City of North Saint Paul: Emerald Ash Borer Management Plan

Photo Courtesy of Jeff Carroll, University of Minnesota

CITY OF NORTH ST. PAUL

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Development of the North Saint Paul Emerald Ash Borer Management Plan was accomplished in consultation with the city of North Saint Paul, Minnesota.

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University of Minnesota, Department of Forest Resources- FRNM 4501 Undergraduate Students
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The University of Minnesota Department of Forest Resources' capstone course in urban forestry cooperated with North Saint Paul's Park and Recreation Department to address emerald ash borer (EAB) management options for publicly owned ash trees. There is no singular solution to the challenge of an EAB infestation, and any actions will require a certain commitment of resources**.** However, there are effective preventative measures that can be taken to protect the ash trees that have proven of value to the community and responsibly manage the removal of trees that don't warrant protection. The ash trees in North Saint Paul save the city ~$200,000 annually in energy savings, storm water treatment reduction, and by decreasing electricity use.

Once established, EAB poses a significant threat to the ash tree population of a region due to its ability to spread rapidly in a short period of time. Thirty-two percent (32%) of the public trees are ash in North Saint Paul and soon these trees will succumb to EAB. Large ash trees begin to die within 3-4 years of initial infestation, while saplings and small trees may die within a single year. Once these trees die they fall apart easily and will need to be removed as quickly as possible in order to eliminate the threat to human health and safety.

The purpose of this management plan is to address the economic, safety, aesthetic, and environmental impacts of emerald ash borer on North Saint Paul's urban forest. The plan will serve to highlight:

- Current information regarding public tree species composition of North Saint Paul
- Benefits of the North Saint Paul's trees
- Three emerald ash borer management strategies
- How North Saint Paul can mitigate future threats to the city's tree population

Three Practical Management Options for North Saint Paul:

1. Wait for ash trees to be killed by EAB, and then remove ash trees as they become unsafe and replant with a different tree species that isn't susceptible to EAB.

2. Remove all ash over a 10-year span and replant with a tree species that isn't susceptible to EAB.

3. Remove small trees and replant with a tree species that isn't susceptible to EAB. Chemically treat valuable large trees with an insecticide that will serve as a prophylactic (preventive) as well as a treatment for EAB infestation in these trees.

Part of the success of any management option is the involvement of the community. This management plan includes four strategies for engaging citizens in the process. These strategies include:

- Ash tree tagging events
- Gravel bed nursery
- Mailings
- Community meetings

1. Introduction - North Saint Paul Emerald Ash Borer Management Plan

1.1. Purpose

The purpose of this management plan is to address the economic, safety, aesthetic, and environmental impacts of emerald ash borer on North Saint Paul's urban forest. This proposal outlines three strategies that can be implemented to fit the needs and resources of the City of North Saint Paul. The plan will serve to highlight:

- Three emerald ash borer management strategies
- How North Saint Paul can mitigate future threats to the city's tree population
- Current information regarding public tree species composition North Saint Paul
- Benefits of the North Saint Paul's trees

1.2. Background

The city of North Saint Paul, Minnesota, is a first ring suburb located 5 miles northwest of Saint Paul (refer to Figure 1.2.1.). The city encompasses 3.1 square miles including a main street that is six blocks long. The city prides itself on a small town feel while remaining connected within a much larger metropolitan area of Minnesota. The recently expanded Minnesota State Highway 36 bisects North Saint Paul. North Saint Paul contains over 4,000 public trees, and of those trees over 1,000 are ash trees that will be killed by Emerald Ash Borer if no preventative measures are taken.

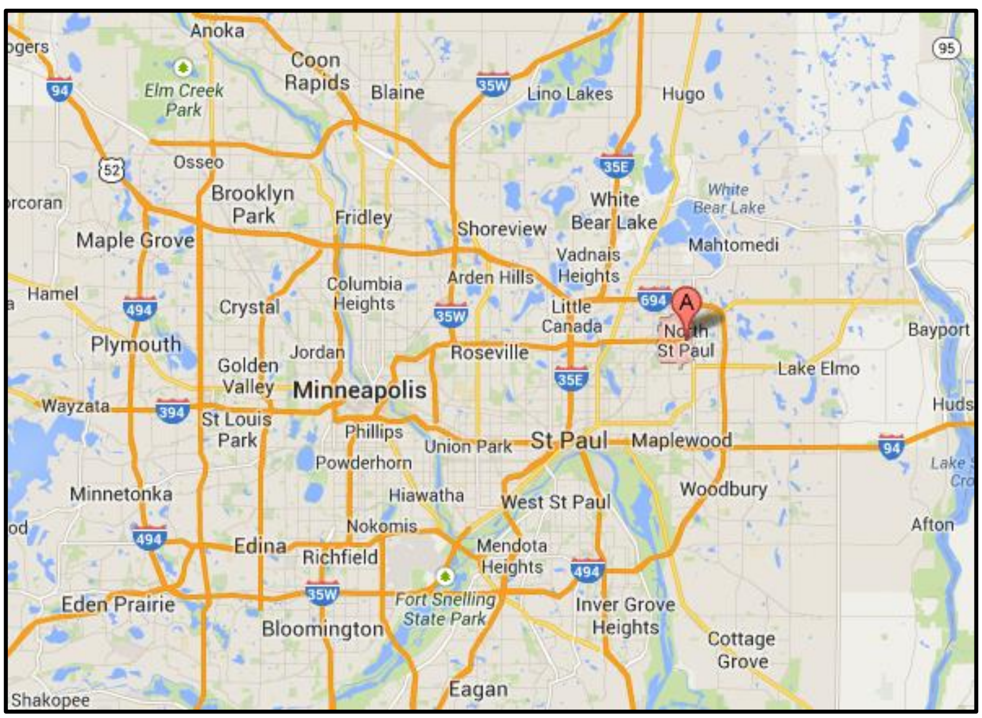

Figure 1.2. 1: City of North Saint Paul, Minnesota; Image Courtesy of Google Maps.

What is emerald ash borer? Why should North Saint Paul be concerned?

Emerald Ash Borer (EAB) is a wood boring insect that has devastated native ash (*Fraxinus spp.*) tree populations since it was discovered in May of 2002 in the Detroit, Michigan area (Haack, 2002). In Ramsey County, the insect was first identified in metropolitan Minnesota in May of 2009 (Minnesota DNR, 2013) and has already caused problems for many communities surrounding North Saint Paul (See Appendix B: EAB Fact Sheet for more detailed information).

There is cause for alarm because there is no singular solution to this challenge, and any actions will require commitment of resources. However, there are effective preventative measures that can be taken to protect the ash trees that have proven value to the community and responsibly manage the removal of trees that don't warrant protection. These options will be further discussed in the recommendations section. Once established, EAB poses a significant threat to the tree population of a region due to EAB's ability to spread rapidly in a short period of time.

EAB overwinters underneath the bark of the ash tree. While there appears to be a common belief that EAB populations were reduced from cold winter temperatures in Minnesota, this is **not** true. EAB has an extreme tolerance to cold temperatures and will be emerging from underneath the bark as usual this spring (Venette, 2014). EAB travels fastest when transported by humans, which is the reason it is present in Minnesota in the first place. Often times people take firewood with them on long trips and do not realize that the insect may be present underneath the bark of the wood. If the wood is not burned the insects will emerge the following spring. This leads to further infestations of nearby ash trees and depending on tree health, **EAB may kill the entire community's ash tree population within 4-5 years after it has become established in an area if nothing is done to manage the insect (United States Department of Agriculture, 2013).**

If a confirmed EAB infestation is within 15 miles of a community, there is a good chance that the community will have an EAB infestation as well (Minnesota Department of Agriculture, December 2011). North Saint Paul is only about 5 miles away from an infestation site in Saint Paul (refer to Figure 1.2.2.), which means **EAB is already present within North Saint Paul.** There are additional confirmed infestations in Minneapolis, Roseville and many other areas within Ramsey and Hennepin Counties. Both counties are currently under ash quarantine, meaning that ash is not to be moved outside of the borders of the county line.

At the time of North Saint Paul's tree inventory in 2011 the city contained 4,285 public trees and of those trees, 1354 (32%) were ash (*Fraxinus spp.*), therefore **32% of the public trees are susceptible to EAB infestation.** The number of trees recorded in North Saint Paul reflects only trees on public land including parks and boulevards, but not trees on private land.

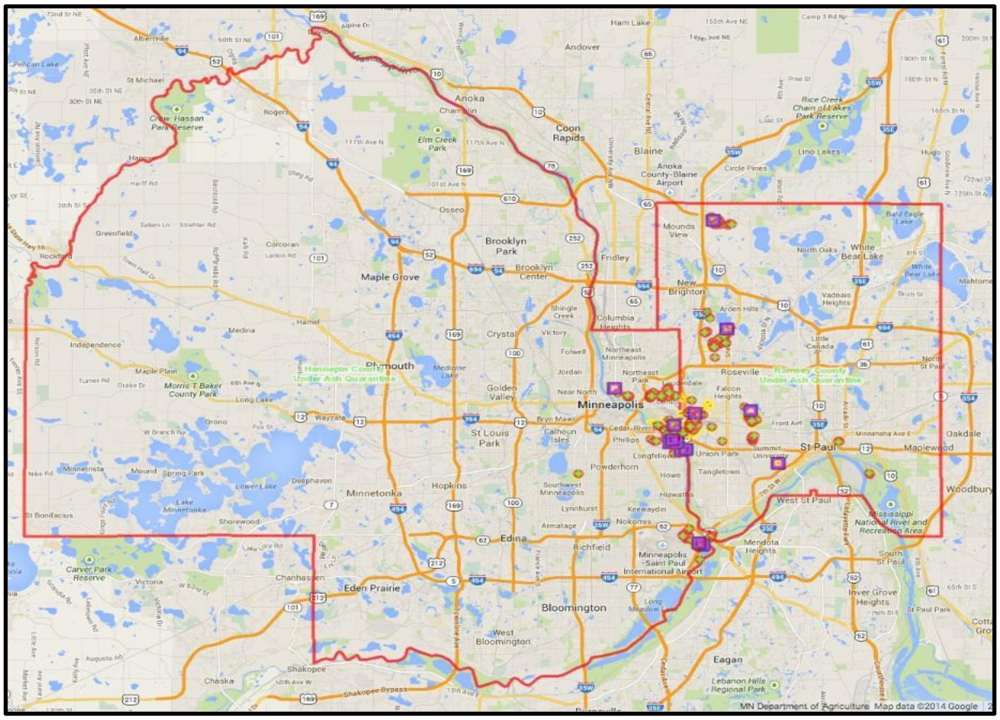

Figure 1.2. 2 Current EAB Infestation Status Map For Twin Cities Metro Area; Image Courtesy of Minnesota Department of Agriculture

Map Legend

	Biological Control Sites-Parasitic wasps used to control EAB populations
	Standing Infested Trees
	Removed Infested Trees
	Trap Finds
	Quarantine Boundaries- Surrounding Hennepin County (West) and Ramsey County (East)

1.3. Community Action

Many communities have already taken major actions designed to limit the economic burdens that result from EAB infestation. EAB infestations are extremely difficult to confirm during the first years of initial infestation, but due to the proximity of confirmed infestations nearby, it is likely that EAB is already present within the North Saint Paul City limits. Communities have begun educating their residents with information on how to identify EAB and why moving firewood rapidly spreads the insect. This is a good starting point, and if done well, can get the community residents involved and take notice to the problem.

Three management strategies have been adopted in Minnesota. In each option replanting is a critical consideration. Failure to replant results in loss of the benefits associated with healthy a urban forests. Stormwater management is a concern of North Saint Paul and may be negatively impacted if replanting is not considered (Living Streets, North Saint Paul).

Three Common Management Options[1] include:

1. Wait for ash trees to be killed by EAB, and then remove ash trees as they become unsafe and replant with a different tree species that isn't susceptible to EAB (e.g, Toledo, Ohio, refer to Figure 1.3.1.). *This option will be referred to as "Removal and Replace Ash Killed by EAB".*

2. Remove all ash over a 10-year span and replant with a tree species that isn't susceptible to EAB (e.g. Minneapolis, MN (City of Saint Paul, 2010). *This option will be referred to as "Remove All".*

3. Remove small trees and replant with a tree species that isn't susceptible to EAB. Chemically treat valuable large trees with an insecticide that will serve as a prophylactic (preventive) as well as a treatment for EAB infestation in these trees (City of Saint Paul, 2010). *This option will be referred to as "Remove and Replace DBH<24" and Treat Large Trees".*

    - This analysis uses TREE-äge™, (emamectin benzoate), a common EAB insecticide, for all cost estimates. Other EAB insecticides can be found under References (EAB Insecticides).

[1] Options were calculated using the Purdue EAB Cost Calculator, Purdue University

Figure 1.3. 1: EAB damage after 3 years in Toledo, Ohio; Photo courtesy of Benzie Voice

These three management strategies will allow North Saint Paul to evaluate how to deal with EAB effectively with respect to available resources. These issues will be further expanded on in this management plan.

1.4. Significance

Pest management, including EAB, is a significant issue for all citizens of North Saint Paul. Thirty-two percent (32%) of the public trees are ash and soon, these trees will succumb to EAB. Large ash trees begin to die within 3-4 years of initial infestation, while saplings and small trees may die within a single year (Poland, 2006). This would result in a loss of ecological, cultural, and economic values for the community (the calculated net value of the ash resource will be a point of discussion later in this report). There is no perfect solution to this problem. Committing to take action is the first critical step towards maintaining North Saint Paul's private and public ash population.

1.5. Benefits of Trees

Beyond providing shade and fall colors trees can benefit North Saint Paul immensely. Trees account for a majority of the ecological, economic, and cultural benefits surrounding the community. Healthy urban forests help make the community safer, more beautiful and a more prosperous place to live.

Ecological Benefits:

Trees serve to reduce stormwater runoff loads and increase infiltration of stormwater, which reduces loading on city infrastructure and facilitates purification of water resources (EPA, August, 2013). Rainfall interception results in more soil moisture retention and groundwater replenishment within a watershed. **By limiting the amount of runoff that occurs after a storm, trees serve to also reduce flooding and erosion and therefore pollution of public lands and ultimately our fresh water storage areas.**

Trees extract CO_2 from the atmosphere and use it to grow. This process is called carbon sequestration. Sequestration mitigates the effects of increasing levels of CO_2 in the atmosphere from fossil fuel burning. According to Davey Resource Group's National Tree Benefit Calculator, a mid sized sedan travels on average 12,000 miles a year, generating 11,000 lbs of CO_2. In North Saint Paul, ash trees sequester 1,228,455 lbs of CO_2 from the atmosphere annually, which helps mitigate pollution (see 3.3 Benefits of Public Ash Trees in North St. Paul).

Trees also serve to mitigate the increases in temperature caused by the urban heat island effect. Urban heat island effect describes urban areas that are highly developed and are warmer than surrounding rural areas. This is due to increased impervious surfaces and increased absorption of solar radiation caused by pavement and building surfaces (EPA, February, 2014). The urban heat island causes an increased demand for energy within urban areas which exacerbates pollution. Reducing pollution limits CO_2 in the atmosphere, helping improve overall air quality and in turn limiting the effect of global climate change.

Trees improve air quality by not only sequestering CO_2, but also by filtering pollutants such as ozone, nitrogen dioxide, sulfur dioxide, limiting the impact of health considerations such as asthma, respiratory problems, heart disease and cancer (Davey National Tree Benefit Calculator, 2014).

Economic Benefits:

Reduction of runoff from a rainfall event will limit the amount of energy that is put in to treat water for community use. Shade from trees has been shown to increase the longevity of infrastructure within a city such as sidewalks and streets. Tree lined streets increase the value of property as well as encourage shoppers to visit businesses. Trees benefit communities and serve homeowners by increasing the value of homes while decreasing the amount paid in energy bills every year (refer to Figure 1.5.1.). Trees around your house have been shown to increase the value of your property by up to 15% (Arbor Day Foundation n.d.).

Cultural Benefits:

Enhanced sense of community provides many cultural benefits which is drawn from a healthy urban forest. Many people ascribe personal significance to certain trees or landmarks that make North Saint Paul a special place. Urban forests can help speed recovery of injury and illness, make citizens feel safe and comfortable, provide a diverse landscape, and also offer many educational learning opportunities (International Society of Arboriculture n.d.). For these reasons, urban forests need to be managed as valuable assets that make communities like North Saint Paul a better place to live.

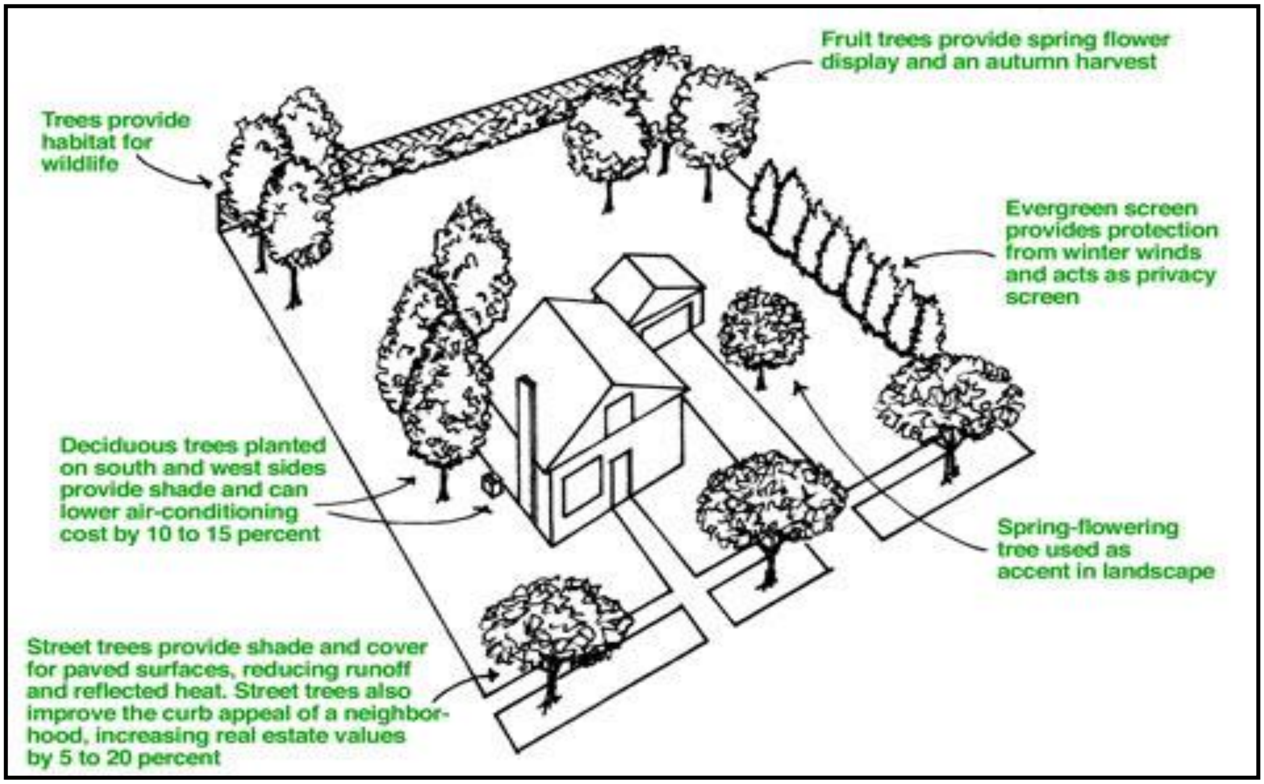

Figure 1.5. 1: General benefits of trees properly planted in an urban setting; Image courtesy of Trees Are Good

2. Process

On Monday, February 3, 2014, the University of Minnesota students in the FNRM 4501 - Urban Greenspaces Management class met with John Fure and Josh Bond at the City Hall Building[2] (refer to Figure 2.1.1.) to discuss the city's concerns with the inevitable emerald ash borer infestation of the city's ash trees. Concerns identified were as follows:

1. Urgent need for an EAB management in order to preserve the character of North Saint Paul's urban forest.
2. Lack of budget dollars to fund an EAB management plan.

[2] City Hall is located at 2400 Margaret Street N> in North Saint Paul, Minnesota 55109

3. Lack of personnel to create and implement an EAB management plan.
4. Lack of resources (equipment, tools, community information, etc.) to implement an EAB management plan.

Figure 2.1.1: North Saint Paul City Hall Building; Photo courtesy of Jeff Carroll, University of Minnesota

The City of North Saint Paul provided the students with tree inventory data that was collected through public tree inventory for the City of North Saint Paul, Minnesota. The tree inventory was conducted and completed by Josh Bond, Forestry Division Intern, from May 2011 to December 2011, as part of an internship for public works. The tree inventory was completed using Davey Resource Group's tree inventory system software called TreeKeeper™, which was purchased by North Saint Paul in 2011.

Josh Bond based the condition rating, meaning the health and structure of each tree, on visible root, trunk, branch, twig, and foliage conditions at the time of the inventory and adapted from the condition rating system established by the International Society of Arboriculture. The condition ratings are split into six categories with percentages; percentages are defined as the percentage that met or exceeded the criteria determined for each condition rating category. The condition ating categories are listed as: excellent (95%), very good (90%), good (75%), fair (50%), poor (25%), critical (10%), and dead (0%).

Tree inventory analysis results listed in *Chapter 3.1. Tree Inventory Analysis* was determined using 2010 - 2011 Microsoft Excel software.

The University of Minnesota students completed a site visit on Monday, February 3, 2014 and on Saturday, March 8, 2014 to visit the commercial and residential areas of North Saint Paul (refer to Figures 2.1.2. and 2.1.3.) in order to determine any significant differences between these two areas, as well as take photographs of these areas.

Figure 2.1 2: Typical commercial area in North Saint Paul, Minnesota; Photo courtesy of Jeff Carroll, University of Minnesota

Figure 2.1. 3: Typical residential area in North Saint Paul, Minnesota; Photo courtesy of Jeff Carroll, University of Minnesota

For cost estimations and comparisons (Purdue University Extension Entomology, 2008), Purdue's EAB Cost Calculator is a useful tool for generating estimates as a basis for comparing management techniques. Estimates used in the calculations were from two sources; defaults given by the program and general estimates of the Twin Cities/Metro from Rainbow Treecare. Measurements are based off of diameter at breast height (DBH) see figure 3.1.6 for more information.

The program can run up to 15 separate management plans, with each plan showing a maximum of 3 options for comparison. In the plan generated, we used 3 techniques; Remove and Replace Ash killed by EAB, Remove and Replace DBH<24" and Treat Large Trees, and Replace All.

These three methods were created based on comparisons of other city EAB management techniques.

To better understand the indirect benefits of the public ash trees, or those benefits that are difficult to quantify, the North St. Paul tree inventory data was analyzed using Davey Tree Company's National Tree Benefits Calculator (Davey Tree Expert Company, 2014). This calculator analyzes species, DBH, and location to give estimates of the benefit to the community. Students used this tool to analyze the real economic and environmental benefits of the publish ash trees in North St. Paul. This analysis is important to look at because these benefits can be lost, reduced, or maintained based on the management strategy chosen. If more total DBH is retained in the management strategy, more of these benefits will be preserved.

3. Results

3.1. Tree Inventory Analysis

Genetic Diversity of Public Trees in North Saint Paul, Minnesota

The city of North Saint Paul has approximately 4,285 public trees; public trees are defined as trees located in parks and along the boulevard of streets. Of those 4,285 public trees, 1,354 (32%) are ash trees, 967 (23%) are maples trees, 556 (13%) are pine/spruce trees, 420 (10%) are oak trees, 297 (7%) are basswood/linden trees, and the remaining 691 (16%) are other species of trees (refer to Figure 3.1.1.). For a complete breakdown of public tree population by family, genus, species, and common name refer to Appendix A.

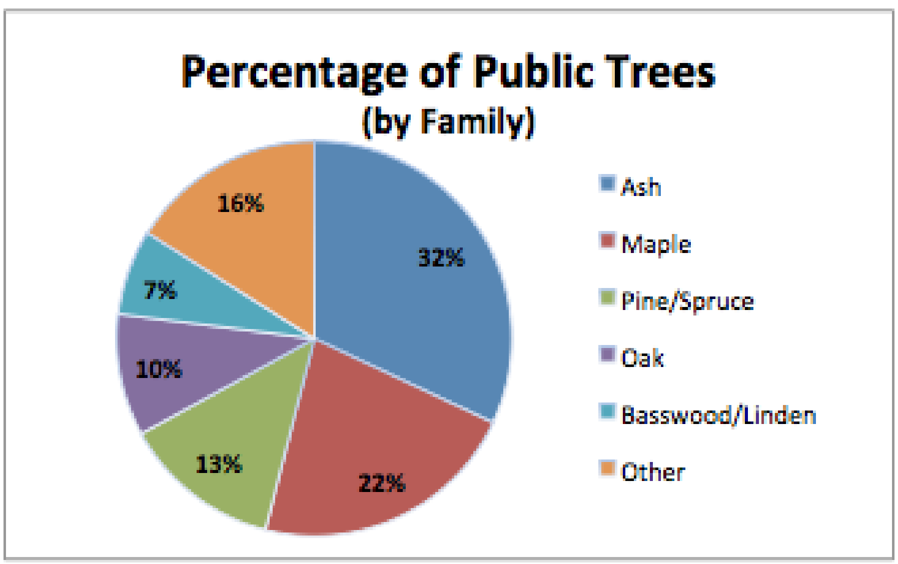

Figure 3.1.1: Percent of Public Trees

Park Ash Trees vs. Boulevard for Ash Trees

Of the 1,354 ash trees in public areas, 120 trees (9%) are located in city park areas and the remaining 1,234 trees (91%) are located in boulevard areas (refer to Figure 3.1.2.).

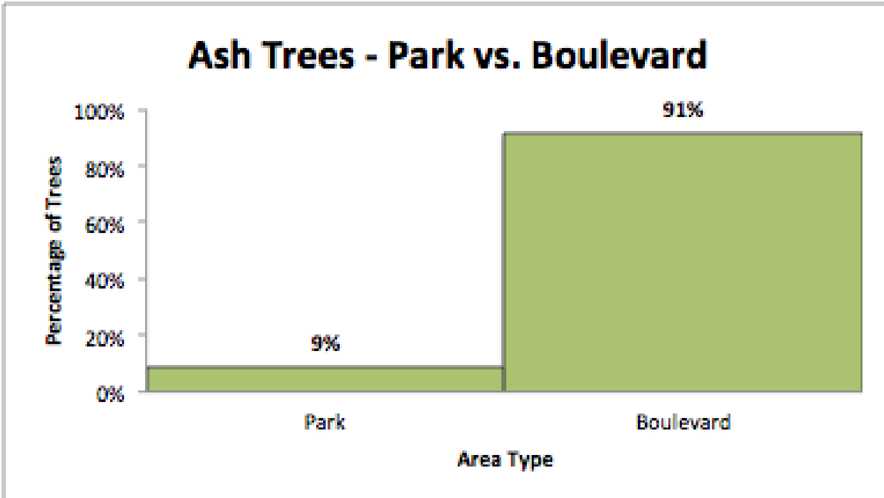

Figure 3.1.2: Percentage of Ash Trees in Park vs. Boulevard

North vs. South City Area for Ash Trees

Of the 1,354 ash trees in public areas, 882 trees (65%) are in the north area of the city and the remaining 472 trees (35%) are in the south area of the city (refer to Figure 3.1.3.). North and south areas of the city were defined as the city areas north and south of Minnesota State Highway 36.

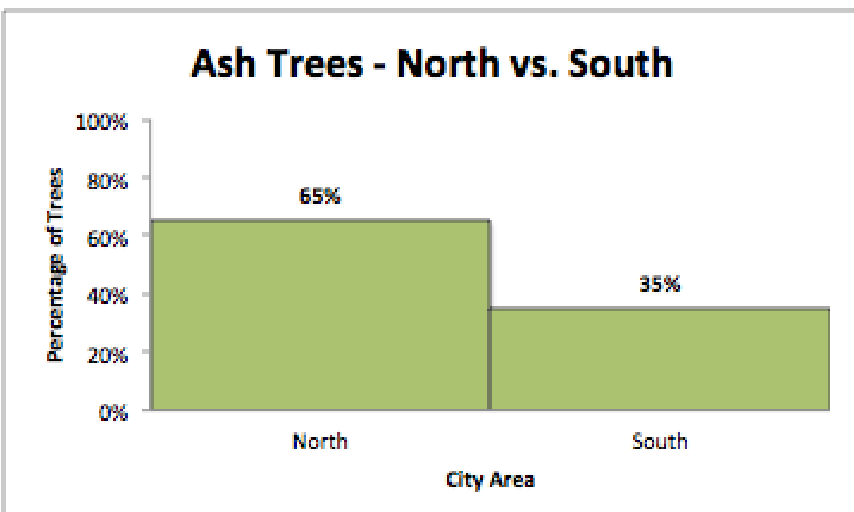

Figure 3.1.3: Percentage of ash trees in north vs. south areas of North Saint Paul

Condition Rating for Ash Trees

Of the 1,354 ash trees in public areas, 614 trees (45%) are in good condition, 596 trees (44%) are in fair condition, 136 trees (10%) are in poor condition, and 8 trees (1%) are in critical condition (refer to Figure 3.1.4.). The condition ratings are split into six categories with percentages; percentages are defined as the percentage that met or exceeded the criteria determined for each condition rating category. The condition rating categories are listed as follows: excellent (95%), very good (90%), good (75%), fair (50%), poor (25%), critical (10%), and dead (0%).

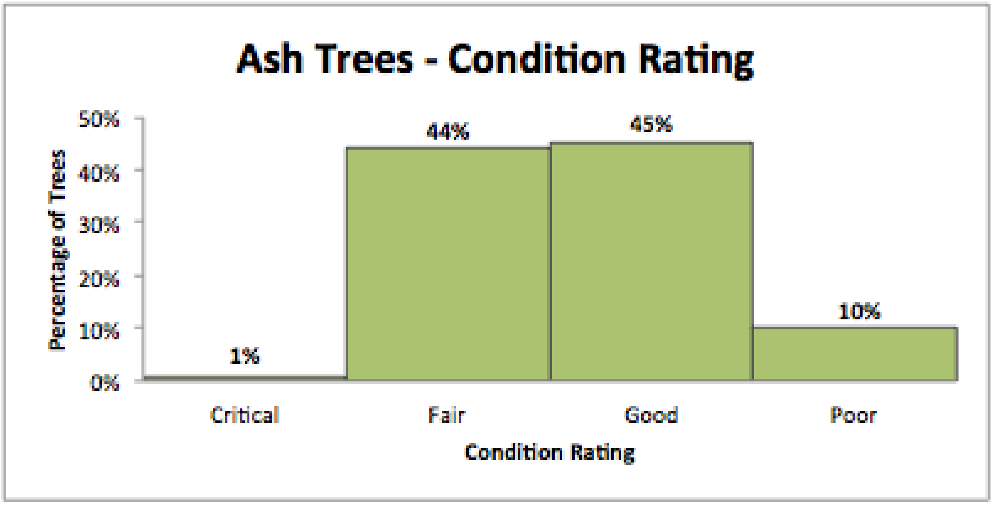

Figure 3.1.4: Percentage of condition ratings of the ash trees in North Saint Paul

Size Class Distribution for Ash Trees

Of the 1,354 ash trees in public areas, 14 trees (1.0%) are between 0 - 5" DBH, 56 trees (4.1%) are between 6 - 10" DBH, 387 trees (28.6%) are between 11 - 15" DBH, 521 trees (38.5%) are between 16 - 20" DBH, 265 trees (19.6%) are between 21 - 25" DBH, 76 trees (5.6%) are between 26 - 30" DBH, 27 trees (2.0%) are between 31 - 35" DBH, 6 trees (0.4%) are between 36 - 40" DBH, and 2 trees (0.1%) are between 41 - 45" DBH (refer to Figure 3.1.5.).

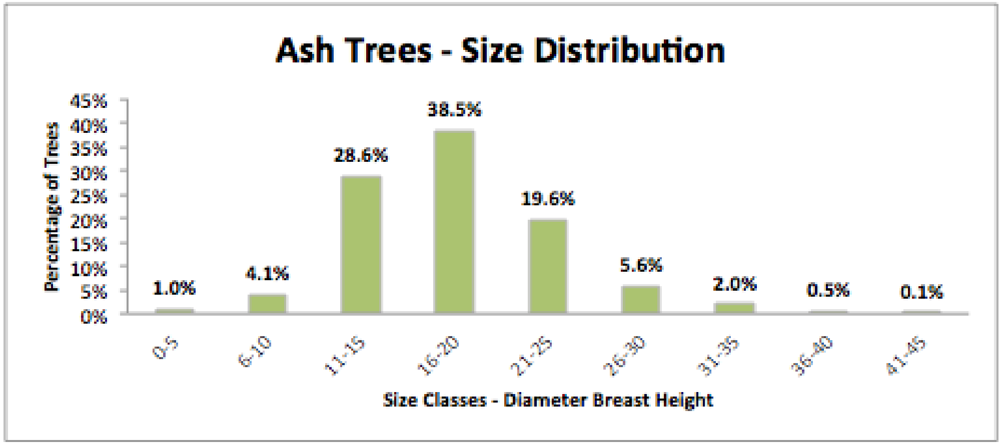

Figure 3.1.5: Percentage of size distribution of ash trees in North Saint Paul

Note: Diameter at Breast Height (DBH) is the most common measure of tree diameter of standing trees where the diameter of the tree trunk is measured at 4.5 feet above ground level (refer to Figure 3.1.6.).

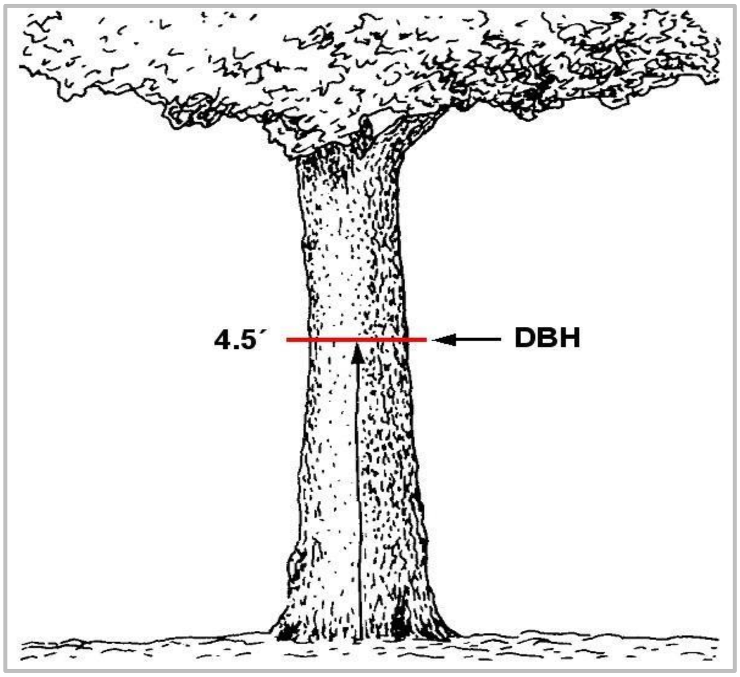

Figure 3.1.6: Diameter at Breast Height (DBH); Image courtesy of Texas A&M Forest Service

3.2. EAB Cost Estimates for Various Management Strategies

The graph below (refer to Figure 3.2.1.) shows the annual costs of three common EAB management strategies. **Annually, the most expensive management strategy is to remove ash as they are killed by EAB and then replant with a species that isn't susceptible to the pest.** The l annual cost results from the "Replace All" strategy, which is the removal of 10% of the cities ash every year over a 10-year span. An intermediate annual cost is the removal and replacement of trees with a DBH < 24" while treating trees with a DBH > 24" with an insecticide to protect them from EAB. This treatment is required every two years, which explains the change in slope of the line after year 11. It is important to note that any of these strategies will require a significant amount of funding. Organizations that may help with funding can be found in Appendix E.

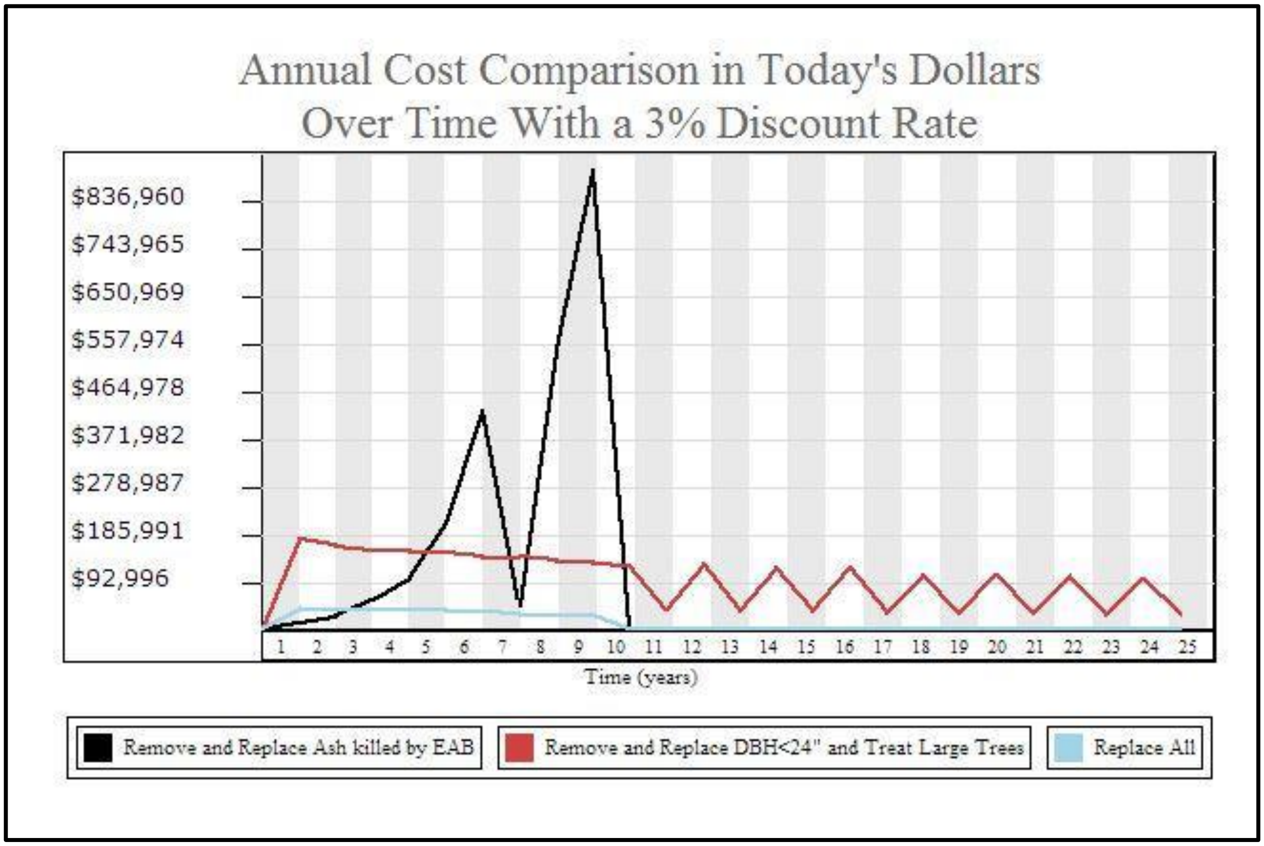

Figure 3.2.1: Graph of Annual Cost Comparison of Management Strategies

The graph below (refer to Figure 3.2.2.) shows cumulative costs of three common EAB management strategies. **The strategy with the highest cumulative cost over 25 years is the Remove and Replace DBH<24” and Treat Large Trees option.** However, the Remove and Replace Ash killed by EAB is very similar and the cumulative cost reaches its maximum sooner (9 years). The Replace All option has the lowest cumulative cost, reaching its total cost at 9 years.

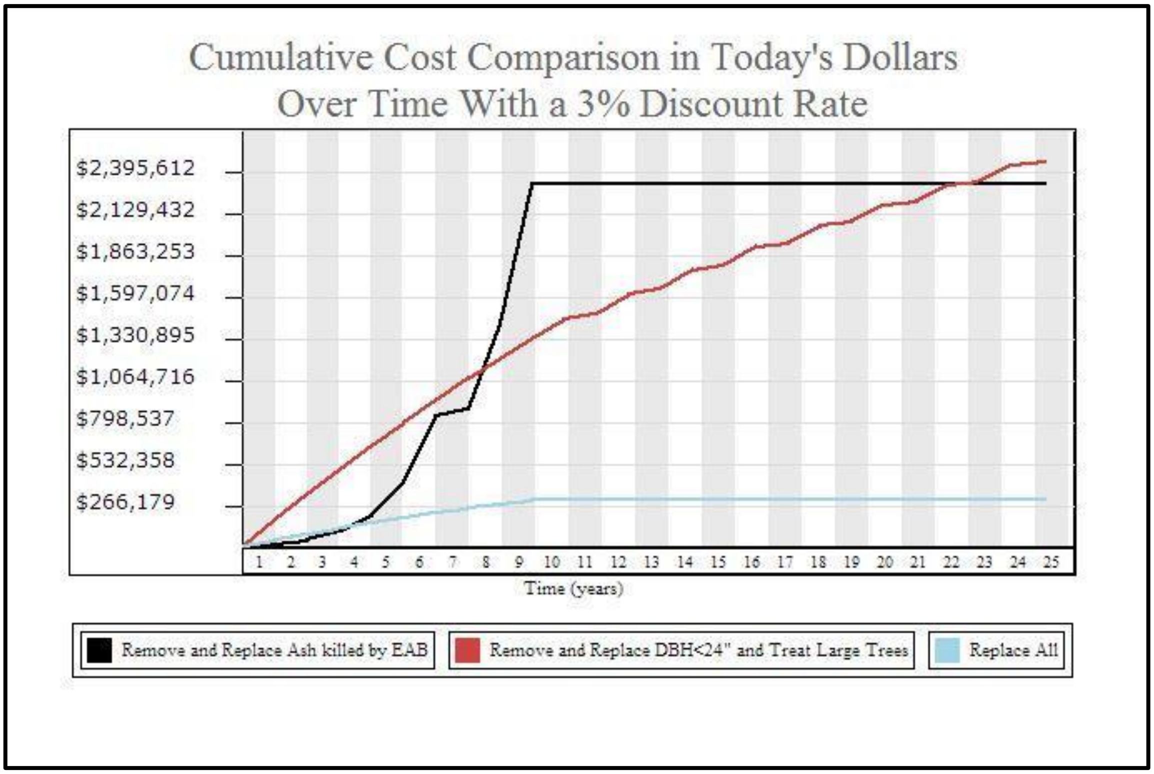

Figure 3.2.2: Graph of Cumulative Cost of Management Strategies

The graph below (refer to Figure 3.2.3.) shows the change in total DBH with respect to each management plan. As a general rule, lower total DBH means lower number of public trees. The gray lines in the graph represent current total DBH and 50% of current total DBH. **The strategy that most significantly decreases DBH is to remove and Replace Ash killed by EAB.** The Remove and Replace DBH<24" and Treat Large Trees strategy preserves the most total DBH.

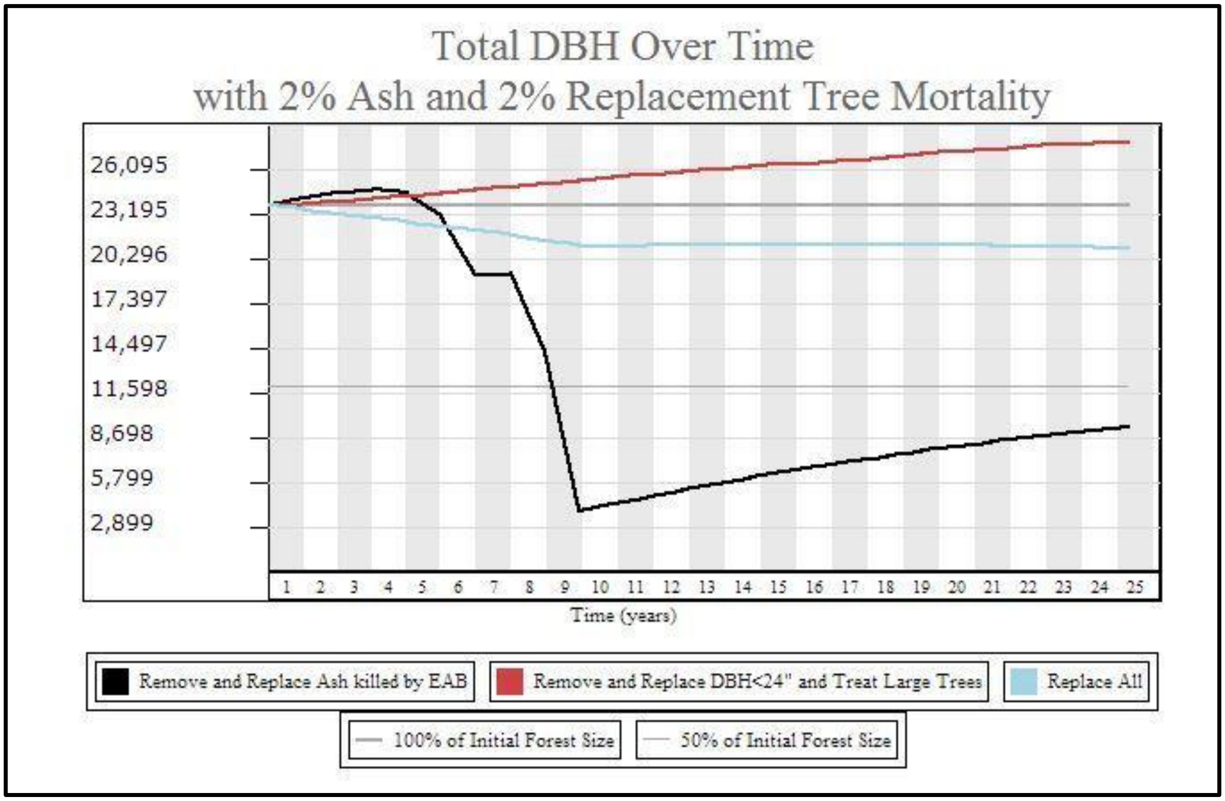

Figure 3.2.3: Graph of Total DBH as a result of each management strategy

3.3. Benefits of Public Ash Trees in North St. Paul

Table 3.3.1. below shows the indirect economic benefits of all public ash trees in North St. Paul based on DBH. These trees save North St. Paul a significant amount on stormwater treatment and runoff management. **The total estimated value of all the public ash trees in North St. Paul is $198,050**. This means that every year, the public ash trees saved North St. Paul $198,050. If these trees continue to grow, this value will increase.

DBH	***Number of Public Ash Trees***	**Annual Economic Benefit of Individual Ash Tree Based on DBH**							***Total* Value All Public Ash Trees Based on DBH**
		Stormwater	***Property Value***	***Electricity***	***Natural Gas***	***CO_2***	***Air Quality***	***Total Value***	
3	5	$2.57	$4.32	$1.20	$2.04	$0.48	$0.70	$11.31	$56.55
4	4	$3.96	$5.69	$1.87	$3.09	$0.77	$1.09	$16.47	$65.88
5	5	$5.96	$7.04	$2.75	$4.71	$1.11	$1.63	$23.20	$116.00
6	12	$8.59	$8.36	$3.86	$6.90	$1.51	$2.31	$31.53	$378.36
7	5	$11.22	$9.69	$4.97	$9.08	$1.91	$2.99	$39.86	$199.30
8	4	$13.85	$11.02	$6.08	$11.27	$2.31	$3.67	$48.20	$192.80
9	13	$16.47	$12.35	$7.18	$13.45	$2.71	$4.36	$56.52	$734.76
10	22	$20.35	$13.60	$8.95	$15.62	$3.28	$5.43	$67.23	$1,479.06
11	38	$24.22	$14.84	$10.71	$17.79	$3.85	$6.51	$77.92	$2,960.96
12	65	$28.09	$16.09	$12.48	$19.95	$4.43	$7.58	$88.62	$5,760.30
13	58	$31.97	$17.34	$14.25	$22.12	$5.00	$8.66	$99.34	$5,761.72
14	122	$35.84	$18.58	$16.01	$24.28	$5.57	$9.73	$110.01	$13,421.22
15	104	$39.72	$19.83	$17.78	$26.45	$6.14	$10.81	$120.73	$12,555.92
16	128	$44.80	$20.68	$18.14	$28.27	$6.44	$11.19	$129.52	$16,578.56
17	132	$49.88	$21.54	$18.51	$30.08	$6.74	$11.58	$138.33	$18,259.56
18	97	$54.96	$22.39	$18.87	$31.90	$7.04	$11.97	$147.13	$14,271.61
19	79	$60.04	$23.24	$19.24	$33.72	$7.34	$12.35	$155.93	$12,318.47
20	85	$65.13	$24.10	$19.61	$35.53	$7.64	$12.74	$164.75	$14,003.75

21	63	$70.21	$24.95	$19.97	$37.35	$7.94	$13.13	$173.55	$10,933.65
22	68	$76.31	$25.52	$20.81	$38.78	$8.28	$13.81	$183.51	$12,478.68
23	60	$82.42	$26.09	$21.64	$40.21	$8.62	$14.49	$193.47	$11,608.20
24	44	$88.53	$26.66	$22.48	$41.64	$8.96	$15.17	$203.44	$8,951.36
25	30	$94.66	$27.23	$23.32	$43.06	$9.30	$15.85	$213.42	$6,402.60
26	26	$100.75	$27.80	$24.15	$44.49	$9.64	$16.53	$223.36	$5,807.36
27	17	$106.85	$28.37	$24.99	$45.92	$9.98	$17.21	$233.32	$3,966.44
28	8	$113.84	$28.44	$25.73	$47.04	$10.17	$17.89	$243.11	$1,944.88
29	18	$120.83	$28.51	$26.46	$48.15	$10.36	$18.57	$252.88	$4,551.84
30	7	$127.82	$28.58	$27.20	$49.26	$10.55	$19.25	$262.66	$1,838.62
31	9	$134.81	$28.66	$27.94	$50.38	$10.74	$19.93	$272.46	$2,452.14
32	5	$141.80	$28.73	$28.68	$51.49	$10.92	$20.61	$282.23	$1,411.15
33	3	$148.79	$28.80	$29.41	$52.60	$11.11	$21.29	$292.00	$876.00
34	8	$156.69	$28.21	$30.05	$53.47	$11.08	$21.96	$301.46	$2,411.68
35	2	$164.59	$27.61	$30.68	$54.34	$11.05	$22.64	$310.91	$621.82
36	2	$172.48	$27.02	$31.32	$55.20	$11.01	$23.31	$320.34	$640.68
37	2	$180.38	$26.42	$31.96	$56.07	$10.98	$23.99	$329.80	$659.60
38	1	$188.28	$25.83	$32.59	$56.93	$10.94	$24.66	$339.23	$339.23
40	1	$196.17	$23.08	$33.82	$58.47	$10.37	$26.03	$347.94	$347.94
42	1	$196.17	$18.79	$35.01	$59.82	$9.28	$27.43	$346.50	$346.50
45	1	$196.17	$12.38	$36.78	$61.84	$7.66	$29.52	$344.35	$344.35
			TOTAL ANNUAL VALUE OF ALL PUBLIC ASH TREES						$198,050

Table 3.3.1.: Annual Economic Value of All Public Ash Trees in North St. Paul Based on Current DBH Distribution

Table 3.3.2. below shows the annual environmental benefits of the public ash trees in North St. Paul. Most notable is the amount of stormwater intercepted (3,441,802 gallons) and the amount of CO_2 sequestered (1,228,455 lbs).

DBH of Ash	*Number of Public Ash Trees*	**Total Annual Environmental Benefits of North St. Paul Public Ash Trees**			
		Stormwater Intercepted (gal)	*Electricity Saved (Kilowatts per hour)*	*Natural Gas Saved (therms)*	*CO_2 Sequestered (lbs)*
3	5	475	80	10	320
4	4	584	100	12	408
5	5	1100	180	25	740
6	12	3804	612	84	2424
7	5	2070	325	45	1275
8	4	2044	320	44	1232
9	13	7904	1235	182	4706
10	22	16522	2596	352	9636
11	38	33972	5358	684	19532
12	65	67405	10660	1300	38350
13	58	68440	10904	1334	38628
14	122	161406	25742	3050	90524
15	104	152464	24336	2808	85176
16	128	211584	30592	3712	109952
17	132	243012	32208	4092	118536
18	97	196716	24153	3201	90986
19	79	167954	19987	2686	77262
20	85	204255	21930	3060	86530
21	63	163233	16569	2394	66654
22	68	191488	18632	2720	75004

23	60	182460	17100	2460	68940
24	44	143748	13024	1848	52536
25	30	104760	9210	1320	37200
26	26	96668	8268	1170	33410
27	17	670327	5593	799	22610
28	8	33608	2712	384	10848
29	18	80262	6282	882	24858
30	7	33019	2506	350	9842
31	9	44775	3312	459	12879
32	5	26165	1890	265	7285
33	3	16470	1164	162	4446
34	8	46256	3168	440	11816
35	2	12146	808	110	2946
36	2	12730	826	112	2936
37	2	13312	842	114	2928
38	1	6947	429	58	1459
40	1	7239	446	60	1382
42	1	7239	461	61	1238
45	1	7239	485	63	1021
TOTAL AMOUNTS		3,441,802 gallons	325,035 kilowatts/hour	42,912 therms	1,228,455 lbs

Table 3.3.2.: Annual Environmental Benefits of Public Ash Trees in North St. Paul

4. Discussion

4.1. Community Engagement and Communication Strategies

Community engagement is a process that allows cities like North Saint Paul to achieve management goals by motivating and utilizing their citizens as volunteers. This process will be crucial to EAB Management in North St. Paul as community engagement is an extremely effective way to mitigate budgetary restrictions and maximize change towards a better urban forest. This section will highlight two volunteer events that utilize community engagement and their benefits and also highlight two communication strategies.

Volunteer Events:

Ash tree tagging is an effective means of community communication that also utilizes active community members interested in the environment.

Preparation:

- Creation of a website that explains the management plan for EAB.
- Posting an advertisement in the local paper and on the North St. Paul website asking for volunteers for a designated day.
- Training of volunteers by the city urban forester on how to identify an ash tree and distinguish between public and private trees.
- Investing in plastic tags to be wrapped around trees, which state something similar to "E.A.B. Kills Ash Trees" (refer to Figure 4.1.1.) and have a link to the North St. Paul website page describing the issue as well as a phone number to call with questions.

Figure 4.1.1: Tree tags used by the City of Minneapolis, Minnesota; Photo courtesy of Tesha M. Christensen

Once this is complete, groups of at least three volunteers can be sent to certain areas of the city where they will tag all public ash trees. This event has been extremely successful in nearby communities, including Saint Paul, MN and Minneapolis, MN.

Benefits of ash tree tagging:

- Communication with citizens is highly increased. More citizens will view the city's EAB management plan, which will likely lead to less community resistance once management actions ensue.
- Citizens will better visualize the impact of EAB on the community, which may motivate them to help with the problem, whether it be through financial support or through volunteerism.
- Citizens will likely feel more involved in decisions made by the city.

Reforesting public areas using a Community Gravel Bed is a cost effective way to reforest by allowing cities to purchase inexpensive bare root tree stock in bulk with a wide variety of species selection and develop root systems on that tree stock. These trees also have great success rates can be planted by community volunteers because they are not as heavy as tree stock with a soil ball (refer to Figure 4.1.2.).

Figure 4.1.2: Reforesting Public Areas; Photo courtesy of Casey Trees

Preparation:

- Post an advertisement in the local paper and on the North St. Paul website asking for volunteers for designated days.
- Build a gravel bed (refer to Figure 4.1.3.), using the publication "All You Need to Know About Gravel Beds" under References.
- Volunteers are trained by the city urban forester on how properly plant trees.
- Invest in trees from a local nursery.
- Use city equipment and tools for tree planting.

Figure 4.1.3: Community Gravel Bed; Image courtesy of Gary Johnson, University of Minnesota

Once completed, volunteers will be able to plant trees on designated planting days in public areas with the guidance of city foresters to ensure proper planting techniques are being employed.

Benefits of reforesting public areas:

- Reforestation with minimal funding is made possible by using community volunteers for labor.
- Community recovery from EAB impact.
- Maintain environmental benefits of trees in urban areas.
- Improve aesthetics of the community.

Communication Strategies:

Mailings are an effective way of communicating with community citizens. According to the last census completed by North St. Paul, 41% of the citizens do not use the Internet. This makes mailings an essential part of communication strategies.

Types of Mailings:

- Utilizing the utility bill to send out information on the management plan and tree removals or treatments.
- Utilizing the local paper to send out updates and information on the management plan.

Community meetings can be held during the decision-making process in order to give citizens a voice in decision-making.

These meetings should cover topics such as:

- Various management strategies, including the positives and negatives of each strategy
- Ask for input from citizens on which management plan they are most supportive on
- Answer questions that citizens may have about EAB and EAB management strategies
- Address citizen concerns of replanting, chemical treatments, tree removal, etc.

4.2. Planting Recommendations For Tree Diversity

Current industry planting recommendations stress the importance of species diversity in the urban forest. By planting a diverse range of species, urban communities are less susceptible to extensive damage from invasive pests such as EAB.

According to the tree inventory analyses in North Saint Paul (see Section 2), ash and maple trees make up the greatest percentage of public trees in North Saint Paul (over 50%, combined). Locally suitable planting recommendation guides (See *Selecting Trees, Shrubs, and Vines* in References) can help to increase tree species diversity in North Saint Paul and mitigate damage from invasive pests in the future.

4.2.1. The 30-20-10 Rule

The 30-20-10 rule (Frank S. Santamour, 2002) was developed as a guide for decisions on planting diversity for urban areas. This rules states that there may be only 30% of trees in the same botanic family, 20% of trees in the same genus, and 10% of trees in the same species within the management area (in this case the management area is North St. Paul). Following this guideline allows communities to mitigate the damage from invasive pests within their urban forest because insect pests and pathogens tend to attack specific tree species. By increasing the number of tree species, it is less likely that a particular insect pest or pathogen will eliminate significant portion of the urban forest at any given time.

4.2.2. Planting Location

The maximum range that a single tree species is planted along a street corridor should not exceed 1-3 blocks. This helps to prevent undesirable loss of canopy in an area if an invasive species becomes an issue. Where visual continuity is required, lengths of 4-6 blocks of a single species can be considered with respects to aforementioned risks. If power lines are present, species should be planted that will not grow tall enough to interfere with the lines.

4.2.3. Species Selection

Recommended Boulevard Tree Species For Increasing Tree Diversity

1	Dutch Elm Disease resistant elms (*Ulmus spp.*)	10	Thornless honeylocust (*Gleditsia triacanthos* var. inermis)
2	Ironwood (*Ostrya virginiana*)	11	Kentucky coffeetree (*Gymnocladus dioicus*) - male only
3	Juneberry (*Amlanchier spp.*)	12	White oak (*Quercus alba*)
4	River birch (*Betula nigra*)	13	Bur oak (*Quercus macrocarpa*)
5	Musclewood (*Carpinus caroliniana*)	14	Japanese tree lilac (*Syringa reticulata*)
6	Northern catalpa (*Catalpa speciosa*)	15	Eastern redbud (*Cercis canadensis*)
7	Common hackberry (*Celtis occidentalis*)	16	American basswood (*Tilia americana*)
8	Ginkgo (*Ginkgo biloba*) - male only	17	Littleleaf linden (*Tilia cordata*)
9	Thornless cockspur hawthorn (*Crataegus crus-galli* var. inermis)	18	Eastern cottonwood (*Populus deltoides*) - male only

Recommended Salt Tolerant Tree Species
(Deciduous tree species tolerant of road salt)

1	White oak (*Quercus alba*)	5	Japanese tree lilac (*Syringa reticulata*)
2	Dutch Elm Disease resistant elms (*Ulmus spp.*)	6	Common hackberry (*Celtis occidentalis*)
3	Bur oak (*Quercus macrocarpa*)	7	Eastern cottonwood (*Populus deltoides*) - male only
4	Ginkgo (*Ginkgo biloba*) - male only	8	Thornless honeylocust (*Gleditsia triacanthos* var. inermis)

Recommended Tree Species by Size
(Deciduous tree species within small, medium and large sizes)

	Small	**Medium**	**Large**
1	Eastern redbud (*Cercis canadensis*)	Thornless honeylocust (*Gleditsia triacanthos* var. inermis)	Dutch Elm Disease resistant elms (*Ulmus spp.*)
2	Ironwood (*Ostrya virginiana*)	River birch (*Betula nigra*)	Common hackberry (*Celtis occidentalis*)
3	Thornless cockspur hawthorn (*Crataegus crus-galli* var. inermis)	Kentucky coffeetree (*Gymnocladus dioicus*) - male only	Ginkgo (*Ginkgo biloba*) - male only
4	Musclewood (*Carpinus caroliniana*)	Littleleaf linden (*Tilia cordata*)	White oak (*Quercus alba*)
5	Juneberry (*Amlanchier spp.*)		Eastern cottonwood (*Populus deltoides*) - male only
6	Japanese tree lilac (*Syringa reticulata*)		Northern catalpa (*Catalpa speciosa*)
7			Bur oak (*Quercus macrocarpa*)
8			American basswood (*Tilia americana*)

4.3. Public Planting Encouragement

4.3.1. Information Availability

4.3.1.1. Guidelines

Easy to read guidelines, such as *Three Steps for Planting Trees and Shrubs* (See References), are an effective way to employ proper planting techniques to the citizens of North Saint Paul. Publications to increase homeowner knowledge should cover subjects such as:

- Proper planting techniques
- How to contact utility companies before planting a tree
- Tree benefit estimation (See *National Tree Benefit Calculator* Under References)
- Appropriate tree selection when planting near power lines

4.3.1.2. QR Codes for Trees

A QR code is a two dimensional barcode that allow people to retrieve more information relevant to a target efficiently by simply scanning the code with a smartphone. When adapted for the urban forest management, the small QR code can be printed on a tag that can easily be affixed to trees (refer to Figure 4.3.1.).

By scanning various QR codes for different tress, people can conveniently retrieve more information about a specific tree, such as its name, history, current condition and management techniques, and even links to its emerald ash borer databases as well as any cost share or self-recognizing programs in the community if applicable. Using existing technology and websites, QR codes can be applied and developed as part of an effective tree and park management system.

Figure 4.3.1: Attaching a QR code to a newly planted public tree; Photo courtesy of 2d code

4.3.2. Cost Share of Planting Investment

Cost share programs are a way for communities to motivate homeowners to plant trees. These city administered programs partially or fully reimburse homeowners for trees. This incentive to homeowners is a cost-effective way to increase the number of trees in a community. These programs can be targeted towards increasing tree species diversity by only sharing costs of preapproved species that will increase species diversity in North St. Paul. An example of a cost share program is using tree coupons (Refer to Figure 4.3.2.).

Figure 4.3 2: Tree Coupon; Image courtesy of the City of Tacoma

Another example of a cost-share program is establishing a Community Gravel Bed (see Community Engagement and Communication Strategies) and selling these trees at a reduced price to homeowners. This can help increase species diversity on private lands as well as public lands.

4.3.3. Official Self-Recognizing

The official self-recognizing project encourages homeowners to plant trees either on their own property or by donating to a tree-planting program. In return, tree planting commissions or companies give the landowners certification of their active involvement and contributions to planting diversity. The official certifications are offered to the homeowners to display on their property (refer to Figure 4.3.3.).

Figure 4.3.3: Certification of Plantation; Image courtesy of Trees 4 Life Campaign

4.4 Pesticides and Pollinators

The general population is becoming increasingly concerned with the significant decline of pollinator populations, specifically in honeybees (Natural Resource Defense Council, July, 2008). A problem concerning bee experts all around the world is Colony Collapse Disorder, termed for the disappearance of honeybees. One possible reason for the decline in pollinators is due to increased use in pesticides. Pesticide use is very common in many agricultural, horticulture, tree care, and pest control companies. Common pesticides such as Imidacloprid and other various neonicotinoids are used to protect and preserve ash trees from EAB in urban settings (Spivak, 2013). Pesticides can weaken the bee's immune system, making them susceptible to many disease and pathogens that can lead to increased stress and eventually lead to death (Spivak, 2013). This is similar to a person getting the flu; it weakens their immune, increases their risk of becoming ill, and puts additional stress on their immune system during recovery. Careful consideration is required when using pesticides for management of EAB, as well as other diseases and insect pests that negatively effect tree health. For more information on this topic, including further readings and videos, refer to Appendix D.

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Appendices

Appendix A: North Saint Paul Public Tree Population by Family, Genus, Species, and Common Name

Family	% of total	Genus	% of total	Species	# of Trees	% of total	Common Name
Aceraceae		Acer		freemanii 'Autumn Blaze'	67	1.56%	Autumn Blaze maple
Aceraceae		Acer		freemanii "Firefall"	4	0.09%	Freeman maple
Aceraceae		Acer		ginnala	13	0.30%	Amur maple
Aceraceae		Acer		negundo	30	0.70%	Boxelder
Aceraceae		Acer		platanoides	168	3.92%	Norway maple
Aceraceae		Acer		platanoides 'Cleveland'	2	0.05%	Cleveland Norway maple
Aceraceae		Acer		platanoides 'Columnare'	2	0.05%	Columnare Norway maple
Aceraceae		Acer		platanoides 'Crimson King'	11	0.26%	Crimson King Norway maple
Aceraceae		Acer		platanoides 'Emerald Queen'	3	0.07%	Emerald Queen Norway maple
Aceraceae		Acer		rubrum	46	1.07%	Red maple
Aceraceae		Acer		rubrum 'Magnificent Magenta'	15	0.35%	Burgundy Belle red maple
Aceraceae		Acer		rubrum 'Northwood'	21	0.49%	Northwood red maple

Aceraceae		Acer		saccharinum	372	8.68%	Silver maple
Aceraceae		Acer		saccharum	86	2.01%	Sugar maple
Aceraceae	22.57%	Acer	22.57%	spp.	127	2.96%	Maple
Anacardiaceae	0.02%	Rhus	0.02%	spp.	1	0.02%	Sumac
Betulaceae		Betula		nigra	28	0.65%	River birch
Betulaceae		Betula		papyrifera	24	0.56%	Paper birch
Betulaceae		Betula	2.10%	platyphylla	38	0.89%	Japanese white birch
Betulaceae	2.15%	Ostrya	0.05%	virginiana	2	0.05%	Ironwood
Bignoniaceae	0.26%	Catalpa	0.26%	speciosa	11	0.26%	Northern catalpa
Cornaceae	0.09%	Cornus	0.09%	spp.	4	0.09%	Dogwood
Cupressaceae		Juniperus	0.70%	virginiana	30	0.70%	Eastern red-cedar
Cupressaceae	1.19%	Thuja	0.49%	occidentalis	21	0.49%	Arborvitae
Elaeagnaceae	0.02%	Elaeagnus	0.02%	angustifolia	1	0.02%	Russian olive

Fabaceae		Gleditsia		triacanthos	88	2.05%	Honeylocust
Fabaceae		Gleditsia		triacanthos 'Skyline'	22	0.51%	Skyline honeylocust
Fabaceae		Gleditsia	2.59%	triacanthos v. inermis Skylin	1	0.02%	Skyline thornless honeylocust
Fabaceae		Gymnocladus	0.12%	dioicus	5	0.12%	Kentucky coffeetree
Fabaceae	3.22%	Robinia	0.51%	pseudoacacia	22	0.51%	Black locust
Fagaceae		Fagus	0.02%	sylvatica	1	0.02%	Common beech
Fagaceae		Quercus		alba	25	0.58%	White oak
Fagaceae		Quercus		bicolor 'Swamp White'	13	0.30%	Swamp white oak
Fagaceae		Quercus		coccinea	13	0.30%	Scarlet oak
Fagaceae		Quercus		ellipsoidalis	15	0.35%	Northern pin oak
Fagaceae		Quercus		macrocarpa	132	3.08%	Bur oak
Fagaceae		Quercus		palustris	4	0.09%	Pin oak
Fagaceae	9.80%	Quercus	9.78%	rubra	217	5.06%	Red oak
Ginkgoaceae	0.12%	Ginkgo	0.12%	biloba	5	0.12%	Ginkgo

Hippocastanaceae		Aesculus		glabra	2	0.05%	Ohio buckeye
Hippocastanaceae	0.09%	Aesculus	0.09%	spp.	2	0.05%	Horsechestnut
Juglandaceae	0.30%	Juglans	0.30%	nigra	13	0.30%	Black walnut
Oleaceae		Fraxinus	31.60%	pennsylvanica	1354	31.60%	Green ash
Oleaceae		Syringa		reticulata 'Ivory Silk'	9	0.21%	Japanese tree lilac
Oleaceae	31.88%	Syringa	0.28%	spp.	3	0.07%	Lilac
Pinaceae		Abies	0.16%	balsamea	7	0.16%	Balsam fir
Pinaceae		Larix	0.40%	laricina	1	0.02%	Tamarack
Pinaceae		Picea		abies	17	0.40%	Norway spruce
Pinaceae		Picea		glauca	135	3.15%	White Spruce
Pinaceae		Picea		glauca 'Black Hills'	14	0.33%	Black Hills white spruce
Pinaceae		Picea		mariana	3	0.07%	Black spruce
Pinaceae		Picea		spp.	39	0.91%	Spruce
Pinaceae		Picea	9.17%	pungens 'Blue'	185	4.32%	Colorado blue spruce
Pinaceae		Pinus		nigra	1	0.02%	Black pine

Pinaceae		Pinus		resinosa	99	2.31%	Red pine
Pinaceae		Pinus		spp.	3	0.07%	Pine
Pinaceae		Pinus		strobus	37	0.86%	Eastern white pine
Pinaceae	13.00%	Pinus	3.64%	sylvestris	16	0.37%	Scots pine
Rhamnaceae	0.02%	Rhamnus		spp.	1		Buckthorn
Rosaceae		Amelanchier	0.07%	canadensis 'Autumn Brilliance'	3	0.07%	Apple serviceberry
Rosaceae		Malus		spp.	12	0.28%	Apple
Rosaceae		Malus		spp. 'Pink Spire Flowering'	5	0.12%	Pink Spire flowering crabapple
Rosaceae		Malus		spp. 'Prairifire'	2	0.05%	Prairifire crabapple
Rosaceae		Malus		spp. 'Profusion'	6	0.14%	Profusion crabapple
Rosaceae		Malus		spp. 'Royal Raindrops'	1	0.02%	Royal Raindrops crabapple
Rosaceae		Malus		spp. 'Snowdrift Flowering'	12	0.28%	Snowdrift Flowering crabapple
Rosaceae		Malus		spp. 'Spring Snow Flowering'	23	0.54%	Spring Snow Flowering crabapple
Rosaceae		Malus	3.27%	spp. Crabapple	79	1.84%	Crabapple

Rosaceae		Morus	0.05%	spp.	2	0.05%	Mulberry
Rosaceae		Prunus		serotina	1	0.02%	Black cherry
Rosaceae		Prunus	0.14%	spp.	5	0.12%	Cherry
Rosaceae	3.83%	Sorbus	0.30%	spp.	13	0.30%	Mountain-ash
Rutaceae	0.05%	Phellodendron	0.05%	amurense	2	0.05%	Amur cork tree
Salicaceae		Populus		deltoides	61	1.42%	Eastern cottonwood
Salicaceae		Populus		spp. 'Silver Leafed'	2	0.05%	Poplar
Salicaceae		Populus	1.68%	tremuloides	9	0.21%	Quaking aspen
Salicaceae	1.80%	Salix	0.12%	spp.	5	0.12%	Willow
Tiliaceae		Tilia		americana 'Boulevard'	1	0.02%	Boulevard linden
Tiliaceae		Tilia		americana 'Redmond'	11	0.26%	Redmond linden
Tiliaceae		Tilia		cordata	61	1.42%	Littleleaf linden
Tiliaceae		Tilia		cordata 'Greenspire'	9	0.21%	Greenspire littleleaf linden
Tiliaceae		Tilia		spp.	16	0.37%	Basswood
Tiliaceae	6.93%	Tilia	6.93%	americana	199	4.64%	American basswood

Ulmaceae		Celtis	0.86%	occidentalis	37	0.86%	Common hackberry
Ulmaceae		Ulmus		americana	24	0.56%	American elm
Ulmaceae		Ulmus		Cathedral'	23	0.54%	Cathedral elm
Ulmaceae		Ulmus		japonica x wilsoniana	8	0.19%	Accolade hybrid elm
Ulmaceae		Ulmus		pumila	18	0.42%	Siberian elm
Ulmaceae	2.66%	Ulmus	1.80%	spp.	4	0.09%	Elm

Appendix B: Emerald Ash Borer Fact Sheet

Emerald Ash Borer
Agrilus planipennis
Order: Coleoptera
Family: Buprestidae

Introduction

Emerald Ash Borer (EAB) is a metallic wood-boring beetle originating from Eastern Asia. First, discovered in Detroit, Michigan and Windsor, Ontario in 2002 and most likely entered Michigan from China via wood packing materials used to transport manufactured goods. EAB infests ash tree species (*Fraxinus spp.*) and feed under the bark, cutting off the flow of water and nutrients in ash trees, eventually leading to the decline and mortality of the trees.

General Characteristics

Adults	**Larvae**

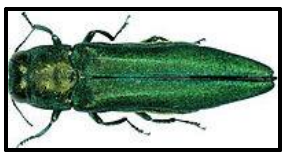
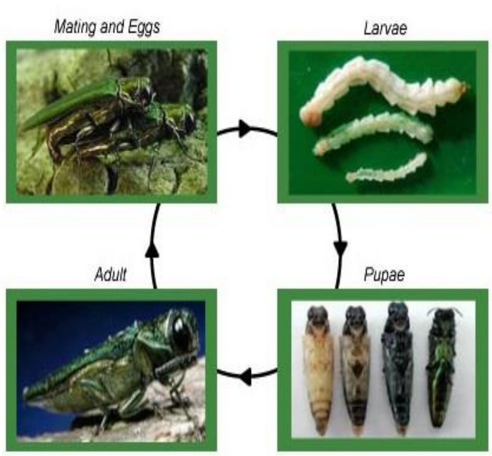



Photo Courtesy of Anoka Master Gardeners	*Photo Courtesy of Emerald Ash Borer*
• Dark metallic green color • Narrow/elongated body • Flat head with black eyes • Length: 10.0–13.0 mm • Width: approx. 1.6 mm	• Creamy white color • Legless • Flattened, bell-shaped body segments • Length: 26.0-32.0 mm • Diameter: approx. 1.0 mm

Lifecycle



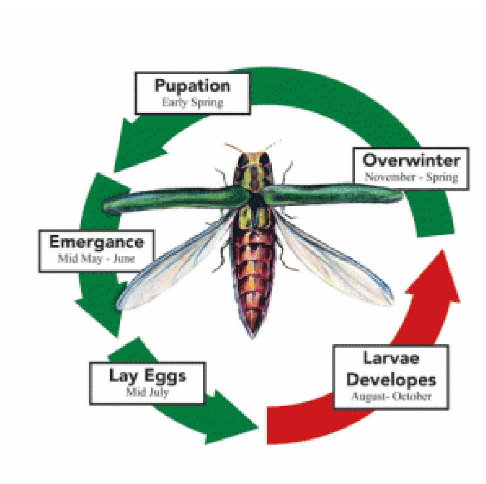


Photo Courtesy of Purdue University Extension

Photo Courtesy of PlantCare Science

Signs & Symptoms

Canopy Dieback

- Begins in the top one-third of tree canopy
- Foliage wilts, branches die, and tree canopy becomes increasingly thin
- Progresses downward until tree is bare

Epicormic Shoots

- Sprouts grow from roots and trunk
- Leaves often larger than normal

Larval Galleries

- Larval feeding galleries, typically serpentine (S-shaped)
- Galleries weave back and forth across the wood grain
- Packed with frass (mix of sawdust and excrement)

Exit Holes

- Adults form D-shaped exit holes upon emergence from tree

Woodpecker Activity

- Several woodpecker species feed on EAB larvae/pupae
- Peck outer bark while foraging
- Create large holes when extracting insects

Management Options

- Insecticides – If within 10-15 mile radius of EAB infestation, and/or ash tree is infested with EAB but tree is healthy and has more than half of its leaves.
    - *Soil-applied drench* – Somewhat effective, costs & results vary, potential to leach into shallow groundwater and highly toxic to aquatic invertebrates
    - *Trunk injection* – Highly effective, long-term investment, high costs, little environmental impact unless spilled
    - *Cover spray* – Somewhat effective, costs & results vary, potential exposure to adjacent water bodies through spray drift and runoff
- Tree removal – If ash tree infested with EAB and is missing more than half of its leaves.
- Don’t move firewood or other ash tree debris.

Appendix C: More Information About Emerald Ash Borer

- Article on the potential impact of extreme cold weather on Emerald Ash Borer
  http://blog.lib.umn.edu/efans/ygnews/2014/02/cold-snap-is-no-snow-day-for-e.html

- General Emerald Ash Borer Information
  http://www.emeraldashborer.info

- General Emerald Ash Borer Information provided by the Minnesota Department of Agriculture website
  http://www.mda.state.mn.us/eab

- General Emerald Ash Borer Information provided by the Minnesota Department of Natural Resources website
  http://dnr.state.mn.us/invasives/terrestrialanimals/eab/index.html

- General Emerald Ash Borer information provided by the University of Minnesota Extension website
  http://www.extension.umn.edu/garden/insects/find/emerald-ash-borer/

- University of Minnesota Extension and Minnesota Department of Natural Resources. *Ash Management Guidelines for Private Forest Landowners*. June 2001.
  http://www.myminnesotawoods.umn.edu/wp-content/uploads/2011/07/103817-Ash-Booklet-5.pdf

Appendix D: Pesticides and Pollinators

- **Background on Pollinator Protection**

  Enivornmental Protection Agency. (2014, March 21). *Pollinator Protection.* Retrieved from Pesticides: Environmental Effects: http://www.epa.gov/pesticides/ecosystem/pollinator/

- **Example of program to aid Pollinators**

  Schwartz, J. (2014, April 2). *Program Looks to Give Bees a Leg (or Six) Up.* Retrieved from The New York Times: http://www.nytimes.com/2014/04/03/science/program-looks-to-give-bees-a-leg-up-or-six.html?emc=edit_th_20140403&nl=todaysheadlines&nlid=61002593&_r=1\

- **Ted Talk by Marla Spivak on Disappearance of Bees**

  Spivak, M. (2013, June). *Why Are Bees Disappearing?* Edinburgh, Scotland. http://www.ted.com/talks/marla_spivak_why_bees_are_disappearing

- **University of Minnesota Bee Lab**

  University of Minnesota. (2014, January 27). *Welcome to Bee Lab*. Retrieved from Bee Lab: http://www.beelab.umn.edu

Appendix E: Potential Assistance Options

- Minnesota Pollution Control Agency
- Ramsey/ Washington County Watershed District
- Soil and Water Conservation District
- Izaac Walton League, Minnesota Division
- Minnesota State Legislature – State Appropriation
- Clubs/Programs
    - Garden Clubs
    - Environmental Clubs
    - Master Gardeners Program