Urban Forest Assessment

ESPM 4041W: Problem Solving for Environmental Change

Report 7/8 Prepared for the City of Shoreview by:

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December 17, 2009

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Acknowledgments

An up-to-date inventory assessment and analysis of the tree cover in Shoreview would not have been possible without help from the City of Shoreview staff members. They helped to create and maintain a positive atmosphere throughout the project and provided us with valuable information necessary to conduct our inventory. The following individuals that shared their knowledge and experience with us were vital to the success of this project.

Gene Kruckenberg- Environmental Officer
Kathleen Nordine- City Planner
Rob Warwick- Senior Planner
Matthew Baker- IS Analyst
Shoreview Residents

Executive Summary

The residents of the City of Shoreview currently express their "high level of satisfaction with the quality of life in Shoreview (City of Shoreview 2008)." Past planning, current actions, and future visions have contributed to a 20-year goal of maintaining this quality of life and striving to "build on existing strengths, participation and inclusiveness, connection, responsibility, and cooperation (City of Shoreview 2008)." Students from the University of Minnesota worked with Shoreview to move toward a more sustainable city by balancing social equity, economic vitality, and environmental integrity. The vision of the Urban Forest Assessment team is:

> *"With increasing development pressure and threats to certain tree species by infectious diseases and pests, Shoreview's urban forest will have a management strategy to ensure that this invaluable resource continues to thrive into the future."*

To accomplish this goal, an inventory of Shoreview's urban forest was conducted and analyzed to make recommendations for a more sustainable forest within the city. Tree inventories provide an integral tool in assessing the viability and vulnerability of the urban forest system and are a required component of a management plan, especially as related to disease and pests such as Emerald Ash Borer, Dutch Elm Disease, or Oak Wilt. Shoreview is a second-ring suburb community in Minnesota that has abundant tree cover. However, despite the importance of this resource, the city does not have an up-to-date inventory of species and age composition of its urban forest.

Urban Forest Assessment Objectives

- Create a sampling method for accurate inventory and status of Shoreview's trees, classified into residential, commercial, right-of-way, and parks and recreation spaces.
- Develop an inventory of species and size of trees found in Shoreview.
- Provide a management plan based on potential threats to the urban forest, including costs of treatment or removal for at-risk trees, and a replacement plan to enhance diversity.
- Offer a feasible method for Shoreview to continue monitoring urban trees and keeping an up-to-date inventory in the future in an efficient, cost-effective manner.

Urban Forest Assessment Methods

- Using the relative proportions of the city's residential (RES), commercial (COM), parks (PR), and right-of-ways (ROW) areas, a stratified sampling method was designed and implemented.
- In Shoreview, 2, 672 trees were sampled per the criteria of the urban forest (UFORE) model sampling methodology, among 143 RES, 27 COM, 22 PR, and 30 ROW sites.
- Trees were identified to species and a diameter-at-breast-height (DBH) measurement was taken to provide information on forest diversity and age structure.

Urban Forest Assessment Results

- Seventy-nine species, 26 genera, and 19 families were found among all strata.
- The top five most common genera were *Acer* (20.3%), *Picea* (12.1%), *Fraxinus* (9.5%), *Quercus* (8.2%), and *Pinus* (6.8%).
- Diversity was in accordance to the "10, 20, 30 rule" across all strata cumulatively.
  - Composition varied within strata, with *Populus, Pinus*, and *Acer* genera in excess of 20% among COM, PR, and ROW.
  - Residential plots contained a diversity within the limits of the "10, 20, 30" rule, with *Acer* species at 19.9%.
  - *Fraxinus* (ash species) were found to be the most abundant in PR (16.3%) and COM (15.4%), as percentage ash by strata.

Introduction

While urban environments are commonly thought of as being dominated by built infrastructure such as roads, houses, commercial, and industrial buildings, the natural landscape in which cities are grounded cannot be ignored. Across all urban environments exists a network of natural resources on which residents depend. Resources such as forests, wetlands, lakes, and streams are valued not only for their aesthetic appeal, which enhances the beauty of homes, but also for the valuable resources they provide. Management of an urban area should work toward the protection and maintenance of its natural resources.

The City of Shoreview exemplifies this style of city management. This second-ring suburban community outside the Minneapolis/St. Paul, Minnesota, metropolitan area is a fully developed community consisting of primarily residential property (42%). However, despite the dominance of developed areas, the city is known for its rich system of natural and recreational spaces, which include parks, trails, lakes, wetlands, and forests. The protection and management of these areas has been a high priority to the city and is widely valued by the community as a whole (City of Shoreview 2008).

A dominant natural resource for the City of Shoreview is the urban forest, or the network of trees found throughout the urban environment. In addition to adding natural character to the landscape, urban forests are becoming increasingly recognized as a provider of economic and environmental services. Economically, without a strong network of trees, a city would be a blank landscape of concrete, steel, and asphalt, providing little aesthetic appeal to current and incoming residents and businesses. In this way, trees add to economic stability by attracting businesses and future residents. In addition, large trees located near buildings can act as natural insulation, which helps to reduce heating and cooling costs. On a larger scale, a healthy urban forest regulates urban heat, which results from an abundance of grey surfaces (such as asphalt and concrete) that store heat during the day and continue to radiate heat through the night, effectively increasing the local temperature. Vegetation can help mitigate this effect by providing shade over these surfaces and simultaneously cooling the air around it through the process of evapotranspiration (Learning 2009). Urban trees also provide benefits to water quality by allowing for greater rain water interception and reducing the amount of runoff into nearby lakes and wetlands (Benefits 2009). Urban forest systems have a global importance as well in that they may mitigate climate change by taking in and storing carbon dioxide, a prominent greenhouse gas.

Health and diversity are essential to urban forest. Greater species and age diversity within an urban forest has been shown to increase the resiliency, or ability of a system to bounce back after a disturbance, such as the devastating potential of tree pests and diseases (Elmquest 2003). Furthermore, healthy tree communities are better equipped to handle other urban stresses invoked by human interaction with nature.

Shoreview has not been immune to tree-related problems in the past. While oak trees are found naturally throughout Shoreview, many other species have been planted as the city has developed. In the early communities, elms were a popular choice for developers, but during the 1970s Dutch Elm Disease devastated the elm community in Shoreview (Kruckenberg 2009). The potential for widespread tree losses as a result of diseases and pests is a constant threat to urban forests. However, the degree of destruction remains unknown as new threats enter the region and the composition of Shoreview's has not been evaluated.

In September 2009, the University of Minnesota began working with Shoreview on multiple projects related to the city's natural resources. This report focuses on the urban forest of Shoreview, particularly the results of an inventory of the city's trees and a management plan for future reference. The purpose of the project is to provide a starting point for Shoreview to manage their urban forest with the assistance of an accurate inventory of their tree diversity. This inventory is intended to assist Shoreview in managing the current forest systems they have and will be easily applicable to future inventories in the city.

Integrated Vision Statement

We envision a sustainable Shoreview: a city that balances social equity, economic vitality, and environmental integrity in order to maintain and improve the quality of life for current and future residents. We aim to further enable Shoreview by:

- Providing relevant tools and information
- Encourage an active and aware citizenry
- Addressing perceived barriers to action
- Fostering responsible and collaborative resource management

Our project strives to empower sustainable behavior and policy changes that will establish Shoreview as a model for other communities.

Urban Forest Assessment Vision Statement

With increasing development pressure and threats to certain tree species by infectious diseases and pests, Shoreview's urban forest needs a management strategy to ensure that this invaluable resource continues to thrive into the future.

Objectives

The goal of this project is to provide Shoreview with information regarding the preservation and management of their urban forest in terms of diversity and coverage area. The project will focus on the status and management of species that are at higher risk of diseases or pests. It will also provide methods and steps involved in order to secure funding for future forest management projects. These goals are consistent with the recommendations in the comprehensive plan for management of Shoreview's vegetation (City of Shoreview 2008), which states:

> *"Consider developing a long-term plan to replant trees throughout the City, taking care to maintain the age diversity of the urban forest," and "consider completing a tree inventory for areas under City management, including streets, parks, and open space, and incorporating this information in the City's Geographic Information System (GIS)."*

The objectives of this project are as follows:

1. Create sampling method for accurate inventory and status of Shoreview's trees classified into residential, commercial, right-of-way, and parks and recreation spaces.
2. Develop an inventory of species and size of trees found in Shoreview.
3. Provide a management plan based on potential threats to the urban forest, including costs of treatment or removal for at-risk trees, and a replacement plan to enhance diversity.
4. Offer a feasible method for Shoreview to continue monitoring urban trees and keeping an up-to-date inventory in the future in an efficient, cost-effective manner.

Site Description

Shoreview, Minnesota, is a beautiful community rich with lakes, wetlands, and forested areas. As a second-ring suburb of the Twin Cities Metropolitan area, it is located only ten miles northwest of Minnesota's capital, St. Paul. Much of the development of Shoreview started in the 1970s and 1980s and has resulted in a fully developed community. In only 12.2 square miles, Shoreview is home to about 27,000 people, 11 lakes, 10 parks, and more than 1,400 acres of parkland and open areas, schools, and businesses. One of the greatest attributes of Shoreview is its pride in caring for and preserving the natural areas within the city.

As in any urban area, trees are an integral part of the community. Shoreview has a rich tree population that is present not only in the natural and undeveloped areas, but also throughout recreational, commercial, residential settings. Within every landscape is a unique structure and composition of trees that vary in species, size, and distribution. The main factor in determining local tree communities is the type and timing of development. For example, a recreational park with playing fields has a different tree community than a residential lot adjacent to a wetland.

Methods

A stratified sampling method was chosen to inventory the species and age composition of Shoreview's urban forest. The proportion of sampling sites was chosen from land use categories, such as residential versus commercial, and based on the relative abundance, or the weighted value, of these areas in the community. Furthermore, the creation of distinct strata allowed qualitative information, such as public versus private lands, to be preserved and utilized for context upon data analysis.

A geographic information systems (GIS) map of Existing Land Use (ELU) designations were provided by the City of Shoreview. This map partitioned the area of Shoreview into polygons, each with an associated zoning designation and its subsequent ELU as determined by the city. Using ArcGIS, these ELU designations were used to assign each parcel of Shoreview into one of four sample strata. The sample strata created for this inventory were reasoned to have similar urban forest characteristics within strata and maintained a clear distinction between private and public domains. The strata created in the private domain are Residential (RES) and

Commercial (COM), while the public domain was comprised of city street Right-of-Way (ROW) and Parks and Recreation (PR) strata. The RES stratum included the ELUs: single family detached (SFD) homes, single family attached (SFA) homes, manufactured housing parks (MHP), multifamily residential (MR) homes, and vacant (V) residential lots. The COM stratum included COM, office (O), industrial (I), and utility (U) ELUs. ROW included Shoreview city streets and a 15.5-foot, two-sided buffer around street centerlines. Finally, PR included the city's parks and recreation designations (PR) and institutions (I). Any properties belonging to the state or county, e.g., county parks or roads, as well as Turtle and Snail lakes were not included in any strata.

From each new stratum layer, the total area, the average area, and the percentage of overall area were determined. This information was used to generate the correct weighted value of sampling plots among strata. The specific numbers of sites were based on logistical constraints, primarily number of people and work hours, and were relative to 143 RES sites, which amounted to 22 sites for PR, 27 for COM, and 30 for ROW based on relative area of each stratum (Table 1). This allocation afforded a total sample size of 223 plots. This was deemed sufficient for an initial sample based on the rule-of- thumb from the urban forest effects (UFORE) model sampling methodology, stating that for an average city a stratified random sample of 200 plots (1/10 acre) will roughly yield a 10% standard error (Nowak 2005).

Table 1: Total and relative area for each of the four strata in the Shoreview forest assessment as calculated from Existing Land Use (ELU) shapefile. Sample frequency of each strata, 223 total, is allocated proportional to each stratum's relative area.

Strata	Area (sq ft)	Percent of Sample Area	Number of Sample Locations
PR	21,380,823	10%	22
COM	26,381,734	12%	27
RES	145,612,697	65%	143
ROW	29,405,444	13%	31
TOTAL	**222,780,698**	**100%**	**223**

Hawth's tools, an ESRI software extension of ArcGIS, was used to generate random plots within each sample stratum. A pre-emptive buffer was assigned to each randomly selected sample site to assure plots did not overlap.

Plot sizes for this sample were generally selected to be 1/10 acre plots to correspond with established methodology for the UFORE model (Nowak 2005). However, plot

design varied based on strata. The COM and PR strata implemented fixed-radius, circular plots (37.25 ft. radius). The ROW stratum used a rectangular plot, based on a 15.5 feet right-of-way either side of the street, perpendicular to the road centerline and extending 140 feet lengthwise. Plot design for the RES stratum, however, did not conform to the 1/10 acre plot size. Instead each randomly selected residential plot was sampled in its entirety in order to maximize the information collected within this stratum. At all sites, diameter at breast height (DBH or diameter of the tree at 4.5 feet high), and tree species information were recorded. Data was entered in a Microsoft Excel spreadsheet upon collection.

Data was analyzed using Microsoft Excel 2007**.** Percentages of each tree species were calculated within and among strata. Species diversity was determined to gauge the absolute number of species present, while a Shannon Diversity Index was calculated to incorporate the relative proportion of each species in a given set. These values were then compared against national averages. The Shannon Index is a measurement of biodiversity, incorporating two important ecological factors: species variety and distribution. Calculation involves utilizing the relative proportion of a particular species (i) relative to the absolute number of species (pi). This way, the calculated value is maximized when (1) many species are present and (2) species are present in equal numbers.

$$H' = -SUM\{ pi*ln(pi)\}$$

Although only a subset of Shoreview was sampled, the number of trees sampled in each stratum was extrapolated in order to provide an estimate for Shoreview's urban forest population. A total estimate for Shoreview was generated based on total area and the number of trees sampled in a portion of the area of Shoreview.

Management techniques and applications that are related to urban forests and invasive pests were researched in primary literature. Case studies of Rochester, MN and the states of Ohio and Michigan, and information provided by governmental agencies, such as the US Department of Agriculture helped guide the development of management plans. Costs of Emerald Ash Borer (EAB) management options were determined using The Emerald Ash Borer Cost Calculator developed by Purdue University's Entomology Extension department. Input data included the number and size of *Fraxinus* trees, the cost of tree removal and replacement, and the insecticide treatment cost. The number of *Fraxinus* trees were counted based on 3-inch interval DBH classes greater than 3 inches. The cost of tree removal and replacement was based on estimated costs given in the Cost Calculator. Insecticide treatment costs were

based on the application of Emamectin Benzoate (Tree-Age®), with an average cost of $12 per diameter inch (S&S Tree Specialists).

Findings

A total of 2,672 trees were inventoried throughout Shoreview. Seventy-nine species and 26 genera, were found in 19 botanical families with only three trees that could not be identified (0.1% of all trees inventoried).

Composition

Acer spp. (maples) were the dominant group of trees found throughout Shoreview, representing 20.3% of all trees surveyed (Figure 1). This was followed by *Picea* (spruce), *Fraxinus* (ash), and *Quercus* (oak) at 12.1%, 9.5%, and 8.2%, respectively.

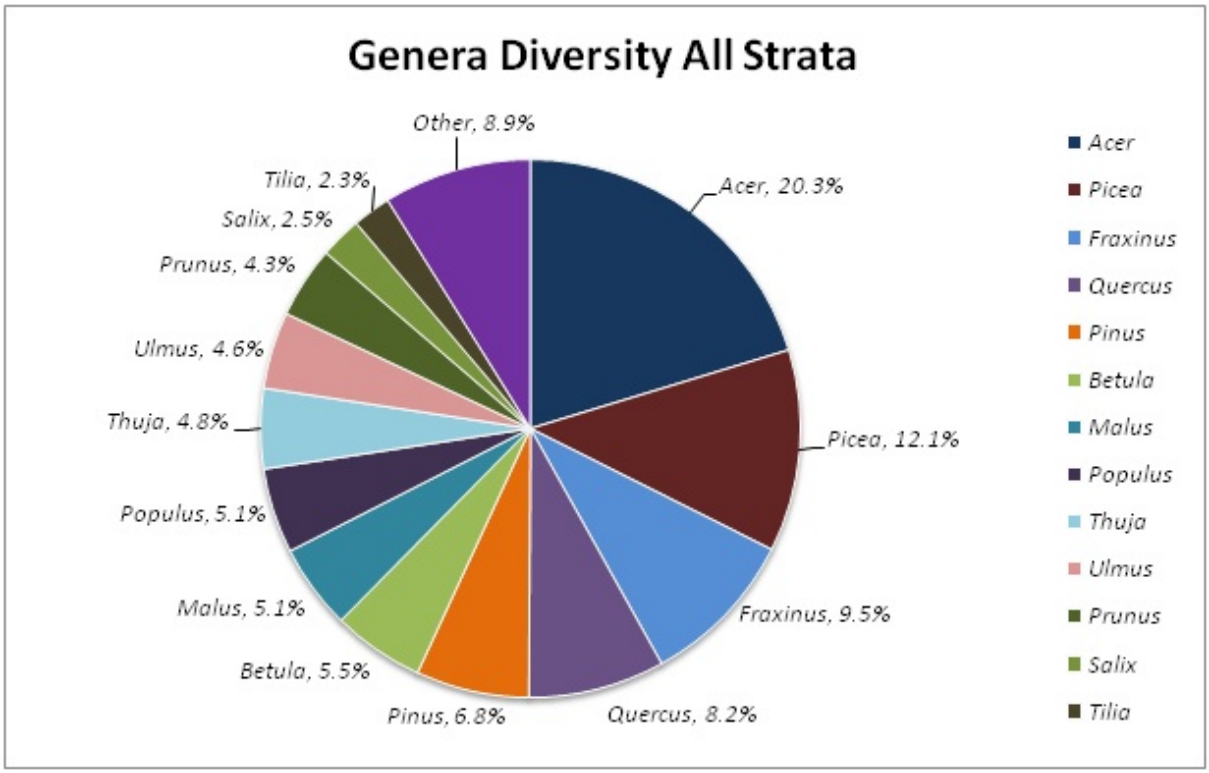

Figure 1: Pie chart of percent trees by genera for the city of Shoreview. Genera representing less than 2% of the genus distribution have been aggregated to the "Other" genus class.

The composition differed among each stratum (Figure 2). In the ROW plots, 92 trees were inventoried. *Acer* dominated at 39.3%, with *Fraxinus, Quercus*, and *Picea* at considerably lower percentages (9.5-11.9%). The PR and COM had much lower tree populations with nearly 20% of all plots having no trees. More than 51% of the trees contained within PR were *Pinus* and *Populus* species, while 53.8% of trees within COM were *Acer* or *Populus* species.

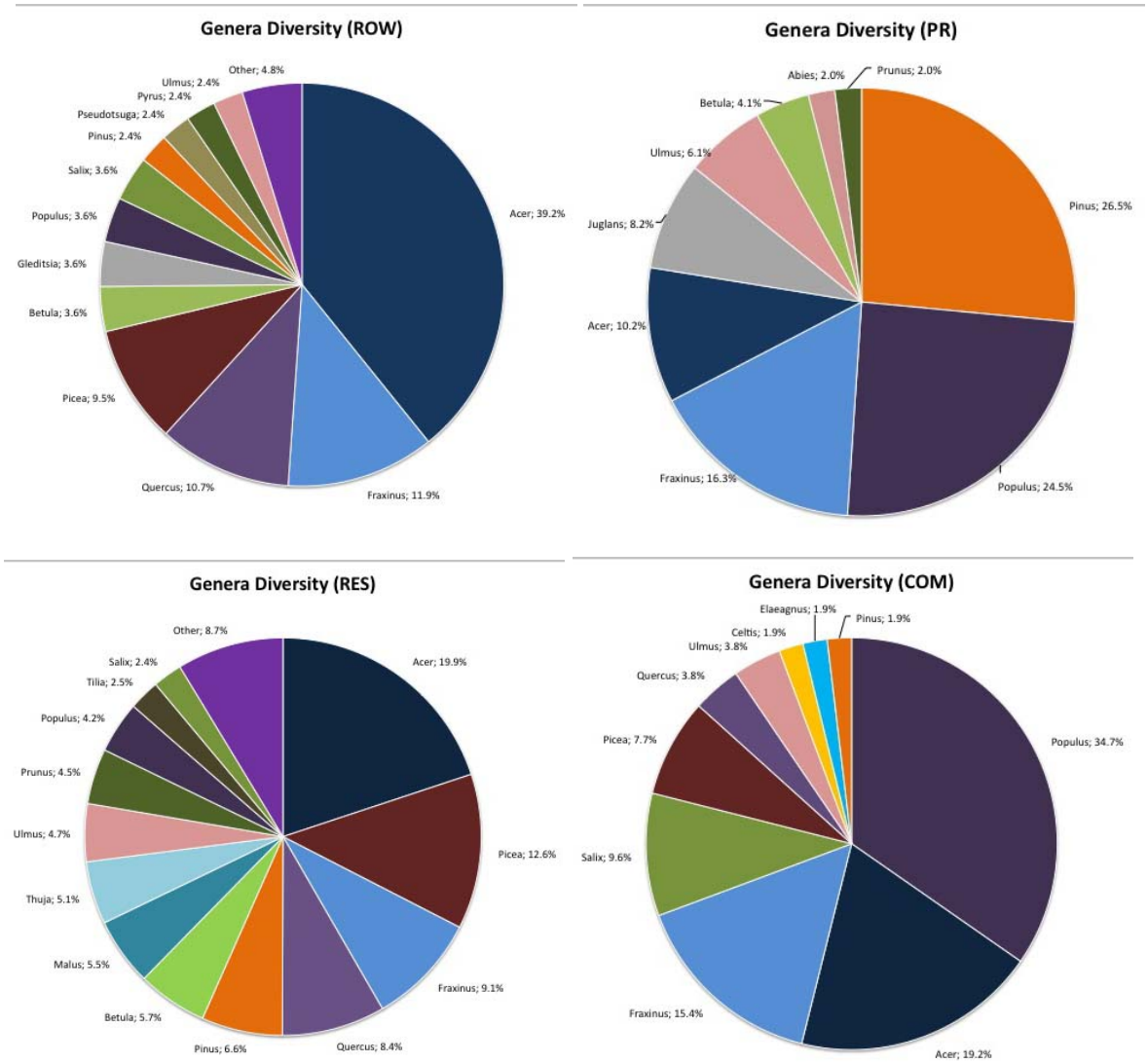

Figure 2: Breakdown of percent genera by stratum. Genera representing less than 1% of the genus distribution within a particular stratum have been aggregated to the "Other" genus class.

Diversity and Density

Shoreview's urban forest consists of 79 species with an overall Shannon Index (H) value of 3.7. At this scale, both measures of diversity come in significantly higher

than the national average of 53 tree species and H=2.7 (McPherson 1989). RES plots, the city's largest stratum containing 65% of area sampled, has a Shannon Index value of H=3.7. This is representative of high species abundance and even distribution.

Density of trees in Shoreview ranged from 17 to 28 trees per acre in each stratum with an average of 23 trees per acre across all strata. The total number of trees estimated was based on the area sampled for each stratum extrapolated to the entire area of Shoreview. The total number of trees estimated for Shoreview does not include county areas and highway right-of-way.

Table 2: Tree density by strata.

	Trees measured	Density (trees/acre)	Estimated total trees
COM	52	19	11,664
PR	49	27	12,238
RES	2,450	17	58,842
ROW	84	28	18,902
TOTAL	**2,635**	**23**	**101,646**

Common Species

While *Fraxinus* species abundance and density is the current primary concern, it is also important to note other species of significant abundance with consideration to the vulnerability they pose. The *Acer* genus, which compromises one-fifth of the total sample tree population, is vulnerable to *Nectria canker*, Anthracnose, or *Verticillium* wilt, each a prolific fungal disease among many more that exist (Maple 2007). ROW, COM, and RES stratum have high relative abundances of *Acer* species, with ROW boulevard trees leading at 39.3%. It is important to strive for an even distribution of diversity of trees in urban areas in order to be better prepared for an outbreak of a pest or disease. Just as oak or elm trees were affected in the past, a continuously changing environment will bring about other stressors that may affect different species.

Ash Population

The *Fraxinus* genus was present in numbers well within the constraints of the "30, 20, 10" base guideline for tree diversity. As explained in the recommendations for Shoreview, this rule states that the tree population should contain no more than 30% from one family, 20% from one genus, and 10% from one species. Upon completion of the inventory, we found less than 10% *Fraxinus* among all strata and no more than 16.3% within. Despite these encouraging numbers, they are still significantly higher than the 5% estimate provided by the Minnesota Department of Natural Resources (MDNR), a discrepancy likely attributable to sampling technique and scale

(Minnesota 2007). Maps providing *Fraxinus* locations and concentrations are provided to guide Emerald Ash Borer management plan development (Appendix B).

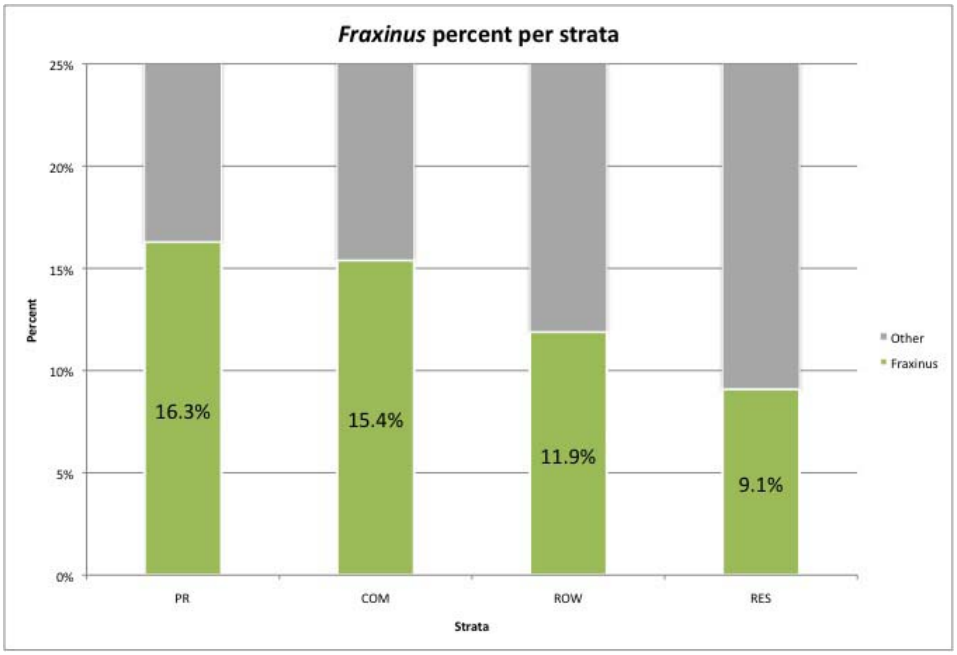

Figure 3: Percent distribution of *Fraxinus*, by stratum.

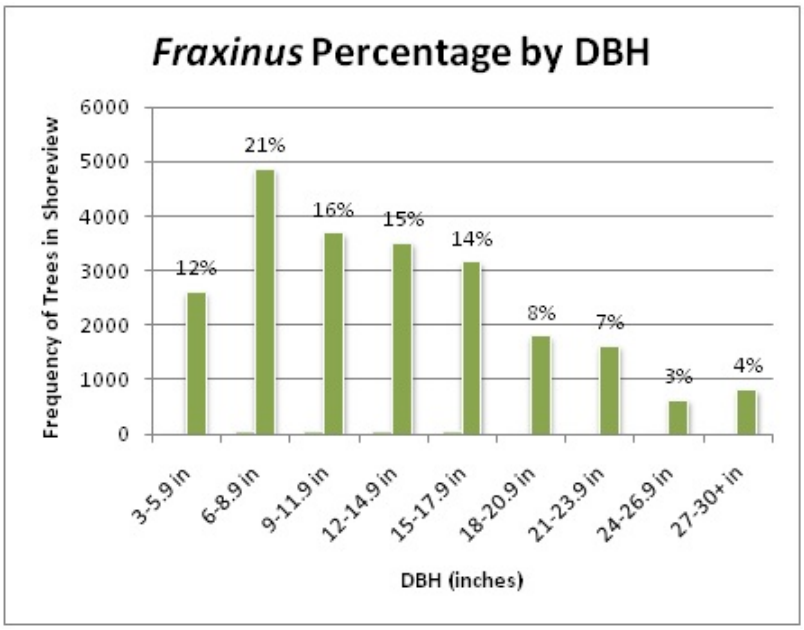

Figure 4: Size distribution of ash trees by DBH size class. Size can be thought of as a rough proxy for age of the ash trees present.

Recommendations and Conclusions

Recommendation 1: Promote and Maintain High Species Diversity

While the diversity of Shoreview's forest was found to be superior to the national average, there still remain areas of potential vulnerability, especially in regards to the dominant species within strata. In three of the four sectors surveyed, two genera comprised 50% of the total tree population. Increasing species, genetic, and spatial diversity within these areas will help to increase the resilience of the urban forest against pests and disease (Richards 1993). Long-term management plans can incorporate these fundamental objectives, in addition to ensuring the short-term success of individual planting projects.

"30, 20, 10" Rule

Shoreview should use the "30, 20, 10" rule as a general guideline for future planting and replacement projects. This rule proposes that: no more than 30% of species belonging to one family should be planted; no more than 20% from each genus; and no more than 10% from each species (Santamour 1990). For example, no more than 30% of trees should belong to the *Rosaceae* family (crabapples, roses, hawthornes, etc.), 20% to the genus *Crataegus* (hawthornes), and 10% to the species *C. monogyna* (Common Hawthorne).

Spatial Diversity

To achieve spatial diversity at any given scale, trees of the same species and genera should be planted as far apart as possible, using other species and genera in between. This can decrease the rate at which pests move throughout preferred host species (Dreistadt 1990).

Genetic Diversity

Genetic diversity of urban forest species can be bolstered by using several kinds of cultivars per species. While individual cultivars are genetically identical, they have been proven to exhibit a consistent and unique set of characteristics, in terms of growth rate, adaptability, color, and longevity, and therefore are desirable for urban planning. For instance, Frontyard, Boulevard, and Redmond are all cultivars of American Basswood, *Tilia americana*, that are slightly genetically unique from one another. Introducing genetic level diversity can further enhance the resistance and resilience to disturbance.

Replacement or Planting Plan

A replacement or planting plan needs to include the following considerations:

- Do not plant additional *Acer* species to keep its relatively high abundance in check**.** A list of alternative species is provided (Appendix D)
- Appropriate species selection for a given site, based on soil, aspect, and drainage characteristics. See list of recommended species for Shoreview provided in the Appendix (Appendix D)
- Site modification or preparation, as necessary. Examples include:
  - Grading (constructing a slope) to improve drainage
  - Adding fill soil to optimize soil texture for root growth and nutrient availability. Specialized fill material, such as Cornell University's Structural Soil can be used; see *http://www.caddetails.com/spotlight/nov06/CU-Soil.pdf* for more information
  - Mitigating soil salt contamination with water, gypsum, or sulfur, when possible
  - Improving compacted soils with aeration equipment
  - Site assessment checklist: *http://www.hort.cornell.edu/uhi/outreach/recurbtree/pdfs/04sitelist.pdf*
- Best planting techniques for each species. Recommendations provided by many government agencies, nonprofit organizations, and academic institutions. Such resources include:
  - National Arbor Day Foundation *(http://www.arborday.org/Trees/video/howtoplant.cfm)*
  - University of Minnesota Extension Service (*http://www.extension.umn.edu/info-u/environment/BD566.html*)
  - International Society of Arboriculture (*http://www.treesaregood.com/treecare/tree_planting.aspx*)

Recommendation 2: Maintain a Long-term Inventory

A continuous inventory, conducted at 5-10 year intervals, will help to assess the changing composition and quality of Shoreview's trees. Updated information can be used to modify management techniques, resource allocation, and objectives.

Preparation for an inventory should include:

- Determining objectives, methods, and resource and time constraints.
- Recruitment and training of personnel who will conduct sampling.
  - City staff, subcontractors, interns, and volunteers.
- Acquisition of proper tools:
  - Measuring tapes (e.g., DBH tape, 50-meter tape)

- Data recording equipment (e.g., Personal Digital Assistant [PDA] or printed spreadsheet, pen/pencil)
- Maps (e.g., city street map, survey plot map, handheld Global Positioning Device [GPS] containing survey plot coordinates)
- Tree identification resources (e.g., books, quick-guide pamphlets, contact personnel for sample submissions)

A 2000 tree sample is adequate to obtain a very accurate representative inventory of the city's overall tree diversity and composition (Bassuk 1990). The methods outlined in this report are a suitable and reliable way of gathering this information. While modifications to sampling technique may be necessary, it is important to maintain the use of strata to ensure the sample will have a good spatial distribution.

Online resources are available to streamline inventory process. These sites offer step-by-step instructions, templates, access to modeling programs, and synchronization to handheld devices. A website designed by the Community Forestry Program Work Team at Cornell University contains these tools in a comprehensive, yet easy to implement context. More information can be found at: *http://www.hort.cornell.edu/commfor/inventory/download.html*. UFORE is yet another useful system, provided by the USDA Forest Service. Links to UFORE software, background information, and instructions can be found at *http://www.ufore.org/about/index.html.*

Recommendation 3: Develop an Emerald Ash Borer Management Plan

Shoreview would benefit from implementing an Emerald Ash Borer Management Plan to ensure effective management of current *Fraxinus* populations.

Emerald Ash Borer Risk to Shoreview

The EAB beetle is a native of Asia and first entered the United States in 2002. Since its initial establishment in Michigan, EAB has quickly spread to neighboring states, leaving behind desolated urban forests. Ohio, Indiana, Illinois, and Maryland have all been affected by EAB. In November 2009, the second EAB infestation of *Fraxinus* species in Ramsey County was discovered on the University of Minnesota St. Paul campus in Falcon Heights, just 4 miles south of Shoreview (Wobbema 2009). After first discovery of EAB in St. Anthony Park in May of 2009, the Minnesota Department of Agriculture (MDA) issued quarantine for Hennepin and Ramsey counties. This quarantine limits the transport of ash wood products outside of the quarantine boundaries in an attempt to limit the transport of EAB larvae.

While EAB has not been documented in Shoreview, it is a major future concern. Based on the close proximity of infestation, Shoreview's urban forest is at considerable risk of losing a large portion of *Fraxinus* trees. An active management strategy such as treatment and/or removal of at risk or infected trees is important for the survival of the *Fraxinus* population within Shoreview.

A Need for a Management Plan

An EAB management plan is a document to be used by the city to guide decisions regarding *Fraxinus* tree management as a way of planning and mitigating the devastating effects on an EAB infestation within the city (Ohio 2009). According to The Ohio Department of Natural Resources, a management plan should help the city "mitigate the disruption to its urban forest caused by the pending infestation of the EAB" (Ohio 2009). By taking a proactive approach before an infestation has occurred, the city can better reduce the economic impact of a loss of a considerable number of *Fraxinus* trees by spreading out the costs in a manageable time period.

Fortunately, many cities in Ohio and Michigan have adopted management plans in response to large-scale EAB infestations (Ohio 2009; Michigan 2009). Similarly, in Rochester, MN, the city's forestry department has developed a management plan including a citywide forest inventory and guidelines for treating or removing at risk or infested trees (City of Rochester 2009). Initial implementation of the EAB plan should remain a practice and only involve the framework of guiding policies, without the legal mandates of ordinances. There will be opportunity to apply ordinance and enforcement as the plan becomes fine-tuned to the economic capacity and resource availability of Shoreview. Shoreview should consider implementing the EAB management plan in the future because management of *Fraxinus* trees now will prevent further spread of EAB. Without a policy for EAB management it is likely that residents will not comply with suggested removal/treatment due to cost.

Example Management Scenarios for Shoreview

While management decisions are dependent on many factors, one of the most important is cost. To determine long-term costs, the Purdue Emerald Ash Borer Calculator was used (Purdue). This web-based program is a free tool that enables users to enter the total number of *Fraxinus* trees for a given range of sizes to estimate the cost of treating, removing, and replacing the trees. Three different scenarios are presented and represent a range of options in *Fraxinus* tree management. The first two scenarios represent two extremes with 100% removal and replacement, and 100% treatment. The third scenario is an intermediate option, with small trees being

replaced, large trees being treated, and intermediate-sized trees being either treated or replaced. See Appendix for complete cost information.

1. Remove and replace 100% of ash trees. The removal and replacement of all ash trees results in the most dramatic decrease in Shoreview's *Fraxinus* population. The threat of EAB establishing in Shoreview's *Fraxinus* population is eliminated because 100% of trees will be removed and replaced with nonsusceptible trees. The city of Falcon Heights, which has a documented infestation of EAB, has decided to remove all ash trees (Wobbema 2009). While this may be a drastic proactive approach, 100% removal could occur following an EAB infestation when dead trees become necessary for removal. In this case, the cost may be higher due to the increased difficulty of removing dead and weak large trees. The removal and replacement of ash trees would occur over a 5-year time span with a first year cost of $1,826,311 and a total cost of $9,131,554. While this scenario represents the lowest cost to the city, it results in a 100% loss of current *Fraxinus* trees. Commercial and park areas would see the most dramatic impact because the highest percentages of *Fraxinus* trees are in these areas.

2. Treat 100% of Fraxinus trees. Treating 100% of *Fraxinus* trees results in the maintenance of the current populations, assuming the treatment is 100% effective. The most effective insecticide treatment of *Fraxinus* trees is application of Emamectin Benzoate, Tree-Age®. Tree-Age® prevents tree damage and death once a tree has become infested with EAB larvae. A single trunk injection during late spring every two years has been shown to be effective in preventing tree death in Michigan and Ohio (Herms 2009). The cost of treatment varies but ranges from $7-16 per diameter inch. Total cost is determined over a 25-year span with the annual cost increasing year to year due to the growth of the trees. First year treatment cost would be $26,280,045 with most of the money being spent on trees with a DBH between 15 and 24. Ending at the 25-year period, the total cost would be $1,241,620,829.

3. Treat all Fraxinus less than 15", treat 50% and remove and replace 50% of Fraxinus between 15-24", and remove and replace 100% of Fraxinus trees greater than 24". With scenarios 1 and 2 being more the extreme cases, scenario 3 presents a middle ground that estimates costs for a variety of management strategies. In this option Shoreview would remove and replace all *Fraxinus* less than 15 inches DBH, treat 50% and remove 50% *Fraxinus* within 15-24 inches, and treat all *Fraxinus* with greater than 24 inches. Assuming effective treatment, the loss of *Fraxinus* trees would be 21%. This scenario would also occur over a 25-year period with a first year

cost of $14,196,575 with the first year having the lowest cost. Total cost of this scenario would be $517,412,165.

Considerations for EAB Management

The scenarios and costs presented should be used to help guide decisions about how to effectively manage the *Fraxinus* population given financial constraints and the value Shoreview places on at risk trees. Table 3 also provides an estimate for the public versus private costs, which is calculated from the percentage of the *Fraxinus* tree population found in each stratum. Since the majority of the *Fraxinus* population is found on private property, residents and business owners may bear a greater financial burden than the city of Shoreview. Each scenario not only differs in cost, but also percentage of *Fraxinus* trees remaining. It is well known that mature trees on residential property add value. While scenario 1 is the least expensive management method to employ, both the property value decrease and the loss of environmental services that tree offers are lost and are not accounted for in the cost estimates provided here.

Table 3: Comparison of mitigation scenario costs.

Scenario	First year cost	Total cost	Duration (years)	% of *Fraxinus* remaining	City cost	Private cost
1	$1,826,311	$9,131,554	5	0	$657,472	$8,474,082
2	$26,280,045	$1,241,620,829	25	100	$89,396,700	$1,152,224,129
3	$14,196,575	$517,412,165	25	21	$37,253,676	$480,158,489

Conclusion

The City of Shoreview provides its residents with a high quality of life, further enhanced by the economic, aesthetic, and ecological services of a rich urban canopy. To ensure it persists into the future as a high value resource, it is necessary to evaluate and manage tree cover as a dynamic system, one that is continuously responding to multiple biological and anthropogenic stressors. The urban forest inventory conducted by students from the University of Minnesota is the first step in achieving this precautionary approach.

Overall results of the city's first tree inventory indicate Shoreview has the benefit of above-average species diversity and relatively low *Fraxinus* population. There remain, however, areas for potential improvement. These improvements, as outlined in each of the three recommendations, can substantially increase Shoreview's capability to

anticipate and mitigate disturbance, such as disease and pest outbreaks. Maintaining diversity throughout the city will achieve additional resiliency in response to a pest or disease outbreak. Increasing the diversity of trees in each stratum, particularly PR, ROW, and COM, will allow the distribution of treatment costs in the presence of an outbreak to be lower. A more diverse urban forest ecosystem and up-to-date inventory will allow Shoreview to be better prepared to deal with catastrophic events financially and will help them be able to respond quickly with management if such an event occurs. It is critical that diversification efforts be supported by a continuous urban forest inventory and a tailored Emerald Ash Borer Management plan specific to the needs and constraints of Shoreview. These tools will provide the structure required to implement measures effectively and remain congruent with the city's established Comprehensive Management Plan.

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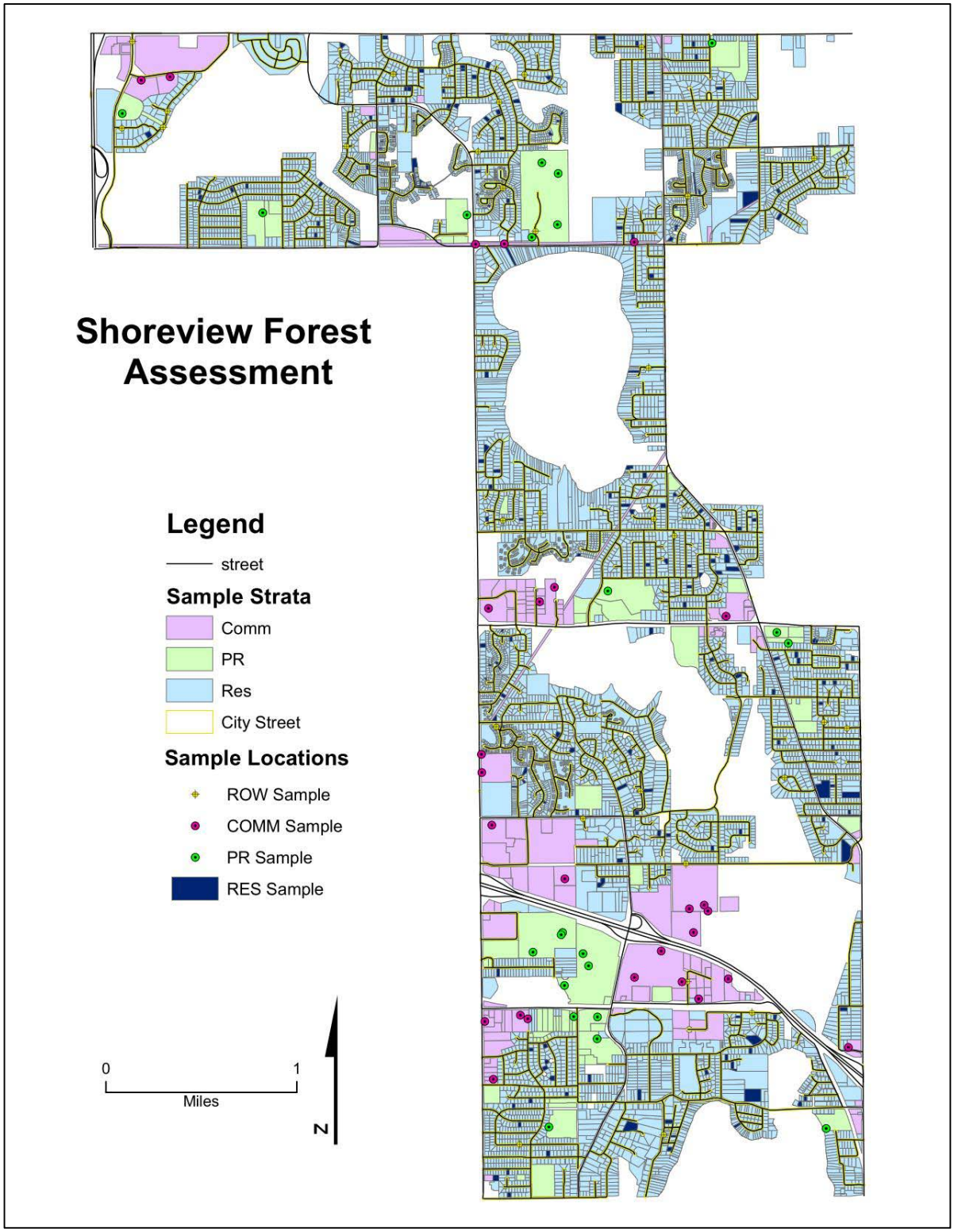
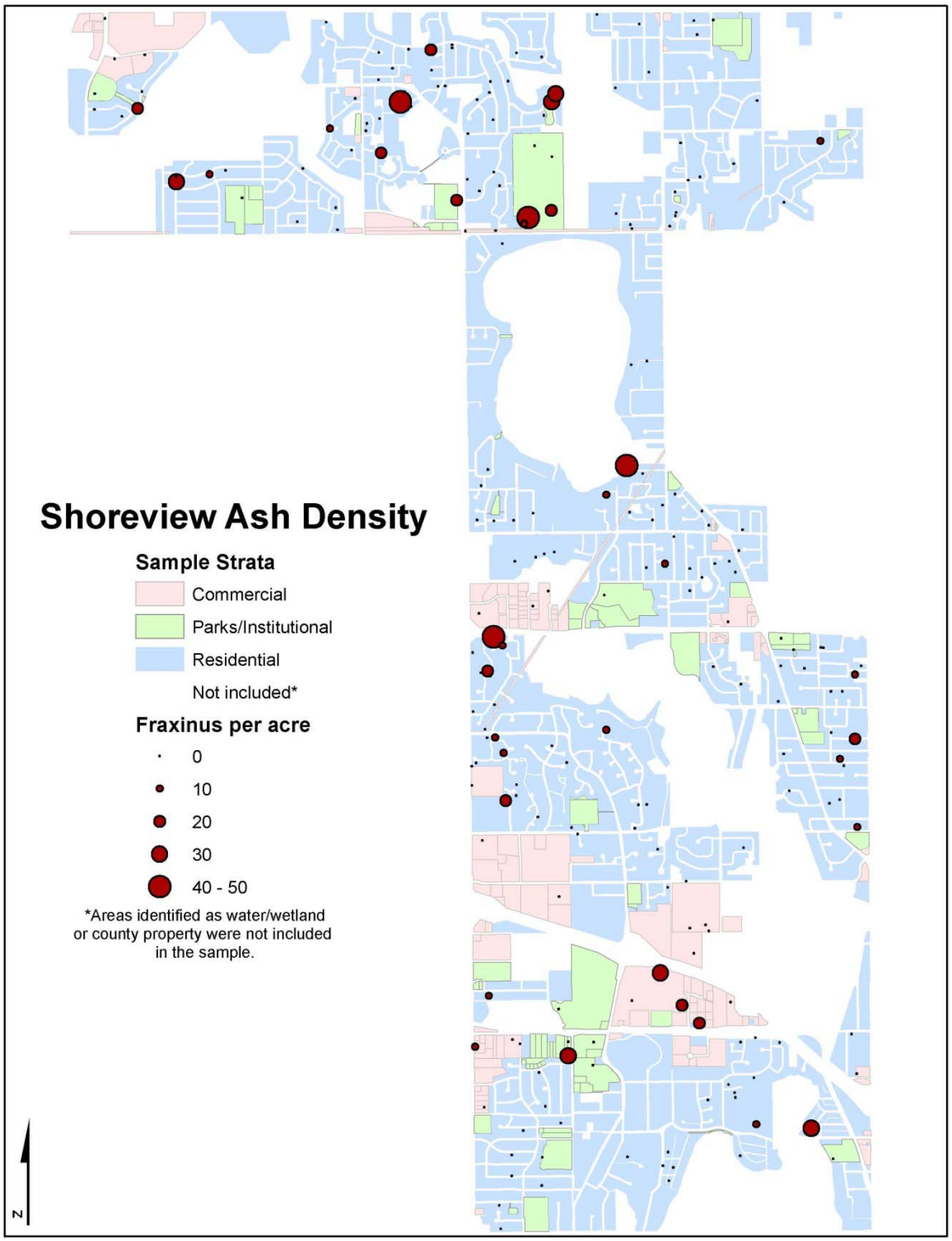
APPENDIX A:

Map of Shoreview forest assessment strata and sample locations.



APPENDIX B:

***Fraxinus* density per acre for sample locations in all strata. No clear spatial trend in *Fraxinus* concentration is apparent within the city of Shoreview.**



APPENDIX C:

Percent genera by strata.

	COM	PR	RES	ROW	Total Shoreview
Abies	0.0%	2.0%	0.5%	0.0%	0.53%
Acer	19.2%	10.2%	19.9%	39.3%	20.30%
Alnus	0.0%	0.0%	0.0%	1.2%	0.04%
Betula	0.0%	4.1%	5.7%	3.6%	5.50%
Catalpa	0.0%	0.0%	0.4%	0.0%	0.42%
Celtis	1.9%	0.0%	0.0%	0.0%	0.04%
Elaeagnus	1.9%	0.0%	0.0%	0.0%	0.08%
Fraxinus	15.4%	16.3%	9.1%	11.9%	9.49%
Ginkgo	0.0%	0.0%	0.0%	0.0%	0.04%
Gleditsia	0.0%	0.0%	1.0%	3.6%	1.06%
Juglans	0.0%	8.2%	0.2%	0.0%	0.34%
Juniperus	0.0%	0.0%	1.4%	0.0%	1.29%
Malus	0.0%	0.0%	5.5%	0.0%	5.09%
Morus	0.0%	0.0%	1.6%	0.0%	1.44%
Picea	7.7%	0.0%	12.6%	9.5%	12.14%
Pinus	1.9%	26.5%	6.6%	2.4%	6.76%
Populus	34.6%	24.5%	4.2%	3.6%	5.12%
Prunus	0.0%	2.0%	4.5%	1.2%	4.25%
Pseudotsuga	0.0%	0.0%	0.0%	2.4%	0.11%
Pyrus	0.0%	0.0%	0.0%	2.4%	0.08%
Quercus	3.8%	0.0%	8.4%	10.7%	8.20%
Rhamnus	0.0%	0.0%	0.4%	0.0%	0.42%
Robinia	0.0%	0.0%	1.9%	1.2%	1.78%
Salix	9.6%	0.0%	2.4%	3.6%	2.50%
Sorbus	0.0%	0.0%	0.5%	0.0%	0.46%
Syringa	0.0%	0.0%	0.7%	0.0%	0.68%
Thuja	0.0%	0.0%	5.1%	0.0%	4.78%
Tilia	0.0%	0.0%	2.5%	0.0%	2.31%
Ulmus	3.8%	6.1%	4.7%	2.4%	4.59%
Unknown	0.0%	0.0%	0.1%	1.2%	0.15%
Total Sampled	**52**	**49**	**2450**	**84**	**2635**
Shoreview Total (estimated)	**11648**	**12250**	**169050**	**18900**	**211848**

APPENDIX D:

Recommended tree species list by site condition.

Common Name	Scientific name	Max. height	Sun tolerance	Soil condition	Type	Native	Notes
Amelanchier	*Amelanchier spp.*	6-60'	Sun to part shade	Silt, well-watered sand D		Yes	Also called serviceberry, saskatoon, and juneberry. Shrubs to small trees. Many cultivars available.
American basswood	*Tilia americana*	120'	Sun to shade	Moist, pH >7 D		Yes	Also called American Linden. Fast growth, good shade tree.
American elm	*Ulmus americana*	100'	Full sun to part sun	Swampy to well-drained D		Yes	Many Dutch Elm Disease resistant cultivars available
Arborvitae	*Thuja occidentalis*	80'	Full to part sun	Wet soils, swamps C		Yes	Can be long-lived. Also called white cedar. Many cultivars available.
Austrian Pine	*Pinus nigra*	100'	Full sun	Sand, silt	C	No	Watch for Diplodia Tip Blight
Balsam fir	*Abies balsamea*	60'	Shade tolerant	Wet soils, swamps C		Yes	Tolerates cool climates. Vulnerable to tipping from strong winds, best in protected site.
Bicolor oak	*Quercus bicolor*	70'	Full sun, part shade	Swampy to well-drained, not alkaline D		Yes	Also called Swamp White Oak. Long-lived, good shade tree.
Black Locust	*Robinia pseudoacacia*	100'	Full sun	Not swamp	D	Yes	**May be invasive in wild.** Drought and pollution tolerant, fixes nitrogen, showy white flowers, may have thorns.
Black spruce	*Picea mariana*	50'	Full sun to part sun	Swampy or wet soils	C	Yes	Small, slow-growing tree. Common in marshes and peat bogs, tolerates nutrient-poor soils.
Black willow	*Salix nigra*	90' Ful	l sun	Wet soils, sandy soils by stream	D	Yes	Upright growing habit (not droopy like weeping willow). Good at preventing streambank erosion.
Bladdernut	*Staphylia trifolia*	25'	Sun to heavy shade	Rich, moist	D	Yes	Grows along stream banks. White flowers in April leading to air-filled seed pods which give the plant its common name.
Bur oak	*Quercus macrocarpa*	100'	Full sun to part shade	All	D	Yes	Prefers open, sunny areas. Very slow growth and long-lived. Tolerates urban conditions very well.
Catalpa, northern	*Catalpa speciosa*	60'	Full sun to part shade	Many, moist, well-drained D		Yes	Tolerates a wide range of tough conditions (heat, drought). Showy spring flowers.
Chokecherry	*Prunus virginiana*	15'	Full sun to part shade	Tolerates alkaline	D	Yes	Some cultivars have edible fruit but commonly bitter.

Common name	**Scientific name**	**Max. Height**	**Sun tolerance**	**Soil condition**	**Type**	**Native**	**Notes**
Cottonwood	*Populus deltoides*	120' Ful	l sun	Sand, silt, wet	D	Yes	Naturally found in floodplains. Grows fast. Plant males to avoid “cotton” from seeds.
Crabapples	*Malus spp.*	25' Ful	l sun	Cultivar dependent; moist, well-drained	D	Yes	Choose disease-resistant cultivars, avoid planting near junipers to prevent cedar apple rust
Eastern hemlock	*Tsuga canadensis*	100' Sha	de	Moist	D	Yes	Long-lived. Watch for pests: hemlock woolly adelgid especially. Many cultivars available.
Eastern redbud	*Cercis canadensis*	30' Partial	sun	Well-drained, high organic matter D		Yes	Showy flowers, popular ornamental tree.
Ginkgo	*Ginkgo biloba*	100'	Full to part sun	Well-drained, well-watered D		No	Long-lived. Plant males to avoid smelly "fruit" in autumn. Very tolerant of pollution and disease resistant.
Gray birch	*Betula populifolia*	30'	Sun to part shade	Does well in poor, dry	D	Yes	Relatively short-lived. Highly resistant to Bronze Birch Borer.
Green alder	*Alnus viridis*	35' Ful	l sun	Wet; tolerates dry, poor	D	Yes	Small and shrubby, fast-growing. Fixes nitrogen into the soil.
Hackberry	*Celtis occidentalis*	60'	Full sun to part shade	Prefers rich, moist, alkaline	D	Yes	Also called Common Hackberry. Fast growth. Tolerates urban conditions (compaction, heat, pollution) well.
Hawthorn	*Crataegus spp.*	45'	Full sun to part shade	Many including alkaline D		No	Select a thornless cultivar for home use; thorny varieties can be pruned into effective barrier hedges. Showy white spring flowers. Avoid planting near Junipers to prevent cedar apple rust
Honey locust	*Gleditsia tricanthos*	100'	Full sun to part shade	Many, not swamp D		Yes	Tolerates almost anything--drought, pollution, heat, compacted soil, alkaline soil. Many ornamental cultivars available. Can be thornless.
Ironwood	*Carpinus caroliniana*	45' S	hade	Deep, moist	D	Yes	Also called musclewood and blue-beech.
Japanese tree lilac	*Syringa reticulata*	35' Ful	l sun	Moist, well-drained, tolerates alkaline	D	No	Ornamental small tree or shrub, otherwise resembles lilac (*Syringa vulgaris*) with white blossoms
London planetree	*Platanus x hispanica*	100'	Full sun to part shade	Wet to moist	D	No	Good city tree--tolerant of compaction and pollution. Can be "messy" with leaves and fruit. Several cultivars available.

Common name	**Scientific name**	**Max. Height**	**Sun tolerance**	**Soil Condition**	**Type**	**Native**	**Notes**
Ohio buckeye	*Aesculus glabra*	80'	Full sun to part shade	Moist, well-drained, tolerates alkaline D		Yes	Common ornamental, can be "messy" with large leaves and nuts (buckeyes). Withstands severe winters well.
Pagoda dogwood	*Cornus alternifolia*	25'	Full sun to part shade	Moist, well-drained D		Yes	Lots of visual interest: flowers, fruit, foliage, and bark.
Pagoda tree	*Styphnolobium japonicum*	65' Ful	l sun	Well-drained, tolerates poor	D	No	Tolerates city conditions (heat, drought, compatction). Ornamental.
Peachleaf willow	*Salix amygdaloides*	60'	Full sun	Moist to wet	D	Yes	Grows quickly, short-lived. Naturally found in prairies with cottonwoods by streams.
Pin oak	*Quercus palustris*	70' Ful	l sun	Wide range, pH <7	D	Yes	Fast growth, good shade tree. Attracts wildlife.
Pitch Pine	*Pinus rigida*	60' Ful	l sun	Tolerates poor soils, dry or wet	C	Yes	Smaller pine. Resprouts after damage; naturally found in fire-dependent ecosystems
Red Cedar	*Juniperus virginiana*	75' Ful	l sun	Wide range, does well in poor C		Yes	Also called Eastern Red Cedar and Eastern Juniper. Avoid planting near *Malus spp*. and whitethorn to prevent cedar apple rust.
Red Pine	*Pinus resinosa*	90' Ful	l sun	Well-drained, well in sand	C	Yes	Good windbreak tree. Attractive, upright growth habit.
River birch	*Betula nigra*	80' Ful	l sun	Wet to dry, prefers moist	D	Yes	Also called Copper Birch due to coppery, curling bark. Fast grower, short-lived. Some cultivars available.
Russian olive	*Elaeagnus angustifolia*	30'	Full sun to part shade	wide range	D	Yes	Small, scrubby tree with silvery foliage. Fixes nitrogen, does well in poor soils. **Can be invasive, outcompeting native species in wild areas.**
Scots pine	*Pinus sylvestris*	75' Ful	l sun	Best in well-drained, acid; tolerates poor	E	No	Native to Europe. Sometimes found as a Christmas tree. Drought tolerant.
Serviceberry	*Amelanchier alnifolia*	25'	Full sun to part shade	Well-drained	C	Yes	Also called Juneberry and Saskatoon Berry. Edible fruit (good for pies and jam), can be ornamental shrub or small tree.
Shagbark hickory	*Carya ovata*	90'	Full sun to part shade	Moist, well-drained D		Yes	Shaggy bark when mature, tasty edible nuts. Slow growing tree. Will tolerate shade while young, but prefers sun mostly.
Speckled alder	*Alnus incana*	30'	Full sun to part shade	Well in poor	D	Yes	Shrub to small tree. Fixes nitrogen into soil. Good for erosion control.

Common name	Scientific name	Max. Height	Sun tolerance	Soil condition	Type	Native	Notes
Sycamore	*Plantanus occidentalis*	130' Ful	l sun	Moist soils, well in drier soils D		Yes	Tolerates city conditions well, good shade tree. Flaking bark provides interest. Can be susceptible to Plane Anthracnose Disease.
Tamarack	*Larix laricina*	60' Ful	l sun	Wide range	D	Yes	Also called Larch. **Appears evergreen—will lose leaves in autumn.**
Weeping willow	*Salix alba*	80' Ful	l sun	Moist, tolerates alkaline soils D		Yes	Also called golden weeping willow. Often loses leafs during drought and can 'shed' branches frequently. Short-lived.
White Oak	*Quercus alba*	70' Ful	l sun	Moist, better in rich	D	Yes	Good shade tree, large crown and spreading branches. Long-lived, doesn't do well in harsh city conditions.
White Pine	*Pinus strobus*	120'	Sun to part shade	Moist, well-drained C		Yes	Very large tree in old age, dominates forest canopy.
White poplar	*Populus alba*	70'	Full sun to part shade	Moist	D	Yes	Can be used in windbreaks. Ornamental bark and leaves.
White Spruce	*Picea glauca*	100'	Part sun to full shade	Moist, pH <7 C		Yes	Several dwarf cultivars available
Witch hazel	*Hamamelis spp.*	25'	Full sun to part shade	Moist, rich	D	Yes	Two species native to North America. Many ornamental cultivars available.
Yellow birch	*Betula alleghaniensis*	60' Ful	l sun	Well-drained, moist	D	Yes	Slow growth and long-lived. Needs sun, space, and adequate nutrients to do well. Attractive yellow-bronze bark.

Type: D=deciduous, C=conifer

Sources

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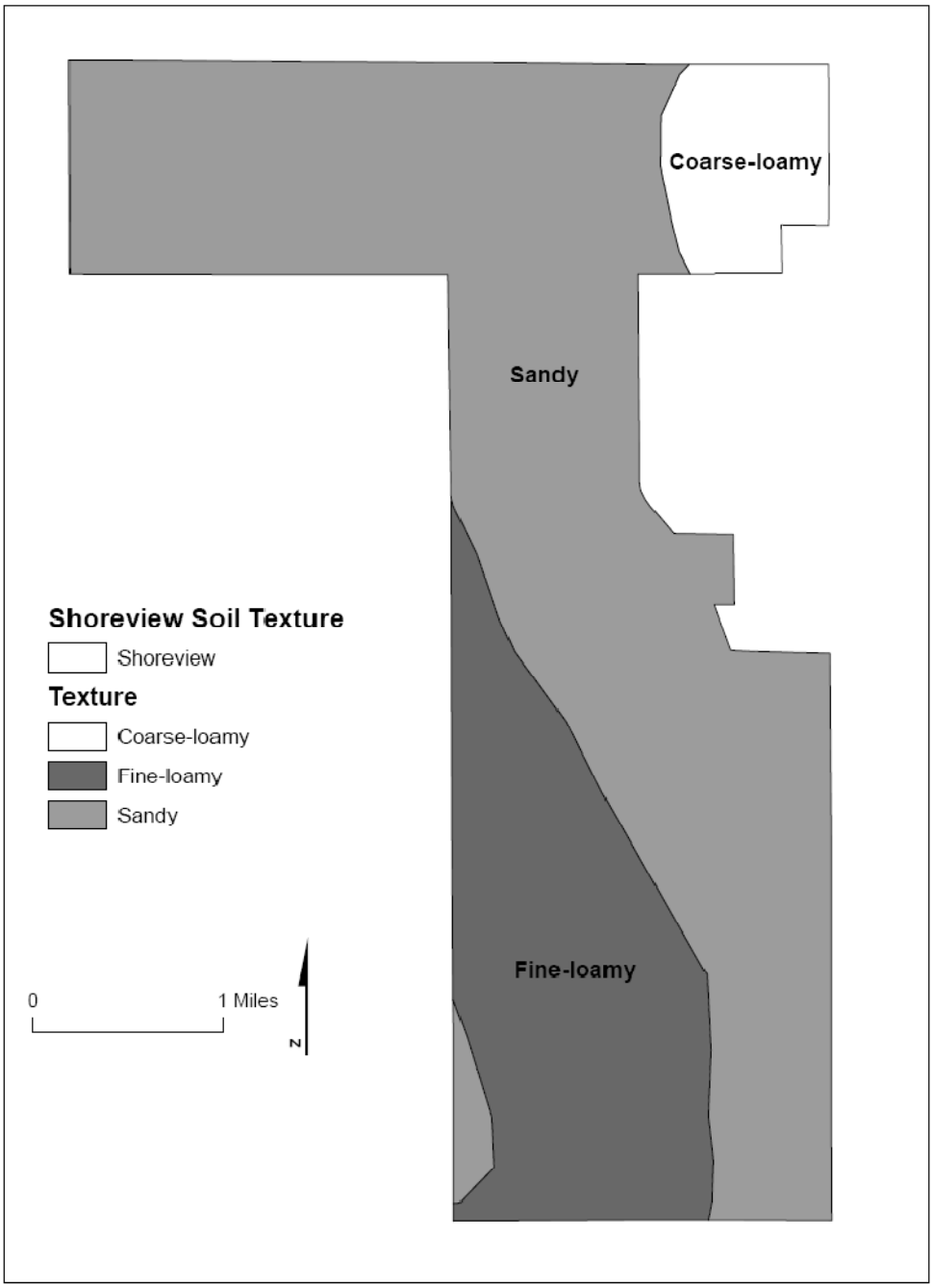
Dana, Michael N., Lerner, Rosie B. *Landscape plants for sandy soils.* Purdue University Department of Horitculture. 2006
http://orb.at.ufl.edu/TREES/index.html
The Gymnosperm database.
http://www.conifers.org/index.html

APPENDIX E:

Shoreview Soil Textures



APPENDIX F:

EAB cost calculator input data.

Tree Size Class Distribution	
Size Span (inches)	Number of Trees
3 - 6	2610
6 - 9	4860
9 - 12	3690
12 - 15	3510
15 - 18	3150
18 - 21	1800
21 - 24	1620
24 - 27	630
27 - 32	810
32 -	0

Treatment and Removal Costs

Treatment Cost:

DBH	Cost / DBH
3 - 6	$36
6 - 9	$72
9 - 12	$108
12 - 15	$144
15 - 18	$180
18 - 21	$216
21 - 24	$252
24 - 27	$288
27 - 32	$324
32 -	$384

Treat Every: 2 year(s)

Replacement Cost: $150 /tree

Removal Cost:

DBH	Cost / DBH
0 - 10	$11.15
10 - 24	$17.75
24 - 40	$25.00
40 -	$33.00

Years to Remove: 5

Discount Rate: 0%

Ash Mortality Rate: 0%

Replacement Mortality Rate: 0%

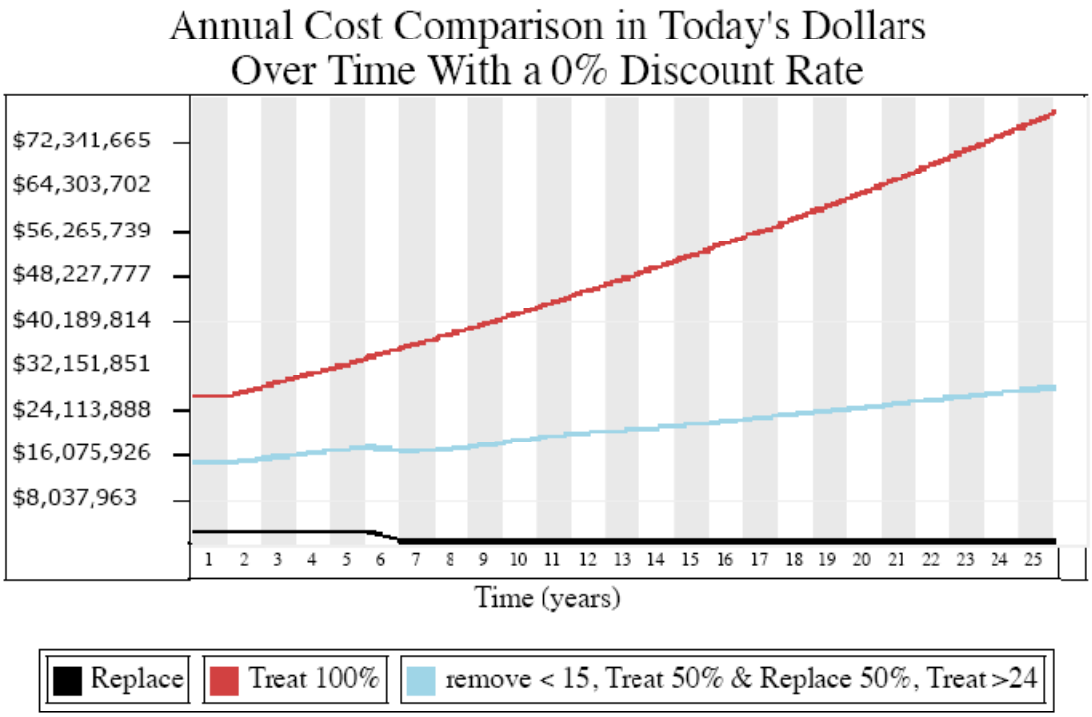
APPENDIX G

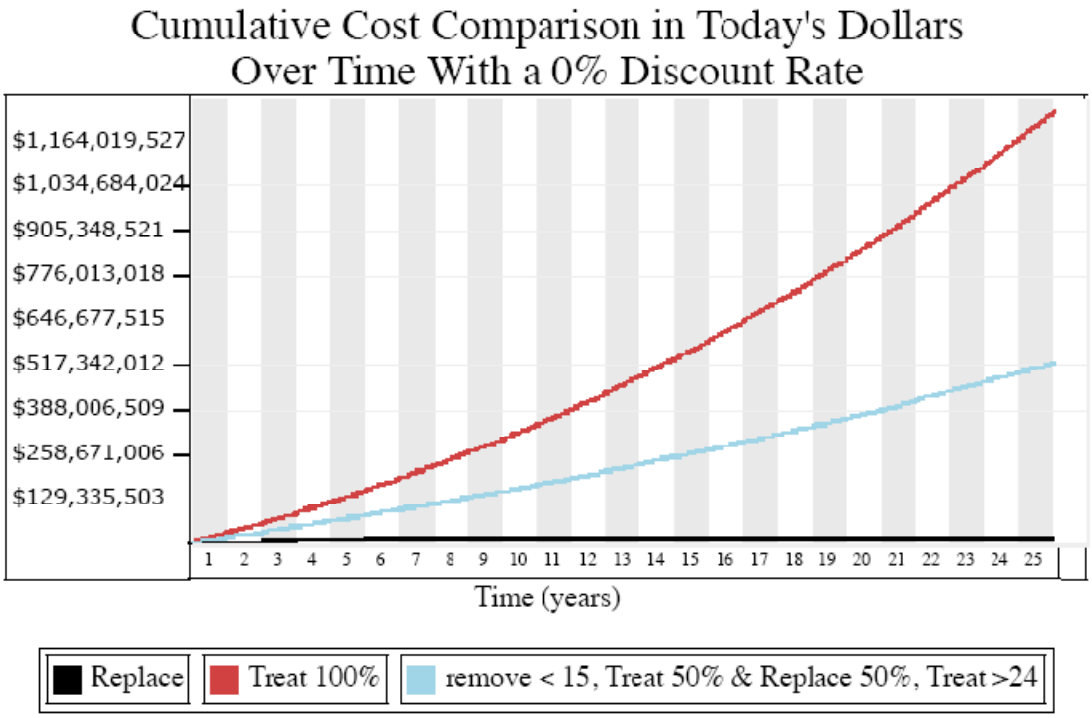
EAB management plan scenarios.

Management Plans		
Plan	**Description**	**Why Important**
Replace	All ash trees will be removed and replaced with non-Ash trees.	After the EAB comes to your city you will have to remove the ash trees in order to prevent dead trees from falling on people or property and causing harm. This plan has the lowest out of pocket expense. This option replaces every ash tree with a new tree that won't get emerald ash borer. No pesticides are applied. In time the ash forest will be replaced with a different forest. This plan is the least costly way to manage your forest and allow it to regain its former size. Use the graph of forest size (Total DBH over Time) to determine how long it will take the forest to get back to its original size.
Treat 100%	All ash trees will be Treated	This plan has the lowest annual out of pocket cost, but the greatest costs over time. It also produces the largest remaining forest over time. Research demonstrates that insecticides can protect small trees (<12" DBH) until they reach a 15" DBH. Effective protection of larger trees is going to require either a more frequent application or a higher dose of insecticide. Current labels for insecticides do not allow for higher rates at this time.
remove < 15, Treat 50% & Replace 50%, Treat >24	All large trees (DBH>24") will be treated. Small trees that are inexpensive to remove (DBH< 15")will be removed and replace. Remaining trees (between 15 and 24" DBH) will either be treated with insecticides every 2 years or removed and replaces.	This plan charts the costs of implementing a variety of management strategies. Removal and replacement of small trees allows the most time for regrowth of replacement trees during the time when larger trees will be removed. Since large trees add property value, these will be treated with an insecticide every 2 years. Intermediate sized trees will either be replaced or treated depending on the health of the tree. Overall, this strategy allows for a gradual management of the Ash population.

APPENDIX H:

EAB scenario cost projections.





APPENDIX I:

Cost table for Emerald Ash Borer mitigation scenarios.

	Replace		Treat 100%		remove < 15, Treat 50% & Replace 50%, Treat >24	
Year	Cost This Year	Total Cost	Cost This Year	Total Cost	Cost This Year	Total Cost
1	$1,826,311	$1,826,311	$26,280,045	$26,280,045	$14,196,575	$14,196,575
2	$1,826,311	$3,652,622	$27,928,825	$54,208,870	$14,945,879	$29,142,454
3	$1,826,311	$5,478,933	$29,598,487	$83,807,357	$15,700,542	$44,842,995
4	$1,826,311	$7,305,243	$31,294,970	$115,102,327	$16,461,644	$61,304,639
5	$1,826,311	$9,131,554	$33,016,175	$148,118,501	$16,969,874	$78,274,513
6	$0	$9,131,554	$34,769,002	$182,887,503	$16,157,672	$94,432,185
7	$0	$9,131,554	$36,551,891	$219,439,395	$16,568,781	$111,000,966
8	$0	$9,131,554	$38,414,179	$257,853,574	$17,134,855	$128,135,820
9	$0	$9,131,554	$40,376,402	$298,229,976	$17,924,881	$146,060,701
10	$0	$9,131,554	$42,369,195	$340,599,170	$18,726,715	$164,787,416
11	$0	$9,131,554	$44,388,567	$384,987,737	$19,489,059	$184,276,474
12	$0	$9,131,554	$46,438,028	$431,425,765	$19,886,767	$204,163,242
13	$0	$9,131,554	$48,532,611	$479,958,376	$20,304,835	$224,468,077
14	$0	$9,131,554	$50,654,342	$530,612,718	$20,724,207	$245,192,283
15	$0	$9,131,554	$52,836,018	$583,448,735	$21,424,779	$266,617,062
16	$0	$9,131,554	$55,051,770	$638,500,506	$22,193,454	$288,810,516
17	$0	$9,131,554	$57,291,848	$695,792,354	$22,969,852	$311,780,369
18	$0	$9,131,554	$59,561,111	$755,353,465	$23,576,552	$335,356,921
19	$0	$9,131,554	$61,915,658	$817,269,123	$24,085,294	$359,442,215
20	$0	$9,131,554	$64,380,802	$881,649,926	$24,678,642	$384,120,856
21	$0	$9,131,554	$66,875,773	$948,525,698	$25,326,473	$409,447,329
22	$0	$9,131,554	$69,406,887	$1,017,932,585	$26,133,816	$435,581,145
23	$0	$9,131,554	$71,972,070	$1,089,904,655	$26,739,939	$462,321,084
24	$0	$9,131,554	$74,551,732	$1,164,456,387	$27,347,544	$489,668,629
25	$0	$9,131,554	$77,164,442	$1,241,620,829	$27,743,536	$517,412,165

APPENDIX J:

List of species found in survey, tree counts are estimates of total within the Shoreview sample area.

Family		Genus		Species		
latin	Trees	Genus	Trees	latin	common name	Trees
Aceraceae	48135	Acer	48135	Acer ginnala	amur maple	5589
				Acer negundo	boxelder	11267
				Acer nigrum	black maple	90
				Acer platanoides	Norway maple	3606
				Acer rubrum	red maple	3786
				Acer saccharinum	silver maple	19470
				Acer saccharum	sugar maple	3966
				Acer spp.	Acer spp.	361
Betulaceae	13160	Alnus	90	Alnus spp.	Alnus spp.	90
		Betula	13070	Betula alleghaniensis	yellow birch	1082
				Betula nigra	river birch	4056
				Betula papyrifera	paper birch	6039
				Betula pendula	European white birch	1893
Bignoniaceae	901	Catalpa	901	Catalpa speciosa	northern catalpa	901
Cupressaceae	14422	Juniperus	3065	Juniperus virginiana	eastern redcedar	3065
		Thuja	11358	Thuja occidentalis	northern white-cedar	11358
Elaeagnaceae	180	Elaeagnus	180	Elaeagnus angustifolia	Russian olive	180
Fabaceae	6760	Gleditsia	2524	Gleditsia triacanthos	honey-locust	2524
		Robinia	4237	Robinia pseudoacacia	black locust	4237
Fagaceae	19470	Quercus	19470	Quercus alba	white oak	4868
				Quercus ellipsoidalis	northern pin oak	3786
				Quercus macrocarpa	bur oak	3245
				Quercus prinus	chestnut oak	270
				Quercus rubra	northern red oak	5949
				Quercus spp.	oak	270
				Quercus velutina	black oak	1082
Ginkgoaceae	90	Ginkgo	90	Ginkgo biloba	ginkgo	90
Juglandaceae	811	Juglans	811	Juglans cinerea	butternut	180
				Juglans nigra	black walnut	541
				Juglans spp.	walnut	90
Moraceae	3425	Morus	3425	Morus nigra	black mulberry	1532
				Morus spp.	mulberry	1893
Oleaceae	24157	Fraxinus	22535	Fraxinus americana	white ash	811
				Fraxinus nigra	black ash	721
				Fraxinus pennsylvanica	green ash	20912
				Fraxinus spp.	ash spp.	90
		Syringa	1623	Syringa reticulata	Japanese tree lilac	1623
Pinaceae	46602	Abies	1262	Abies balsamea	balsam fir	1262
		Picea	28845	Picea abies	Norway spruce	5048
				Picea glauca	white spruce	9555
				Picea mariana	black spruce	3966
				Picea pungens	Colorado spruce	9465
				Picea spp.	spruce	811
		Pinus	16225	Pinus banksiana	jack pine	180
				Pinus nigra	Austrian pine	90
				Pinus ponderosa	ponderosa pine	2794
				Pinus resinosa	red pine	6310
				Pinus strobus	white pine	3966
				Pinus sylvestris	Scots pine	2884
		Pseudotsuga	270	Pseudotsuga menziesii	douglas-fir	270
Rhamnaceae	992	Rhamnus	992	Rhamnus cathartica	European buckthorn	992
Rosaceae	23436	Malus	12079	Malus spp.	crabapple	12079
		Prunus	10096	Prunus americana	American plum	631
				Prunus pennsylvanica	pin cherry	1352
				Prunus serotina	black cherry	3065
				Prunus spp.	Prunus spp.	4777
				Prunus virginiana	choke cherry	270
		Pyrus	180	Pyrus spp.	pear	180
		Sorbus	1082	Sorbus americana	American mountain-ash	451
				Sorbus aucuparia	European mountain-ash	631
Salicaceae	18118	Populus	12169	Populus deltoides	eastern cottonwood	8744
				Populus nigra	lombardy poplar	361
				Populus spp.	aspen	90
				Populus tremuloides	quaking aspen	2975
		Salix	5949	Salis spp.	willow	541
				Salix babylonica	weeping willow	270
				Salix nigra	black willow	5138
Tiliaceae	5408	Tilia	5408	Tilia americana	American basswood	901
				Tilia cordata	little-leaf linden	1893
				Tilia spp.	basswood spp.	2614
Ulmaceae	11177	Celtis	180	Celtis occidentalis	hackberry	180
		Ulmus	10997	Ulmus americana	American elm	2344
				Ulmus pumila	Siberian elm	5859
				Ulmus rubra	slippery elm	1803
				Ulmus thomasii	rock elm	992