation of the Town Highway Department and the Town Engineer, such improvements as it considers are not requisite in the interest of public health, safety and general welfare.

C. Utilities. Underground utilities shall be placed between the paved roadway and street line to facilitate location and repair of the lines. The applicant shall install underground connections, where required, to the property line of each lot before the street is paved.

F. Trees. A conscious effort shall be made to preserve all worthwhile trees and shrubs which exist on the site. Such features may well be suggested for park or playground areas. On individual lots or parcels, care should be taken to preserve selected trees to enhance the landscape treatment of the development.

G. Sight lines and visibility at intersections. Within the triangular area formed at corners by the intersection of street center lines, for a distance of 75 feet from their intersection and the diagonal connecting the end points of these lines, visibility for traffic safety shall be provided. Fences, walls, hedges, or other landscaping shall not be permitted or placed so as to obstruct such visibility.

The Public Works guidelines date should be updated the next time the Subdivision Regulations is updated. Language in item F should be revised so that trees located in areas where a future roadway is planned or where such future roadway placement is logical shall be preserved to the extent practicable. Additional language could be added to broaden the areas which trees could be added to include street trees. This language could read: "A conscious effort shall be made to preserve all worthwhile trees and shrubs which exist on the site. Trees located on or near a planned roadway or land which is well suited for a roadway or roadway connection shall be preserved to the extent practicable. Such features may well be suggested for park or playground areas or adjacent to roadways or pedestrian or bicycle pathways. On individual lots or parcels, care should be taken to preserve selected trees to enhance the landscape treatment of the development."

The Town should consider adding provisions to the subdivision regulations chapter to address avoidance of the critical root zone (CRZ) through fencing requirements and the protection of existing trees through pre-construction pruning.

§ 103-16 Required public improvements.

A. **Improvements.**

(I) Street trees.

No change recommended at this time.

103-35 Major Sub application and preliminary plat data

Applicant must show street trees on plans.

No change recommended at this time.

CHAPTER 124: WATER

§ 124-19 Hydrant location and access requirements.

A. All town-owned hydrants shall be installed on lands, easements, or rights-of-way permanently owned or controlled by the town.

B. Relocation of fire hydrants, curb boxes, or valve boxes at a previously fixed location due to changes in property status or land use may be made by the Department or may be made by the owner/customer only after obtaining prior written consent from the Department. All work done in connection with such relocation shall be at the expense of the person seeking such relocation.

C. No bushes, shrubs, trees, fences, stones, or any other objects may be placed closer than five feet in any direction from a hydrant. Any object within said five feet in any direction of a hydrant may be removed by the Department, at the owner's expense, after the Department has given the owner five days' written notice to correct the obstruction.

No changes recommended at this time.

CHAPTER 128: ZONING

128-22: Definitions

STREET

A strip of land, including the entire right-of-way, publicly or privately owned, serving primarily as a means of vehicular, pedestrian, and bicycle travel, and furnishing access to abutting properties, which may also be used to provide space for sewers, public utilities, shade trees, sidewalks, and streetscape amenities.

This section should be revised to apply to trees beyond shade trees, such as ornamental trees. Removing the word 'shade' would be the most appropriate change and make this definition more accurate. This language could read: "A strip of land, including the entire right-of-way, publicly or privately owned, serving primarily as a means of vehicular, pedestrian and bicycle travel, and furnishing access to abutting properties, which may also be used to provide space for sewers, public utilities, trees, sidewalks, and streetscape amenities."

CALIPER, TREE

The diameter of a tree as measured at a point 6 inches above the ground level (up to and including 4-inch caliper size) and 12 inches above the ground level (for larger sizes).

Since the common method currently used for measuring tree size is by using diameter at breast height, this section should be updated to reflect this method of measurement. This language could read: "*The diameter of a tree as measured at breast height in inches.*"

128-24 E Core Residential District

Core Residential District. Areas of the town designated under this district are generally mature residential neighborhoods. The purpose of this district is to ensure that the general character of these neighborhoods, which include tree-lined streets, sidewalks, smaller lot sizes, moderately sized homes, interconnected street patterns, and a location near some small-scale services, is protected from pressures to convert residential structures to inappropriately sized nonresidential uses.

The language "tree-lined streets" could be reasonably associated with other zoning districts, not just the Core Residential District. This language should be added to the purpose sections for other applicable districts.

128-25, 128-26, 128-32 Zoning District Specific Standards

The following design guidelines appear as zoning district specific regulations for several zoning districts and could apply to trees along a future roadway, right-of-way dedication, or easement.

Existing tree rows and hedgerows, stone walls, and similar features should be retained in the development of any new use or the expansion of any existing use.

New streets should be designed with [rural] characteristics, including minimal tree clearing, minimal grading and filling of existing topography, and usage of natural drainage where practicable.

Major modifications to the existing landscape, such as extensive grading, clear-cutting of trees, or other similar activities, should be avoided.

Zoning district specific standards that apply to multiple zoning districts, including those potentially related to street trees, could be consolidated in a general development regulations section the next time the zoning code is rewritten and streamlined. These regulations could be broadened to apply to more areas of town in the process.

§ 128-41 Planned Hamlet District PHD.

[Added 12-14-2016 by L.L. No. 5-2016]

*A. **Purpose.** Planned hamlet districts are intended as floating zones to provide for mixed residential and commercial uses in a compact hamlet-like setting that encourages pedestrian activity using traditional hamlet design principals. Typically, such districts would contain mixed-use buildings with retail, personal service, restaurant and related uses on the ground floor, and residential and/or office uses in the upper floors. Expected features of the district include buildings fronting up close to and with entrances and fenestration orientated toward the street, curbside parking, and/or parking to the rear of structures in shared parking facilities, sidewalks, pedestrian-scale street lighting, street trees, street furniture and public spaces, and pedestrian connections to surrounding neighborhoods. Land uses that cater to patrons in their automobile with drive-through or similar facilities are discouraged. In no case shall the regulations of this section be so interpreted as to circumvent the benefits of this chapter to the owners or residents of such development or the owners or residents of adjacent properties. Planned hamlet districts and building projects within planned hamlet districts may be established in accordance with the procedure specified below.*

No changes recommended at this time.

F. (4) Public space. Developments within the PHD shall include formal, landscaped, outdoor amenity area(s), such as a plaza, courtyard, square, or common that is accessible to the general public. No less than one square foot of public space shall be provided for every 40 square feet of gross floor area within the PHD. Individual public spaces should be appropriately sized for their intended use and at a reasonable scale to the buildings they are intended to support. Generally, such spaces should be no smaller than 2,500 square feet and no larger than 6,500 square feet. At least 25%, but not more than 50% of the public space shall be landscaped with trees, shrubs, and other plantings as approved by the Planning Board. Such public space shall be conveniently accessible and integral to the development and designed as a focal point for the PHD.

No changes recommended at this time.

§ 128-67 Route 9W Corridor design guidelines

(13) Development projects should be designed with a minimum 20-foot-deep landscaping strip along the US Route 9W right-of-way. Said landscape strip should be designed to contain street trees and other landscape material of such size and spacing so as to enhance the visual environment along US Route 9W and provide a unifying streetscape element to the Corridor.

No changes recommended at this time.

§ 128-70 Preapplication conference and conceptual site plan review.

[Amended 2-8-2012 by L.L. No. 1-2012]

*Conceptual site plan review. Prior to making a formal application for site plan approval as outlined in § **128-71** of this chapter, an applicant may at his or her discretion submit to the Planning Board an application for conceptual site plan review. The purpose of this review is to provide an opportunity for the applicant to receive preliminary feedback from the Planning Board as to the merits of the proposal prior to investing substantial resources in preparing detailed plans and studies for a formal site plan application., an applicant may at his or her discretion submit to the Planning Board an application for conceptual site plan review. The purpose of this review is to provide an opportunity for the applicant to receive preliminary feedback from the Planning Board as to the merits of the proposal prior to investing substantial resources in preparing detailed plans and studies for a formal site plan application.*

There is an opportunity to add text to subsection B.(c)[4] that requires applicants to include “street trees” in conceptual site plan designs if applicable based requirement found in Town Subdivision Regulations or Zoning Law. This would allow departments to discuss the potential for street trees with the applicant and their location and any possible conflicts with other site features and allow for residents to provide comments.

§ 128-71 Site plan review and approval.

The following design guidelines appear as landscaping design criteria in Subsection 128-71 E.(3):

Landscape, buffering, and site treatment.

(a) Where possible, natural or existing topographic features and patterns that contribute to the beauty and character of a site or neighborhood should be preserved.

(b) Grades of walks, parking spaces, terraces, and other paved areas should provide an inviting appearance and should be of such width, as determined by the Planning Board, to easily accommodate pedestrian movement.

(c) Landscape treatment should be provided to enhance architectural features, strengthen vistas and visual corridors and provide shade.

(d) Unity of design should be achieved by repetition of certain plant varieties and other materials and by coordination with adjacent developments.

(e) Plant material should be selected for interest in its structure, texture, and color and in consideration of its ultimate growth pattern. Vegetation indigenous to the area and others that will be harmonious with the design and exhibit a good appearance should be used.

(f) In locations where plants will be susceptible to injury by pedestrian or motor traffic, appropriate curbs, tree guards, or other devices should be installed and maintained. The Planning Board may require the use of markers to delineate curbing and other sensitive features to alert snowplow operators of the existence of such features and curbing.

(g) Parking areas and trafficways should be enhanced with landscaped islands containing trees and tree groupings. The interior (i.e., nonperimeter) areas of a proposed parking area should be appropriately landscaped, and such landscaping shall comprise not less than 10% of the land area of the proposed parking facility.

(h) Screening of service yards, commercial vehicles, commercial trailers, passenger vehicles, parking areas, refuse containers, and other places that tend to be unsightly should be accomplished by use of walls, fencing, planting, or combinations of these with all such enclosures being compatible in material, texture, and color with the principal building or buildings on the site.

(i) Landscaping should be designed and maintained so as not to create hazardous conditions.

(j) Landscaping shall be maintained to preserve its original integrity and intended purpose during the life of the proposed use or project. All approvals granted under this section are expressly conditioned on the maintenance of the approved landscaping during the life of the proposed use or project.

(k) The Board may, at its discretion, consult with one or more persons or firms having experience in landscape architecture and landscape planting as to the appropriate design of lawns and open spaces around proposed buildings and uses and the appropriate species, size and number of plants to be installed. The reasonable cost of any landscaping review shall be borne by the applicant.

There is an opportunity to add tree preservation guidelines to the existing guidelines. These provisions may include requirements for preserving trees in or near the right-of-way or trees that could contribute to a walkable or bikeable environment on or off the site. Additional provisions could require use of structural soils in certain contexts where there is extensive use of hardscape materials and trees are critical elements that support a walkable environment. Finally, additional provisions could address avoidance of the critical root zone (CRZ) through installation of protective fencing and pre-construction pruning of particular trees prior to construction. The Town should review provisions addressing these issues in the codes of Tree City USA communities in this region to understand what types of provisions would provide the best starting point for additional code provisions.

Climate Crisis

While expanding the street tree canopy and maintaining the health of street trees are important steps for the Town to take to mitigate and adapt to a changing climate, the changing climate has implications itself for how Bethlehem expands and manages its street trees. Planting zones are expected to shift, and this is likely to have an impact on the makeup and diversity of the street trees within town. Northern species, such as sugar maple (*Acer saccharum*), will see more frequent failures due to the changing climate, and their planting should be limited. Species, such as southern magnolia (*Magnolia grandiflora*), will be able to overwinter better and can be added to the urban forest.

The timing of plantings may become more challenging due to variable weather conditions year on year. Planting season is extended due to warmer climates in early/late winter; however, planting in weather greater than 90 degrees Fahrenheit is not recommended. Therefore, the summer growing season will need to see pauses.

Properly managing street trees, especially large ones, can be important for reducing the town's vulnerability to extreme weather events expected to become more frequent due to the climate crisis. The Town should work closely with their local utility company to ensure best practices are being followed from planting new trees near utilities to properly pruning existing ones near power lines. The Town should continue to prioritize windshield surveys of trees along snow routes and high traffic areas before storm season.

Direct climate change impacts related to stormwater, such as increased frequency and total precipitation amounts, may also make current planting sites unviable.

GLOSSARY

address (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 the suffix field (assigned address field) was set to "Yes".

air pollution removal: In i-Tree Eco, air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$).

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.

assigned address (data field): see **suffix**

avoided runoff: In i-Tree Eco, avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events.

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

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

Carbon Monoxide (CO): A colorless, odorless, highly toxic gas formed as a result of the incomplete combustion of a carbon or carbon compound.

carbon sequestration: The capture and storage of carbon from the Earth's atmosphere. In i-Tree Eco, carbon sequestration is calculated as an annual functional benefit of trees.

carbon storage: Storage of carbon in plant tissue. In i-Tree Eco, carbon storage is calculated as a structural benefit over the lifetime of the tree.

comments (data field): Additional comments on the state of the inventoried site. Comments may include the number of stems if the tree was multi-stemmed, additional defects that were significant but not the primary defect, explanations for why further inspection is needed, and other general information considered important by the inventory arborist.

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: Good, Fair, Poor, or Dead.

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

defect (data field): The primary defect noted by the inventory arborist. Defects include missing or decayed wood, dead or dying parts, broken or hanging branches, weakly attached branches and codominant stems, cracks, root problem, tree architecture, other, and none.

diameter: See **tree size**.

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

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

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

functional benefit: In i-Tree Eco, a benefit which is due to the physiological processes carried out by trees, calculated on an annual basis.

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

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

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

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

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

importance value (IV): A calculation in i-Tree Eco displayed in table form for all species that make up more than 1% of the population. The IV calculated by the i-Tree Eco model factors in the total number of trees for each species, each species' percentage of the total population, and each species' total leaf area. The IV can range from 0 to 200, with higher IVs indicating higher reliance on one species to provide ecosystem services. IVs offer valuable information about a community's reliance on certain species to provide functional benefits.

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

inventory: See **tree inventory**.

i-Tree Eco: i-Tree Eco is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental benefits, including runoff reduction, air pollution reduction, and carbon sequestration, as well as life-long structural benefits trees provide, including carbons storage and structural value.

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase. While i-Tree Streets was not used for the tree benefits analysis in this management plan, it is still used as the basis for the tree benefits tab in TreeKeeper®.

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.

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

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

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

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

multi-stem (data field): Indicates whether a tree has multiple trunks splitting less than 1.5 feet above ground level. If a tree had multiple stems, a comment was adding indicating the number of stems.

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

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

on-street (data field): The street a site is physically located on.

ordinance: See **tree ordinance**.

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

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

Particulate Matter ($PM_{2.5}$): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

plant (primary maintenance need): If collected during an inventory, this data field identifies planting sites as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growing space 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.

residual risk (data field): The risk rating of a tree after the recommended primary maintenance has been carried out. Residual risk may be equal to but never greater than the original risk rating.

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): see Appendix E.

risk assessment complete (data field): Indicates whether or not the arborist was able to complete a Level 2 qualitative risk assessment. Arborists may not be able to fully assess tree risk due to embankments, homeowner conflicts, fences, or other obstacles to getting a 360 degree view of the tree.

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

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

site: Any point for which data was recorded during the inventory, including trees, vacant sites, and stumps.

species (data field): 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.

street (data field): The name of a street right-of-way or road identified using posted signage or parcel information. The street to which the parcel a site is on is addressed.

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 benefit: In i-Tree Eco, a benefit which is produced by the physical arrangement and composition of trees and tree parts and which is calculated as an aggregate over the lifetime of a tree.

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

structural value: In i-Tree Eco, the compensatory value calculated based on the local cost of having to replace a tree with a similar tree.

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

suffix (data field): Data field indicating whether the address was assigned by the arborist.

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

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

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

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

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

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

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

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

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

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APPENDIX A: DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

DRG collected tree inventory data using a system that utilizes a customized 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 DRG's arborists ensure the high quality of inventory data. Data quality control checks were conducted by DRG's on-site manager on a weekly basis and any errors found were addressed and fixed. A minimum of 2% of the total inventoried sites were assessed as part of these quality control checks. Further quality assurance checks were completed after the inventory was concluded using TreeKeeper© to ensure the quality and accuracy of the inventory data.

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

• Address/Location Information*	• Overhead Utilities
• Comments	• Photo**
• Condition	• Primary Maintenance
• Date of Inventory	• Residual Risk
• Defects	• Risk Rating
• Further Inspection	• Species
• Multi-stem	• Tree Size***

* including address, street, on street, side, and x/y coordinates
** if tree was in Poor condition
*** measured in inches in diameter at 4.5 feet above ground (or diameter at breast height [DBH])

Maintenance needs are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011).

The inventory data collected were provided in DRG's TreeKeeper© software, an ESRI® shapefile, and a Microsoft Excel™ spreadsheet. An i-Tree Eco data file was also provided with the results of the i-Tree Eco analysis of the inventory data.

Selected Inventory Areas

Due to grant budgetary constraints, the 2019 Bethlehem inventory did not include the entirety of the town's roadways. Instead, the inventory area was organized into primary, secondary, and tertiary inventory areas based on location and road importance to the town with the intent that high priority areas would be completed first, while lower priority study areas would be completed if budgets permitted. Ultimately, all primary, secondary, and tertiary areas initially determined for inventory by the Town were completed. See Section 1 of this management plan for further information on why certain areas were assigned priority over others.

Primary inventory areas were completed first and included state and county-owned roads including Route 85 (New Scotland Road), parts of Route 140 (Cherry Avenue, Elm Avenue, and Kenwood Avenue), Route 443 (Delaware Avenue), Fisher Boulevard, and Feura Bush Road. The secondary inventory area was completed next and included all Town-owned streets bounded by Delaware Avenue to the north, Elsmere Avenue to the east, Delmar Bypass (New York State Route 32) to the south, and Elm Avenue to the west. Finally, tertiary inventory areas were broken down into areas 3A through 3J (see Section 1, Map 1) and were completed in alphabetical order after all primary and secondary study areas had been completed.

Site Location Methods

Equipment and Base Maps

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

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

Imagery/Data Source	Date	Projection
Shapefiles Town of Bethlehem, NY Department of Economic Development and Planning	2018-2019	NAD 1983 StatePlane New York East; Feet
Aerial Imagery 6in New York GIS Clearinghouse	2017	NAD 1983 StatePlane New York East; Feet

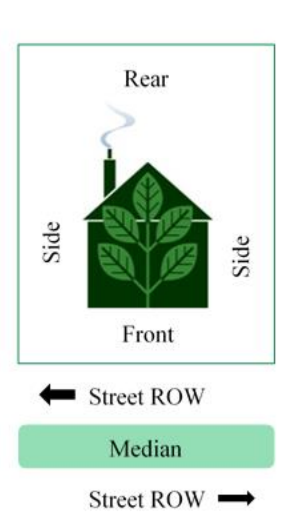
Street ROW Site Location

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

Address Number

The *address number* was automatically filled based on GIS parcel addressing and was edited in the field as needed based on visual observation by the arborist at the time of the inventory (if the address number was posted on a building at the inventoried site). Where there was no posted address number on a building, or where the site was located by a vacant lot with no GIS parcel addressing data available, the arborist used their best judgment to assign an address number based on opposite or adjacent addresses. If an address was assigned by the arborist, the Suffix (assigned address) field was changed from No to Yes or X.

Sites in medians or islands were assigned an address number using the closest parcel address and the Suffix (assigned address) field was changed from No to Yes or X.



Side values for street ROW sites.

Side Value and Site Number

Each site was assigned a *side*. Side values include *front*, *side*, *median* (includes islands), or *rear* based on the site's location in relation to the lot's street frontage. The *front* is the side that faces the address street. Sites assigned the side value *front* will have the same street and on street value. *Side* indicates the side of a lot perpendicular to the address street. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front. Sites assigned the side values *side* or *rear* will have different street and on street values.

Street and On Street

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

- The *street* is the street to which the lot is addressed. It is usually (although not always) the street which buildings on the lot face.
- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street). Sites with side value *front* will always have the same street and on street values. Sites with side value *side* or *rear* will never have the same street and on street values.

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*, *street*, and *address* would be the park and/or public space's parcel information and many not uniquely identify the location of the site.

Site Location Examples

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

Corner Lot A

Address: 205
Street: Hoover St.
On Street: Taft St.
Side: side

Address: 205
Street: Hoover St.
On Street: Taft St.
Side: side

Address: 205
Street: Hoover St.
On Street: Taft St.
Side: side

Address: 205
Street: Hoover St.
On Street: Hoover St.
Side: front

Corner Lot B

Address: 226
Street: E Mac Arthur St.
On Street: Davis St.
Side: side

Address: 226
Street: E Mac Arthur St.
On Street: E Mac Arthur St.
Side: front

Address: 226
Street: E Mac Arthur St.
On Street: E Mac Arthur St.
Side: front

Vacant Site Collection Methods

Vacant sites were collected along primary study area roadways to provide a guide to potential locations for planting new trees. DRG uses a standard set of criteria to collect only high-quality potential planting sites. The criteria for the three sizes of vacant site collected during this inventory were as follows:

Large Vacant Site

Must have a minimum growing space dimension of 8’ or greater

Must not be located below any overhead utility lines

Must be located at least:

40’ from any other tree, stump, or vacant site

30’ from road intersections

20’ from stop signs

15’ from utility poles

15’ from buildings

10’ from driveways

10’ from street signs (including yield, pedestrian crossing, and other street signs, but excluding parking signs which can be relocated) and placed so as not to interfere with street signs as the tree grows

10’ from crosswalks

5–10’ from underground utilities, including water lines, buried electric, or cable lines, etc.

5’ from culverts and other water drainage infrastructure

Medium Vacant Site

Must follow all the same location requirements as large vacant sites, except:

- Must have a minimum growing space dimension of 6’ or greater

Small Vacant Site

Must follow all the same location requirements as large vacant sites, except:

- Must have a minimum growing space dimension of 4’ or greater
- May be located underneath overhead utility lines

DRG arborists used both their observations of the surrounding area at the time of the inventory as well as a Town-provided map of underground utilities loaded into the Rover data collection software to locate appropriate vacant sites. As such, no vacant site recorded during the inventory should conflict with underground or overhead utilities. Although a small tree could be planted in a large vacant site, DRG arborists strove to record the largest possible vacant site for any given location to maximize the potential benefits provided by newly planted street trees.

I-Tree Eco Methodology

i-Tree Eco can be utilized with a complete inventory to simplify the benefit quantification process. The monetary values of trees are based on four characteristics: Condition, Location, Species, and Trunk Area. When location in the landscape is matched with healthy, high-quality tree species, the benefits can be readily quantified utilizing the Council of Tree and Landscape Appraiser's methodology within the i-Tree Eco suite of software. This information has been complemented with United States Forest Service (USFS) software programs like i-Tree Eco to provide benefit-based assessments of what trees are worth on an economic level (McPherson 2007; Nowak et al. 2008).

To identify the *dollar value* provided and returned to the community, the town's tree inventory data were formatted for use in the i-Tree Eco benefit-cost assessment tool. 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 Eco uses frequently updated economic inputs for georeferenced locations selected by USDA FS for the climate zone in which the community is located.

To provide an estimate of *avoided runoff due to interception of stormwater* by the inventoried trees, i-Tree Eco contrasts a model using the calculated leaf area for the inventoried area with a model assuming zero leaf area for the same area. Avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events. Surface runoff from rainfall contributes to the contamination of streams, rivers, lakes, and wetlands by washing oils, pesticides, and other pollutants either directly into waterways or into drainage infrastructure that ultimately empties into waterways. For this analysis, annual avoided runoff is calculated based on the estimated amount of intercepted rainfall and the local weather in Pittsfield, MA, where annual precipitation in 2015 equaled 43.0 inches. The monetary value of avoided runoff is based on the United States Forest Service's Community Tree Guide Series at a rate of $0.07 per cubic foot.

Air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$). For this analysis, the pollution removal value is calculated based on the prices of $1,200 per ton of ozone, $40 per ton of sulfur dioxide, $140 per ton of nitrogen dioxide, $1,380 per ton carbon monoxide, and $44,880 per ton of particulate matter less than 2.5 microns.

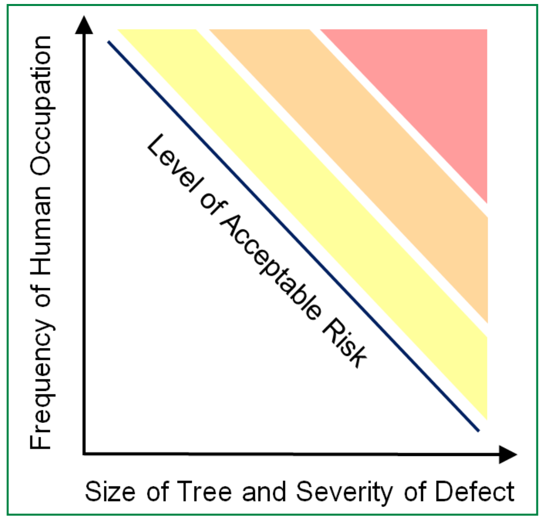
Carbon sequestration refers to the capture and storage of carbon from the earth's atmosphere. The i-Tree Eco calculation considers the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The i-Tree Eco analysis reports on the gross annual amount of carbon sequestered as well as the total amount of carbon stored over the lifetime of the tree. For this analysis, carbon storage and sequestration values are calculated at a rate of $171 per ton.

Structural value is a compensatory value calculated based on the local cost of having to replace a tree with a similar tree. In other words, it is a measurement of the value of the resource itself. The structural value of an urban forest is the sum of the structural values of all the individual trees contained within. Monetary values are assigned based on valuation procedures of the Council of Tree and Landscape Appraisers using information on species, diameter, condition, and location (McPherson 2007) and (Nowak et al. 2008).

APPENDIX B: RISK ASSESSMENT/ PRIORITY AND PROACTIVE MMAINTENANCE

Risk Assessment

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



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

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

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

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

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

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

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

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

  - None—Used for planting and stump sites only.
  - Low—The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.
  - Moderate—The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.
  - High—The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.
  - Extreme—The Extreme Risk category applies in situations where tree failure is imminent and there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area to avoid injury to people.

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

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

Priority Maintenance

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

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

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

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

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

Proactive Maintenance

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

APPENDIX C
TREE PLANTING

Tree Planting

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

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

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

Tree Species Selection

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

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

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Some grow tall, some grow wide, and some have extensive root systems. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating some shade may be a priority, but it is important to consider how a tree may impact existing utility lines as it grows taller, wider, and deeper. If the tree's canopy, at maturity, will reach overhead lines, it is best to choose another tree or a different location. Similarly, trees should be selected to fit the hardscape and underground utilities surrounding their planting space. If mature root characteristics are likely to interfere with hardscape or underground utilities, a different species or planting site should be considered. Refer to DRG's vacant site criteria (see Appendix A) for a set of general guidelines for the growing space and clearances all planting sites should have. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

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

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

Appendix D outlines recommended species for future planting, arranged by tree type (deciduous/ broad leaf vs coniferous/ evergreen) and size (large, medium, and small).

Bare Root Tree Planting

DRG recommends that the bare-root tree planting method developed by the Cornell University Urban Horticulture Institute in collaboration with the City of Ithaca Parks and Forestry Section should become the primary way that the Town of Bethlehem plants public trees.

Bare-root trees are less expensive to buy and to ship than balled & burlapped (B&B) trees. They generally have bigger root systems than B&B trees of the same caliper, and it is easier to avoid planting too deeply, a common problem with young tree establishment.

We recommend that Bethlehem use the method outlined in the document, "Creating the Urban Forest: The Bare-Root Method". This document has valuable information including an Appendix – Level of Transplanting Difficulty of Various Species. This appendix has lists of trees that were found easy to transplant bare root as well as those that are moderately difficult and species that were found to be difficult to transplant bare root. This document should be made a part of Bethlehem's standard operating procedures and referred to when Bethlehem plans a tree planting project. It is further recommended that Bethlehem use the video, "Creating An Urban Forest The Bare Root Tree Planting Method" as a reference and a training tool. https://vimeo.com/9729714

Tree species that were found to be difficult to establish using the bare-root method should be planted as B&B material. Research and trial and error has shown that a very successful municipal tree planting program can be developed by planting bare-root trees in the fall and B&B trees in the spring.

Finally, the ANSI A300 Standards address tree care performance. DRG supports, helps to develop, and recommends these standards for creating specifications for tree care. For tree planting, the pertinent one is ANSI A300 (Part 6) – 2012 Planting and Transplanting (R 2018). Note that these standards are revised periodically.

Tips for Planting Trees

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

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift trees by the trunk.
- If trees are stored prior to planting, keep the roots moist.

- Dig the planting hole according to the climate. Generally, the planting hole is two to three times wider and not quite as deep as the root ball. The root flair is at or just above ground level.
- Fill the hole with native soil unless it is undesirable, in which case soil amendments should be added as appropriate for local conditions. Gently tamp and add water during filling to reduce large air pockets and ensure a consistent medium of soil, oxygen, and water.
- Stake the tree as necessary to prevent it from shifting too much in the wind.
- Add a thin layer (1–2 inches) of mulch to help prevent weeds and keep the soil moist around the tree. Do not allow mulch to touch the trunk.
- There is no substitute for purchasing high-quality trees. All trees should be inspected to ensure that they meet the size and proportion guidelines set out in the American Standard for Nursery Stock (ANSI Z60.1). Some of the characteristics of healthy nursery trees include free of bark injuries and wounds, healthy root systems, balanced branch distribution, proper taper, and good vigor.
- Initially, watering is the key to survival; new trees typically require at least 60 days of watering to establish. Determine how often trees should be irrigated based on time of planting, drought status, species selection, and site condition.
- Mulch should be applied to the grow space 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 grow space is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches, and the growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Newly Planted and Young Tree Maintenance

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

Watering

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

Mulching

Mulch can be applied to the grow space 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 grow space is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches, and the growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Lifelong Tree Care

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

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

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

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

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

APPENDIX D
RECOMMENDED SPECIES FOR FUTURE PLANTING

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

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on DRG's experience. Tree availability will vary based on availability in the nursery trade. Also consider Dirr's new book, *The Tree Book – Superior Selection for Landscapes, Streetscapes, and Gardens*, with Keith Warren from 2019. For New York State, consider species from the NYC approved species list: https://www.nycgovparks.org/trees/street-tree-planting/species-list.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
Celtis laevigata	sugar hackberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	Katsura tree	'Aureum'
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus imbricaria	shingle oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	'Splendens'

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

Scientific Name	Common Name	Cultivar
Quercus shumardii	Shumard oak	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	'Sterling'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Pistacia chinensis	Chinese pistache	
Prunus maackii	amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
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'
Crataegus viridis	green hawthorn	'Winter King'
Laburnum × watereri	goldenchain tree	
Maackia amurensis	amur maackia	
Malus species	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus subhirtella	Higan cherry	'Pendula'
Prunus virginiana	common chokecherry	'Schubert'
Stewartia ovata	mountain stewartia	
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

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'
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Psedotsuga menziesii	Douglas-fir	
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

APPENDIX E
INVASIVE PESTS AND DISEASES

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

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

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

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

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

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

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

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

Asian Longhorned Beetle

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an exotic pest that threatens a wide variety of hardwood trees in North America. The beetle was first discovered in the United States in Brooklyn, New York in 1992. Since then, further infestations have been discovered in Illinois (1998), New Jersey (2002), Massachusetts (2008), and Ohio (2011). It 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, with the potential to destroy more than 30% of the US's urban forests.

Adult Asian longhorned beetle on a poplar stem.

Photograph courtesy of Gillian Allard, FAO of United Nations, bugwood.org

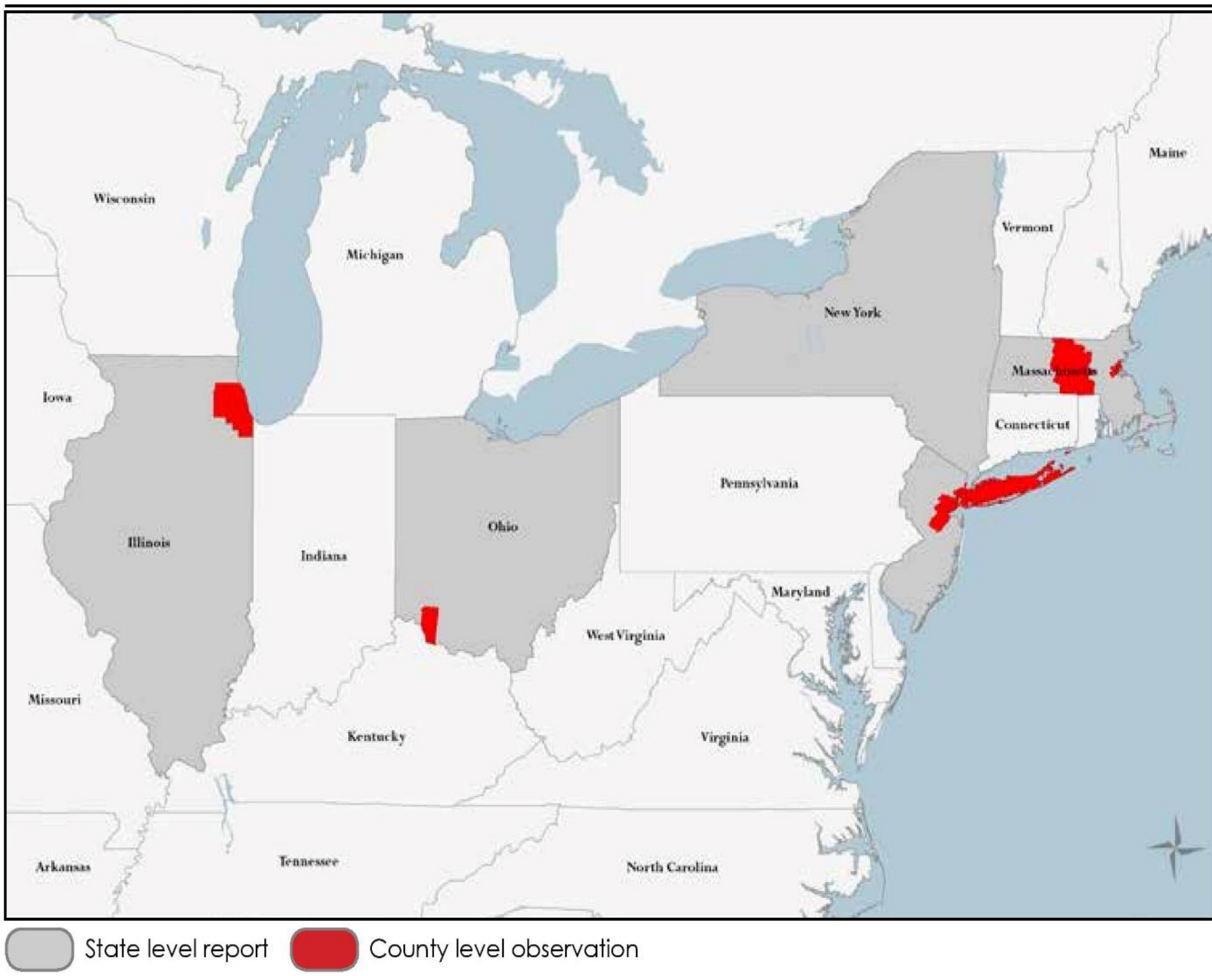
ALB egg sites (left) in a characteristic zig-zag pattern and sunken gallery and round exit hole (right).

Photographs courtesy of Emmah Day, inventory arborist, DRG.

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 are wood boring insects that leave distinctive damage on host trees, including sunken, softball-shaped galleries, almond-shaped egg sites with distinct mandible marks along the margins, and perfectly round dime-sized exit holes. Egg sites may weep when sap is actively flowing in the spring and may push frass with the consistency of shredded wheat when beetles are actively boring. Once infested, it may take several years for a tree to show signs of decline and tree death typically occurs within 10-15 years after infestation.

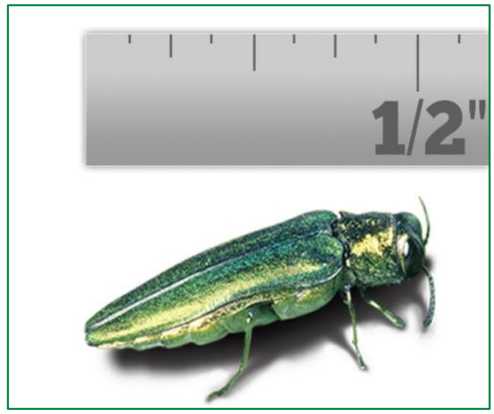
ALB has a long list of host species; however, the beetle prefers hardwoods, and particularly *Acer* (maple) species. Other hosts in the United States include *Fraxinus* (ash), *Betula* (birch), *Ulmus* (elm), *Koelreuteria* (golden raintree), *Platanus* (London planetree/sycamore), *Aesculus* (horsechestnut/buckeye), *Cercidiphyllum* (katsuratree), *Albizia* (mimosa), *Sorbus* (mountain ash), *Populus* (poplar), and *Salix* (willow). 32% of the inventoried tree population in Bethlehem is susceptible to ALB, and the high proportion of maple (31% of the inventoried population), the beetle's preferred host, makes this invasive pest a potentially serious threat to the town.

Once infested, it is generally not possible to salvage the tree, as it is nearly impossible for pesticides to reach beetles and larvae within the wood of the tree. Timely detection of ALB infestations is therefore necessary to provide rapid and effective control programs. ALB is most easily detected either by deploying traps during their active flight period, which is generally late summer to early fall, or by visual surveys of susceptible trees for characteristic beetle damage. The most effective control method found to date is to identify, remove, and finely chip infested trees to stop the spread of the beetle. Fortunately, unless manually transported by humans, ALB has been observed to spread relatively slowly, and eradication programs in Boston, MA and New York City, NY have been successful in eliminating this invasive insect. Bethlehem should be aware of any newly discovered ALB infestations near Albany County, NY and should begin monitoring for presence of the beetle and educating the local citizenry accordingly.



ALB Map by United States Forest Service, Northern Research Station and Forest Health Protection. USDA Forest Service, Northern Research Station and Forest Health Protection. "Alien Forest Pest Explorer - species map." Database last updated 25 March 2019.

Emerald Ash Borer



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

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

Emerald ash borer (*Agrilus planipennis*) 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 and by 1940 it wiped out most of the mature American chestnut population. Dutch elm disease is a fungus spread by the elm bark beetle. Since its discovery in the United States in 1928, it has killed millions of elm trees. EAB is thought to have been introduced into the United States and Canada in the 1990s but was not positively identified in North America until 2002 in Canton, Michigan. It has now been confirmed in 14 states and has killed at least 50 to 100 million ash trees so far and threatens another 7.5 billion ash trees throughout North America. The EAB is a serious pest and is known to attack all native ash trees, including black, blue, green and white ash. The state is committed to early detection and thoughtful management of this pest.

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.

EAB adults grow to 5/8 inch in length

Photograph courtesy of www.wisconsin.gov.

EAB larvae

Photograph courtesy of www.emeraldashborer.info

Gypsy Moth

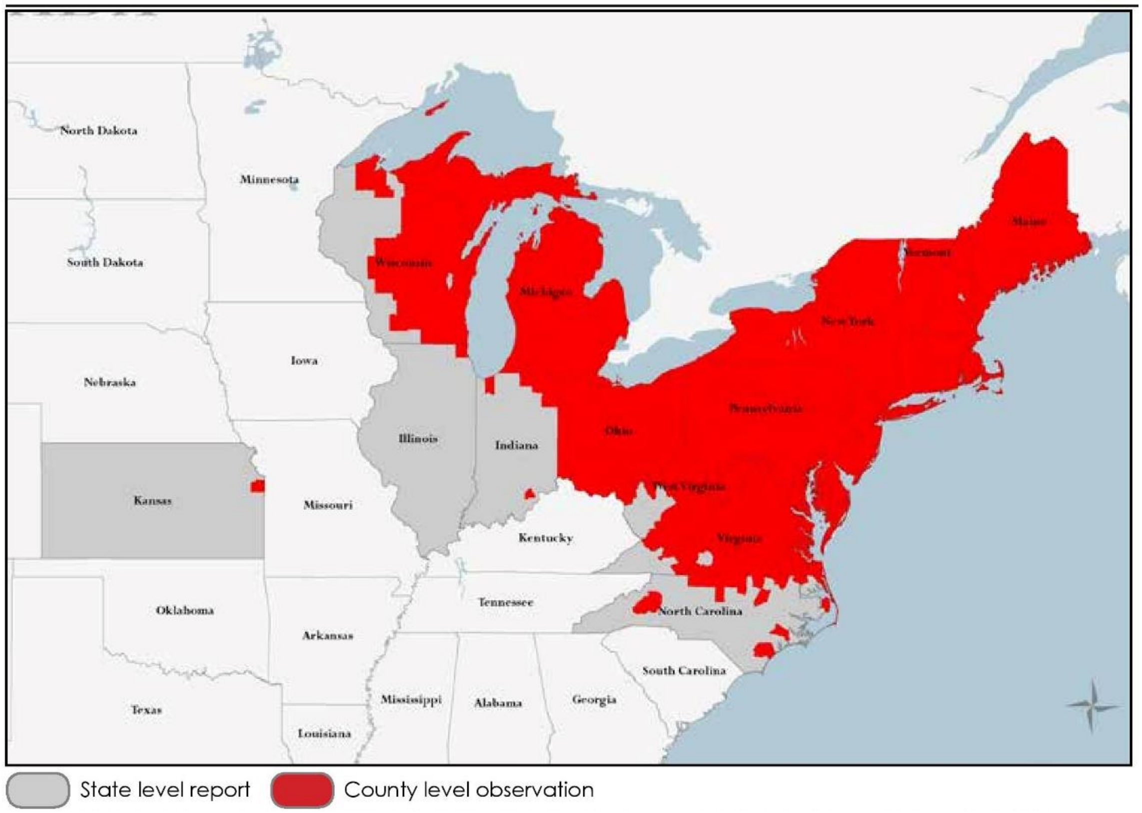
Lymantria dispar (gypsy moth) is native to Europe and first arrived in the U.S. in Massachusetts in 1869. Unlike many invasive species, gypsy moths were imported to the U.S. intentionally as part of a plan to breed a hardy, silk-spinning caterpillar with greater disease resistance that the domesticated silkworm. Unfortunately, the caterpillars escaped confinement and began defoliating trees in a boom-and-bust cycle common to tussock moths, the family to which gypsy moths belong. This moth is a significant pest because its caterpillars have an appetite for more than 300 species of trees and shrubs and are capable of completely defoliating individual trees very rapidly. While host trees may be able to recover from a single defoliation, repeated years of defoliation often kill the host tree or leave it highly susceptible to other pests or diseases.

Late instar gypsy moth caterpillar (left) and adult female (white) and male (brown) gypsy moths (right).

Photographs courtesy John Yuschock, bugwood.org & USDA APHIS PPQ, bugwood.org, respectively.

Male gypsy moths are brown with a darker brown pattern on their wings and have a 1/2-inch wingspan. Females are slightly larger with a 2-inch wingspan and are nearly white with dark, saw-toothed patterns on their wings. Although they have wings, the female gypsy moths cannot fly. They instead emit pheromones to attract males to mate with them, after which they lay 750–1,000 eggs, mixed with yellowish hairs their abdomen, in clusters on tree trunks. These fuzzy, buff-colored egg masses overwinter and hatch the next May. The caterpillars go through a number of instars and, once large enough, can be easily identified by their blue and red spotted backs. Infestations tend to be obvious, with the caterpillars appearing all over trees and the ground in the area. Defoliation is typically evident, and caterpillar feces will pile up underneath affected trees. The egg masses are also quite distinctive and easy to spot.

Gypsy moths have approximately 150 primary hosts but will feed on more than 300 species of trees and shrubs. Common hosts in the northeast include *Quercus* (oak); *Acer* (maple); *Betula* (birch); *Populus* (poplar); *Salix* (willow); *Malus* (apple); and *Cretaegus* (hawthorn), along with many others. While the moths prefer broad-leaf trees, certain conifers may be attacked if preferred hosts are in short supply. Conifers often affected by gypsy moths include *Pinus* (pine) and *Picea* (spruce). Twenty-four percent of the trees in Bethlehem are highly susceptible to gypsy moth.



Gypsy moth detections as of March 2019. Map by United States Forest Service, Northern Research Station and Forest Health Protection.

While pesticide applications may be effective at reducing populations of gypsy moth in the year they are deployed, it is generally recommended to use other control methods aside from chemical, as pesticide applications do not completely eradicate the moth and may harm other, beneficial insect species as well. *Bacillus thuringiensis*, a naturally occurring bacteria, if applied early in the larval stages by a licensed pesticide applicator, may be effective in managing gypsy moth populations on a small scale. Many common management methods, including traps, tree wraps, and manual removal of caterpillars and egg masses, have proven ineffective, particularly in outbreak years.

Spotted Lanternfly

The spotted lanternfly (*Lycorma delicatula*, SLF) is native to China and was first detected in Pennsylvania in September 2014. Spotted laternfly prefers the host tree-of-heaven, but it feeds on a wide range of fruit, ornamental and woody trees, and agricultural crops (such as apple, peach, grape, and hop). While the science of the spotted laternfly is still unfolding, removing tree-of-heaven may help slow its spread.

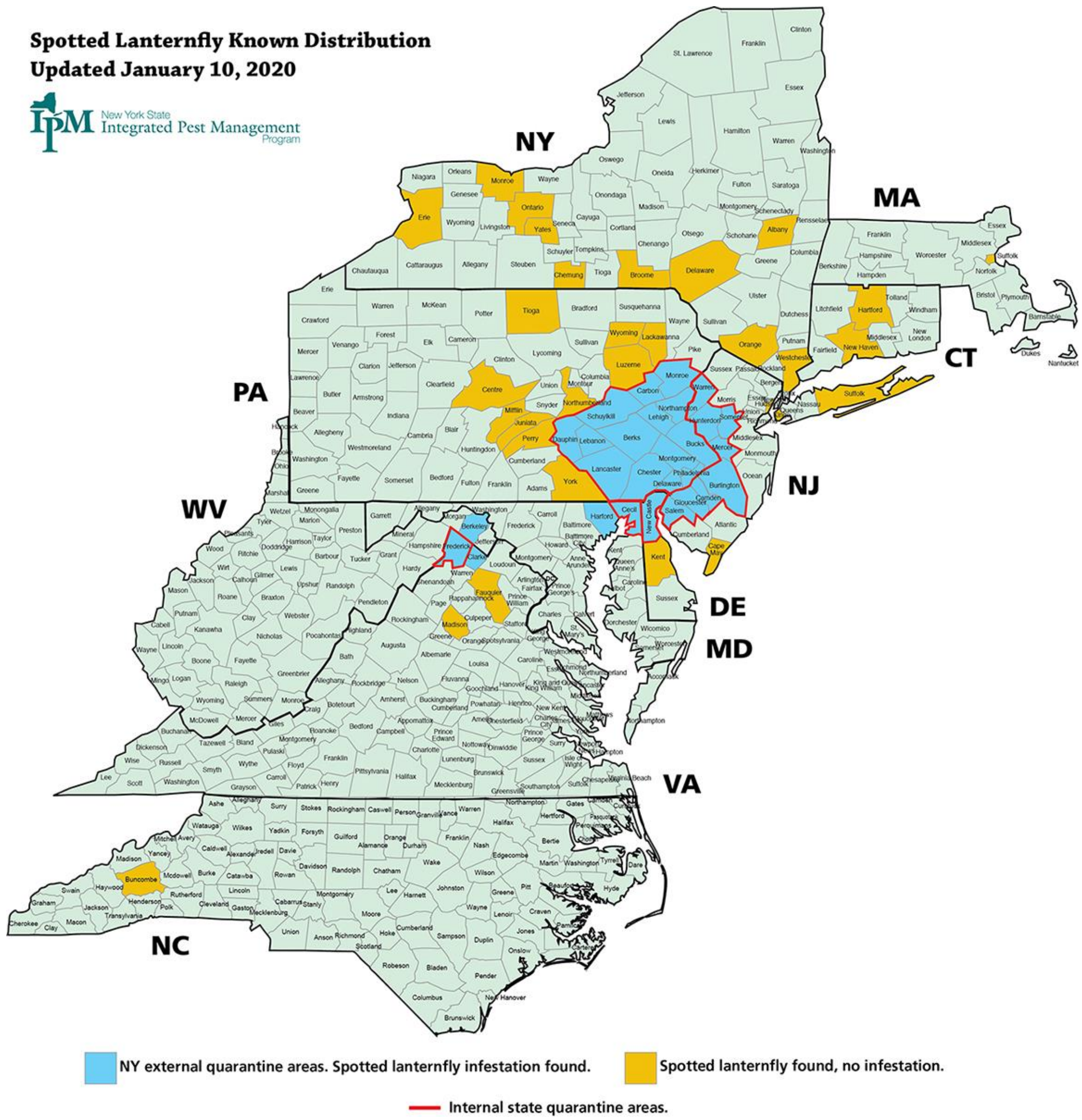
Profile of spotted lanternfly adult at rest.

Photograph courtesy of Pennsylvania Department of Agriculture

Spotted lanternflies are invasive and can be spread long distances by people who move infested material or items containing egg masses. If allowed to spread in the United States, this pest could seriously impact the country's grape, orchard, and logging industries.

In December 2018, a single dead adult was found in Boston, Massachusetts after being discovered in a shipment of poinsettias from Pennsylvania. The spotted lanternfly will lay its eggs on plant surfaces, firewood, cars, and other non-host material, which can easily be transported. It can also be transported along rail lines; whereas, Bethlehm has an active rail line (CSX Selkirk Yard). An adult SLF was found in Buffalo in the last several months. The town's residents should be educated about the spotted lanternfly, because early dection can help prevent an infestation.

Adult spotted lanternflies are approximately 1" long and 1-1/2" wide, and they have large and visually striking wings. Their forewings are light brown with black spots at the front and a speckled band at the rear. Their hind wings are scarlet with black spots at the front and white and black bars at the rear. Their abdomen is yellow with black bars. Nymphs in their early stages of development appear black with white spots and turn to a red phase before becoming adults. Egg masses are yellowish-brown in color, covered with a gray, waxy coating prior to hatching. The spotted lanternfly lays its eggs on smooth host plant surfaces and on non-host material, such as bricks, stones, and dead plants. As a result of the diverse egg laying sites, the insect is easily transported to new locations by humans accidently. Eggs hatch in the spring and early summer, and nymphs begin feeding on a wide range of host plants by sucking sap from young stems and leaves. Adults appear in late July and tend to focus their feeding on *Ailanthus altissimia* (tree-of-heaven) and *Vitis vinifera* (grapevine). As the adults feed, they excrete sticky, sugar-rich fluid similar to honeydew. The fluid can build up on plants and on the ground underneath infested plants, causing sooty mold to form.



Spotted Lanternfly Detections in New England as of January 2020. Map by New York State Integrated Pest Management Program

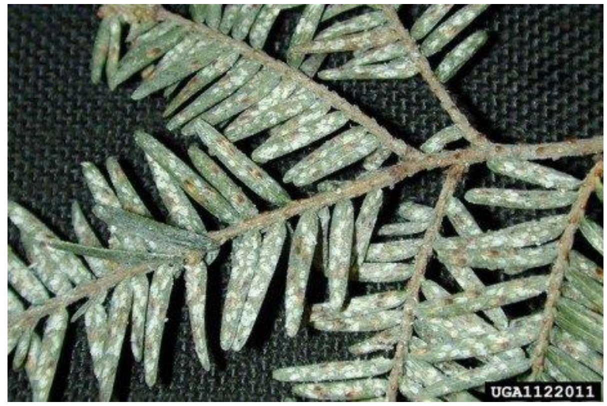
https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/introduction-native-range-and-current-range-us/

Research into control and detection methods for SLF are ongoing. Currently, a combination of removal of life stages of the insect as well as removal of tree-of-heaven, an invasive and prolific host tree species is the best method. These cultural and mechanical control methods can potentially be supplemented by pesticide applications. Public outreach is ongoing in infested areas to educate homeowners about the danger of accidently spreading this invasive insect. While SLF has been found in Albany County, New York as of January 2020, no associated infestation was found.

Spotted lanternfly, *Lycorma delicatula,* is an invasive insect native to China. It was first discovered in Pennsylvania in 2014, and the infestation has since spread into New Jersey, Maryland, Delaware, and Virginia.

Elongate Hemlock Scale

The elongate hemlock scale (*Fiorina externa*, EHS) was introduced from Japan and was first observed in Queens, NY as early as 1908. It was not considered a major pest, however, until the 2000s, when it is range and prevalence increased dramatically. This invasive scale insect has been found in 16 states to date, including Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, Nevada, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, and Virginia, as well as the District of Colombia. The insect is thought to have been spread widely on infested conifer products, including holiday wreaths and Christmas trees.



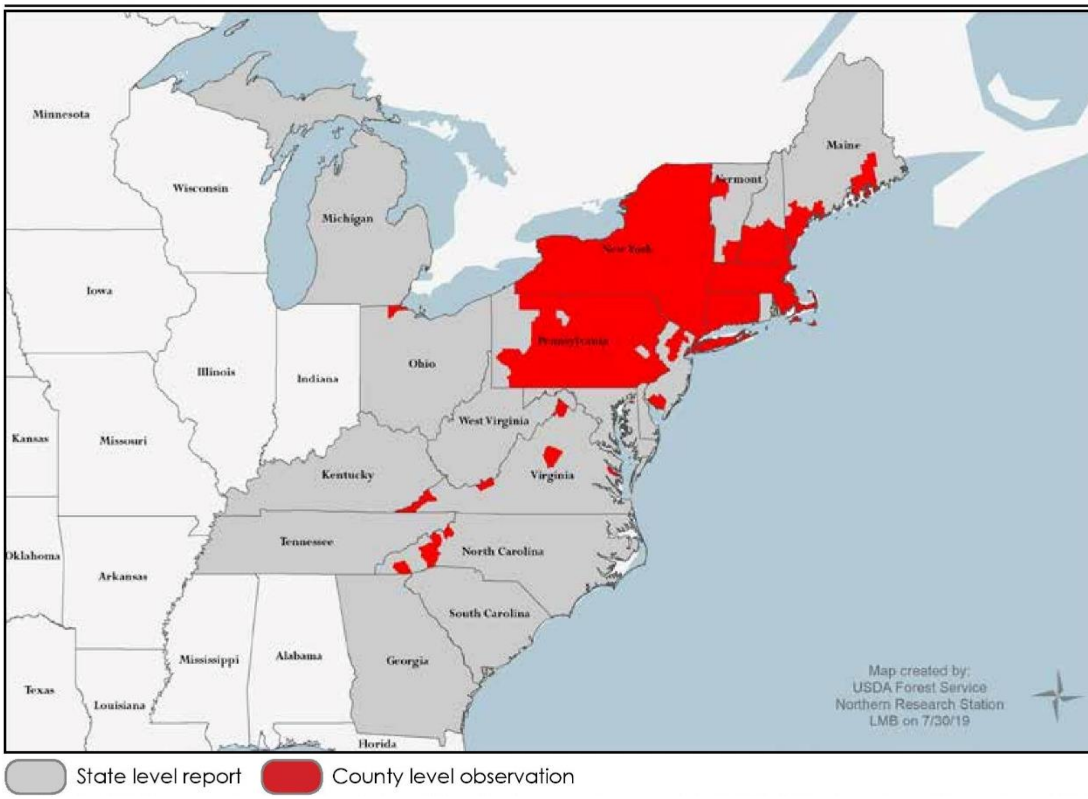
EHS covering the undersides of Tsuga needles.

Photograph courtesy of Eric R. Day, Virginia Polytechnic Institute and State University, bugwood.org

Adult female EHS are soft-bodied, amber, legless, and wingless. They are encased in a 2mm long, brown, waxy scale covered under which they feed and lay around 20 lemon-colored eggs. Males are enclosed in white, 1.5mm scales. While they have wings, they are weak fliers and travel only to mate. They do not feed. Young instars are called crawlers and are yellow and legged. They emerge from May–September and mature to later instars which feed under scales. The scales are a visible sign that a tree is infested with EHS, and needle yellowing, especially on lower branches, premature needle drop, and branch dieback are all common symptoms of EHS infestation. While these insects can kill trees outright by siphoning away nutrients and water from the tree, more commonly they weaken hosts, leaving them susceptible to other pests or environmental conditions.

EHS's preferred host species include *Tsuga* (hemlock), *Abies* (fir), and *Picea* (spruce). Other, less preferred hosts include *Cedrus* (cedar), *Pseudotsuga menziesii* (douglas-fir), *Pinus* (pine), and *Taxus* (yew). EHS is frequently found on the same trees as *Adelges tsugae* (hemlock wooly adelgid), and correct identification of the pest insect is important for effective treatment of the infestation. Twenty-four percent of the inventoried tree population of Bethlehem is susceptible to EHS. It is worth noting that while most of the invasive pest species of concern in Bethlehem attack broad-leaf trees, EHS only attack conifers. Thus, should both EHS and another invasive insect pest both affect Bethlehem's urban forest, the losses of urban canopy would be massively compounded.

EHS is very difficult to control as all life stages tend to be present on a tree concurrently and no single type of treatment or pesticide application will eradicate all life stages. The most effective method of control is to treat affected trees with an appropriate pesticide several times during the most active crawler season, generally once in May–June, and again in July, with a potential third application in September. This type of treatment can help reduce the population of EHS on the tree although it will not eradicate the insects. Certain wasp parasitoids, lady beetles, *Chilocorus stigma* (twice-stabbed ladybug), and several species of lacewing are predators of EHS and can provide some biological control on the pest population. EHS is present in Albany County, NY as of July 2019.



EHS detections as of July 2019. Map by United States Forest Service, Northern Research Station and Forest Health Protection.

Hemlock Woolly Adelgid

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

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

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

Hemlock woolly adelgids on a branch

Photograph courtesy of USDA Forest Service (2011a)

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 U.S. 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, thus increasing 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 1.0–1.5” 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 woodwasps 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 three to six months following attack. Infested trees may have resin beads or dribbles at the egg laying sites, but this is 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 1/8–3/8” 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), which 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.

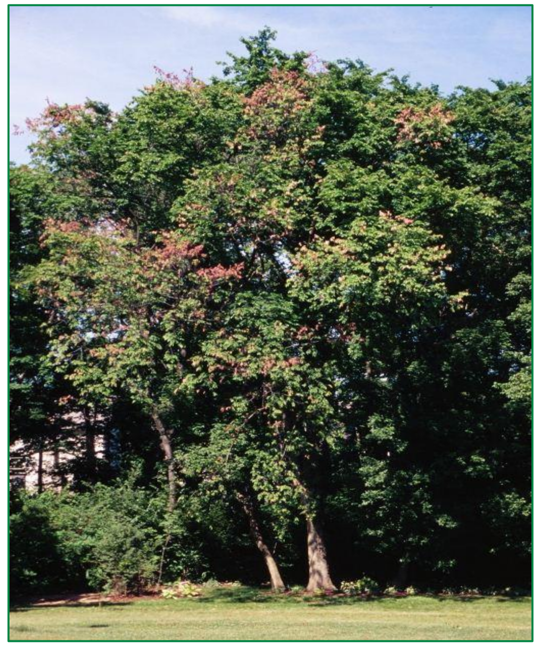
Adult southern pine beetles

Photograph courtesy of Forest Encyclopedia Network (2012)

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.

Dutch Elm Disease

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



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)

There are two closely-related fungi that are collectively referred to as DED. The most common is *Ophiostoma novo-ulmi*, which is thought to be responsible for most of the elm deaths since the 1970s. The fungus is transmitted to healthy elm 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 the *Ulmus americana* (American elm).

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

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