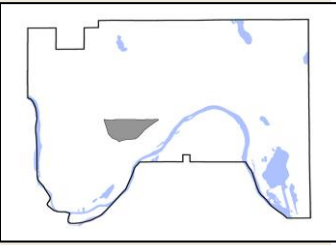


Urban Forest Benefits Report

District 16-Summit Hill

Zachary Jorgensen



The Summit Hill neighborhood is located west of downtown Saint Paul and south of Summit Avenue. The neighborhood is a mix of residential neighborhoods and community scale commercial businesses located along Grand Avenue. At 616 acres the district accounts for approximately 1.7% of the city's 35,931 acre land area.

Single and multi-family residential land accounts for the largest percentage of land use in Summit Hill supporting a significant level of urban tree cover. A 2011 tree canopy assessment found that District 16 has the third highest canopy cover of any district at 40.3% of land area, almost 8% higher than the city average of 32.5%. This canopy cover can be attributed to the pattern of low density residential development that includes large yards and wide boulevards that provide good urban conditions for tree growth.

During 2011-2013, a comprehensive street tree inventory update was completed cataloging the boulevard trees of District 16. The resulting inventory data including the species, size, and condition of each tree was entered into i-Tree Streets¹ to analyze the structural and functional characteristics of the urban forest including species and age diversity, the level of environmental benefits being provided by street trees, and the associated economic value of these benefits. With the possibility of significant structural changes resulting from the potential spread of emerald ash borer into the Summit Hill neighborhood, the environmental benefits of the ash tree population were also calculated to determine the mid-term impact on forest benefits associated with a rapid loss of the district's ash trees. The following results are a summary of the findings:

<u>Summit Hill Benefits Summary</u>	
District area	616 acres
Number of street trees	2,840
Canopy area	45*/84** acres
Energy reduction	\$75,085
Carbon sequestered	989,670 pounds
Total carbon stored	10.5 million pounds
Avoided carbon emissions	808,595 pounds
Air pollutants removed	798 pounds
Air pollutants avoided	5120 pounds
Stormwater runoff avoided	3.5 million gallons
Aesthetic/Other benefits	\$119,732
Total annual benefit	\$318,993

Table 1: Benefits summary

*Canopy provided by public boulevard trees growing on public land.

**Total public right of way canopy cover identified by the 2011 canopy assessment. This figure includes canopy extending over the public right of way that originates from trees planted on private property.

¹ Tree benefit model developed by the USDA Forest Service

Forest Structure

Tree Genera and Species Distribution

Analysis of the 2,840 street trees cataloged as part of the 2011-2013 Summit Hill street tree inventory update reveals that three tree genera, maple, linden, and ash, comprise 76% of the street tree population. Maples are a dominant part of the tree canopy and as a genera comprise 41% of the street tree population followed by linden (18%) and ash (18%). Oak trees are also widely planted and account for 11% of the street tree population. Norway maple, a species which includes a number of cultivars and varieties, is the primary tree comprising 22% of the street tree population followed by green ash (18%) and littleleaf linden (10%). Species including river birch, Kentucky coffeetree, hackberry, honeylocust, and other canopy trees are currently underutilized and could be more widely planted to support species diversity goals.

Tree species diversity levels in Summit Hill are heavily reliant on maple, ash, and linden with maple comprising 41% of the street tree population.

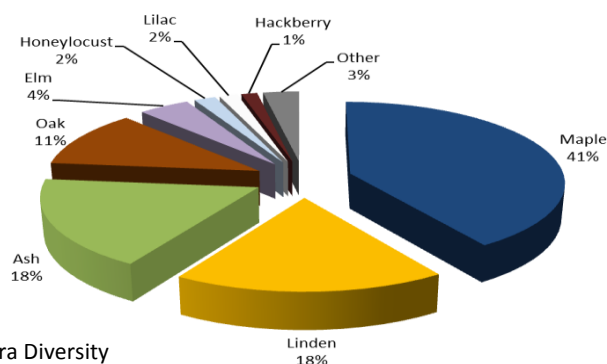


Figure 1: Genera Diversity

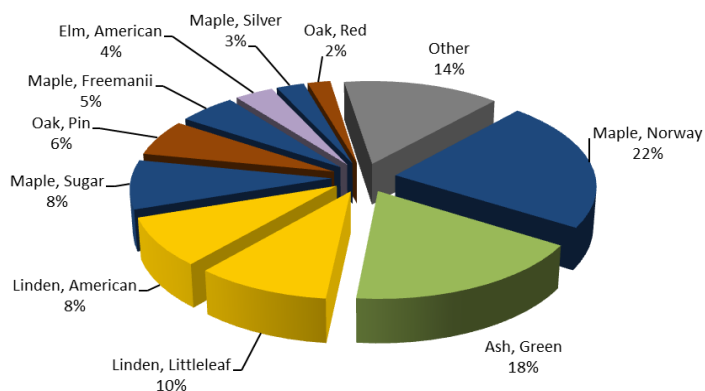


Figure 2: Species Diversity

Size Distribution

The size distribution of trees, determined by measuring the trunk diameter 4.5' above ground level (DBH), reveals a maturing tree canopy with an average trunk diameter of 12". Two diameter classes, 10"-12" and 13"-15", show an increased number of trees and account for 41% of the street tree population at 20% and 21% respectively. Trees under 3" DBH currently account for 9.7% of the population though these numbers will increase as District 16 is scheduled to be planted in 2013 which will increase the number of 2" diameter trees in the street tree inventory. Mature trees over 18" in diameter account for 13.5% of district street trees.

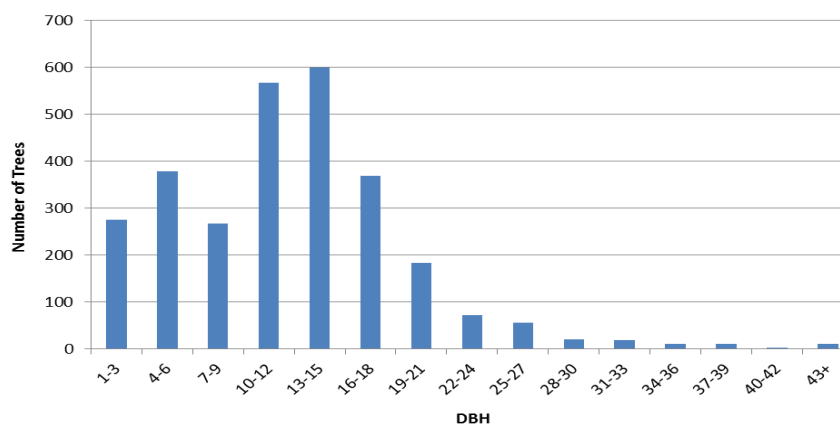


Figure 3: Size distribution as measured by tree diameter 4.5 feet above ground (DBH)

Further analysis of the seven most widely planted genera reveals that current tree diversity ratios are likely to shift over time:

- Dutch elm disease (DED) lead to the dramatic loss of elm trees in Saint Paul and for years no new elm trees were planted. The subsequent development of new varieties of DED resistant elms has resulted in an uptick in the percentage of elm trees within the urban forest. Elm trees 0"-6" in diameter represent 2.4% of the district's street trees while all other elms account for only 1.9% of the street tree population.
- Due to the 2009 discovery of emerald ash borer (EAB) in Saint Paul, ash trees are no longer planted on city boulevards. Combined with the probable loss of mature ash trees as EAB spreads, the replacement of ash trees with other species will significantly reduce the ash tree population from its current level of 18% of the street tree population.
- New and underutilized tree types will continue to be selected and planted to increase species diversity on the public right of way.

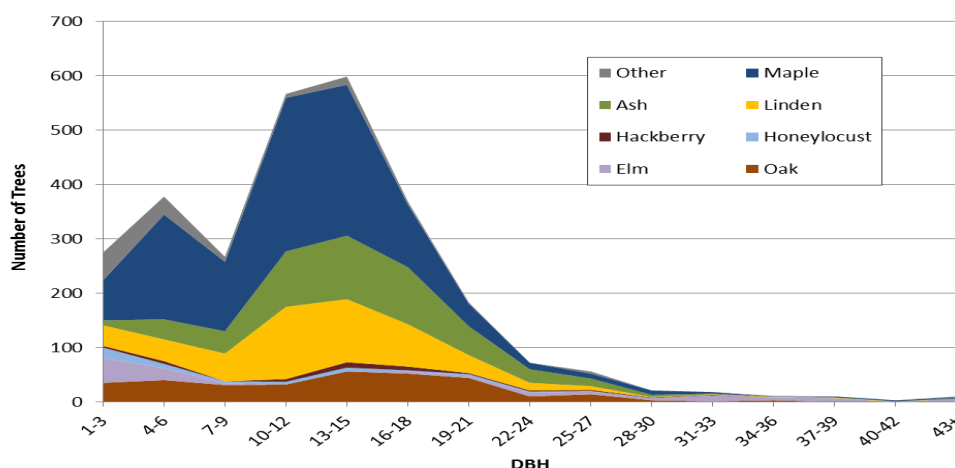


Figure 4: Primary Species Distribution

Maple trees are widely planted in Summit Hill representing 41% of all trees growing in District 16. Calculated by size category, maples represent 27% of all trees 0"-3", 51% of trees 4"-6", 48% of trees 7"-9", 50% of trees 10"-12", 46% of trees 13"-15", and 31% of all trees 16"-18" in diameter and will continue to comprise a significant portion of urban tree canopy moving forward. While these trees provide significant environmental and social benefits, the continued wide spread planting of maples limits overall species diversity and forest resiliency.

Tree condition ratings in District 16 are favorable with 60% of boulevard trees rated in good condition, 34% rated in fair condition, and 6% considered to be in poor condition. Ash trees rated less favorably in overall condition with 34% in good, 64% in fair, and 2% rated in poor condition.

Land Use + Planting Site Locations

Land use analysis within District 16 measured land area as 57% residential, 5% commercial, 4% park land, and 34% public right of way (streets, sidewalks, and boulevards) with the remaining defined as other land uses (2011 Canopy Assessment). The existing street tree population is located largely located in residential areas with 93.6% of trees found on residential boulevards and the remaining 6.4% found along commercial corridors.

Tree planting sites in the district's residential neighborhoods are located primarily on wide turf covered boulevards while commercial corridors located along Grand Avenue have narrower boulevards with a mix of sidewalk cutouts and turf. Boulevard width and soil volumes available for tree growth are influenced by the surrounding land use and development patterns. Residential turf boulevards range in size from as little as 4 feet wide to 15 feet or more while commercial streets vary widely. Wider boulevards provide greater soil volumes and better soil conditions that typically support larger tree canopies and tree growth.

Canopy Cover

District 16 has a land area of approximately 616 acres and a total tree canopy cover of 40.8% as measured by the 2011 city wide canopy assessment. Canopy cover over the public right of way, which includes street trees, was identified as 40%, or 84 acres of tree cover on 209 acres of right of way land, 45 canopy acres of which is provided directly by street trees. Street trees contribute 18% of the district's overall canopy cover.

Importance Value

iTree assigns a relative importance value (RI) to compare the environmental, economic, and social benefits provided by each tree species based on current population size and characteristics. RI values are determined by calculating the percentage of the total street tree population that each tree type represents for the number of trees, leaf area, and canopy cover and then averaging these three numbers. The resulting number



Residential land use, represented in yellow, accounts for 57% of district land area and contains over 93% of city managed boulevard trees.

Map Key:
Green-Park Land
Purple-Industrial
Red/Pink-Commercial
Yellow/Brown-Residential

provides an indication of which tree types have the greatest capacity to mitigate stormwater, improve air quality, shade buildings and provide other benefits.

Within District 16, green ash received the highest importance value rating of 20.6 points. While a smaller percentage of the street tree population, green ash provide the highest amount of canopy cover and leaf area by species due to the relatively large size of these trees. Norway maples are the most widely planted tree in Summit Hill with 634 trees, or 22% of the population, have the second highest importance value of 20.0 points with 899,523 square feet of leaf area and 409,235 square feet of canopy cover. Linden are also widely planted in District 16 and the littleleaf variety has the third highest value of 9.3 points followed closely by pin oak with a rating of 8.3 points.

Crabapple trees (RI value of 0.5), Japanese tree lilacs (RI value of 0.6), and other small ornamental tree types receive lower RI values due to the relatively small leaf surface area and small population size of these trees in the urban forest. While these characteristics reduce the ability of ornamental trees as a whole to intercept large volumes of stormwater or sequester and store large amounts of carbon, their value and use should not be overlooked. Smaller trees are able to be planted in locations larger trees cannot while simultaneously providing additional aesthetic and design benefits.

	Number of Trees	Percent of Trees	Leaf Area (ft2)	Percent of Total Leaf Area	Canopy Cover (ft2)	Percent of Total Canopy Cover	Relative Importance Value
Green Ash	505	17.8	1,205,213	22.6	416,335	21.3	20.6
Norway Maple	634	22.3	899,523	16.9	409,235	21.0	20.0
Linden, Littleleaf	276	9.7	515,269	9.7	168,841	8.6	9.3
Pin Oak	176	6.2	482,488	9.0	187,803	9.6	8.3
Elm	123	4.3	618,688	11.6	137,176	7.0	7.7
Sugar Maple	237	8.3	322,108	6.0	140,417	7.2	7.2
Linden, American	239	8.4	333,416	6.3	125,004	6.4	7.0
Red Maple	204	7.2	172,959	3.2	92,931	4.8	5.1

Table 2: Trees with the a relative importance value over 5 on a 100 point scale

Canopy Benefits

Annual Benefits:

The 2,840 street trees planted in District 16 provide an estimated \$318,993 worth of environmental services to the residents of Summit Hill and form an important part of Saint Paul's green infrastructure network. This represents an average annual economic value of \$112.32 per tree and is significant considering that these values only account for trees found along the public right of way and do not include the substantial number of trees planted in parks or on private property.

When accounting for the five primary benefits iTree uses to calculate these values including energy, air quality, carbon, stormwater, and aesthetics the trees with the largest per tree economic benefit are silver maple (\$226.83/tree), pin oak (\$172.79/tree), and green ash (\$137.21/tree). Japanese tree lilac contribute one of the smallest environmental benefits at \$5.76/tree. As a genera, maple and ash trees are the

Refer to page 9 for a complete list of the environmental and economic benefits provided by the street trees in the Summit Hill neighborhood.

most widely planted and provide the largest overall contribution of environmental benefits to the Summit Hill neighborhood.

Energy Savings

One of the most direct benefits urban trees provide to residents is their ability to alter microclimates within the metropolitan region and reduce energy usage for property owners. By providing shade in the summer and reducing wind speed in the winter trees reduce the demand and expense for cooling and heating services.

In District 16 this environmental service totals \$75,085 per year in energy and natural gas savings, reducing electricity demand by 482 MWh per year and natural gas usage by 63,648 Therms, or nearly 6.3 cubic feet of natural gas. While these are calculated estimates, the savings provided are substantial and reduce the amount of carbon released into the atmosphere from the production and use of these energy sources.

Trees with large canopies including silver maples (\$39.67/tree) and pin oak (\$37.60) provide the largest per tree benefit. As a group, Norway maple provide the largest cumulative benefit (\$17,593) followed by green ash (\$15,912), two trees that are widely planted across District 16. Unsurprisingly, small trees provide the smallest energy saving. Their role should not be overlooked however, as they provide effective shade in areas where larger species may not have room to grow including near residential air conditioner units adjacent to homes and on boulevards with overhead utility lines.

Air Quality

Urban air quality can be impaired due to pollutants, particulate matter, and the urban heat island effect which can increase the formation of ozone. Trees are able to mitigate air pollution by removing pollutants through their leaves and by altering local microclimates, reducing energy demand and with it the emissions associated with energy production.

Boulevard trees in Summit Hill remove an estimated 798 pounds of air pollutants. The shade these trees provide also reduces energy consumption, avoiding the release of 5,120 pounds of emissions annually. The estimated economic value of these services is \$15,932. Silver maple (\$9.12/tree), hackberry (\$8.07), and elm (\$7.59/tree) provide the greatest per tree environmental and economic benefit with maple and ash providing the largest benefit by genera.

Trees release Biological Volatile Organic Compounds (BVOC) which can increase urban ozone levels at higher ambient temperatures and in the presence of particulate matter (Owen). However, while BVOC emissions from trees may cause increases in localized ozone production, the presence of trees is beneficial in the urban environment and may actually reduce overall ozone levels by lowering air temperatures and altering wind patterns which effect air pollution levels and ozone formation (Nowak 2000).

Planting trees on the west and east sides of buildings to provide summer shade and to the north to decrease winter winds can reduce energy demand. While street trees often provide less direct shading to homes, they reduce ambient urban air temperatures and wind speeds increasing energy savings across Saint Paul.

Carbon Sequestration and Storage

Trees in the urban landscape play an important role in the mitigation of atmospheric carbon levels. The community forest reduces atmospheric carbon in two primary ways:

- 1. by sequestering carbon through photosynthesis and storing it as plant biomass
- 2. by altering local microclimates and avoiding the carbon emissions generated from the production and use of energy used to heat and cool buildings (tree canopy lowers ambient air temperatures in the summer and reduces wind speeds in the winter, reducing overall energy demand).

Currently, street trees in District 16 are storing 10.5 million pounds (5254 tons) of carbon with an estimated economic value of \$78,819. The biomass of green ash trees comprises the largest share of carbon storage within the district at 2.3 million pounds, or 22% of total stored carbon followed by Norway maple at 1.8 million pounds, or 17% of the total. Individually, silver maple (\$74.53/tree) and elm (\$59.82/tree) provide the greatest amount of carbon storage per tree in district 16 due to the relative mature size of these species within the street tree population.

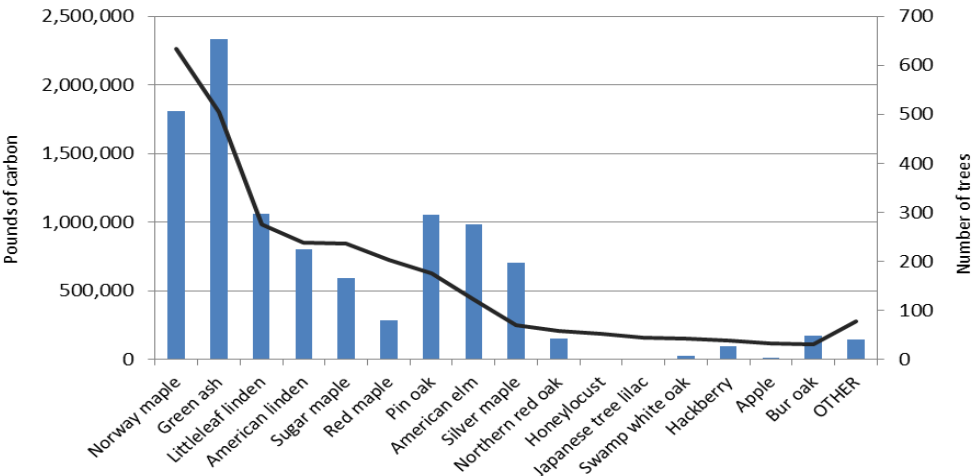


Figure 5: Carbon storage per species

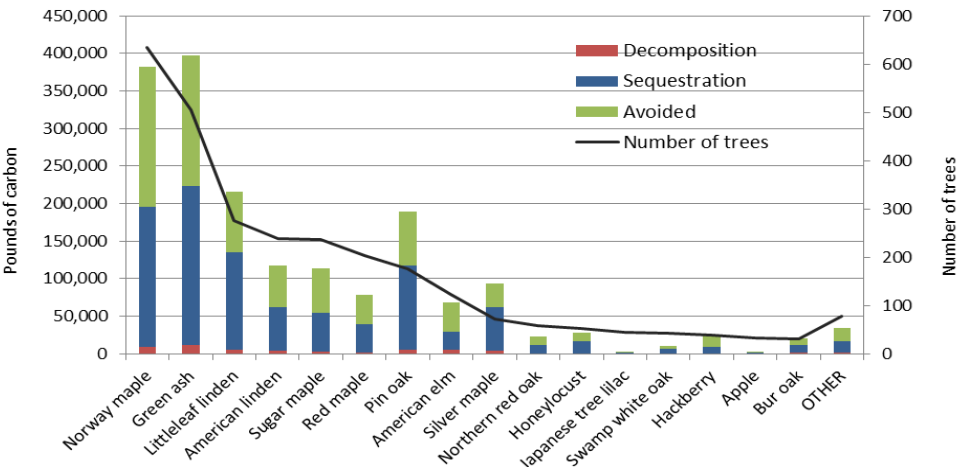


Figure 6: Carbon sequestration per species population
Dark blue represents annual carbon removed from the atmosphere while light blue represents carbon emissions to the atmosphere from the decomposition of plant biomass

The annual uptake of atmospheric carbon in Summit Hill through sequestration captures 989,670 pounds of carbon each year with an estimated economic value of \$7,423. Most of this is stored as woody biomass though 50,561 pounds, or 5%, is returned to the atmosphere via decomposition. Silver maples again provide the largest per tree benefit due to their fast growth rate and large size. Ash trees sequester 223,751 pounds of carbon annually, or about 23% of the district total.

In addition to sequestering carbon directly from the atmosphere, trees provide shade and mitigate local microclimates reducing energy demand and avoiding an estimated 808,595 pounds of carbon emissions that would otherwise be released to heat and cool buildings. In total the trees in District 16 reduce atmospheric carbon by 1.74 million pounds annually through sequestration and pollution avoidance at an economic value of \$13,072.

Stormwater

Trees are a multi-functional green infrastructure element in the landscape and an effective stormwater management tool that has the ability to intercept significant amounts of rainfall before it falls on impervious surfaces and becomes runoff. Preventing stormwater runoff has multiple economic and environmental benefits that include water quality improvements, reduced pollutant loads entering local water bodies, increased infiltration rates, and volume load reductions on storm sewer infrastructure.

Currently, boulevard trees in the Summit Hill neighborhood intercept an estimated 3.5 million gallons of stormwater annually with an estimated economic value of \$95,172. Tree species with a large canopy including silver maple (\$81.86/tree) and pin oak (\$49.45/tree) provide the greatest per tree benefit due to the amount of leaf surface area and canopy spread available to capture rainfall. Green ash trees provide the greatest contribution to stormwater reductions as a genera intercepting over 803,000 gallons, or 23%, of the total volume captured by the street tree canopy.

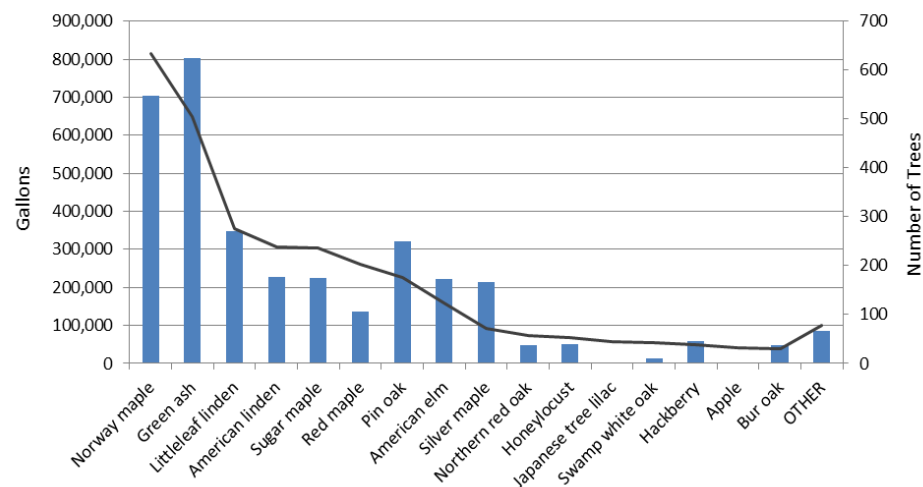


Figure 7: Stormwater runoff reductions per species population

Street trees in District 16 intercept 3.5 million gallons of rainfall, reducing runoff and improving local water quality. Combined with other stormwater best management practices to capture and infiltrate rain fall, trees are an integral part of an effective green infrastructure system.

District 16-Summit Hill Street Tree Canopy Assessment Results			
	Current Benefits	Ash Tree Population**	% Ash
District Land Area (does not include water surface area)	616 acres	616 acres	
Number of Street Trees	2,840	508	18%
Street Tree Canopy Area*	45 acres	10 acres	22%
Percentage of Land Cover	7.3%	1.6%	22%
Annual Energy Reductions			
Electricity	482 MWh	104 MWh	22%
Natural Gas	63,648 Therms	13,317 Therms	21%
Annual Economic Value	\$75,085	\$15,899	21%
Carbon Reductions			
Stored in Street Trees	10.5 million pounds	2.3 million pounds	22%
Sequestered Annually	989,670 pounds	223,470 pounds	23%
Avoided Annually	808,595 pounds	173,915 pounds	22%
Annual Economic Value	\$91,891	\$20,332	22%
Annual Removal of Air Pollutants			
Ozone	455 pounds	70 pounds	15%
Nitrogen dioxide	77 pounds	11 pounds	14%
Particulate matter	246 pounds	39 pounds	16%
Sulfur dioxide	20 pounds	3 pounds	15%
Annual Air Pollutants Avoided			
Nitrogen dioxide	2,282 pounds	487 pounds	21%
Particulate matter	334 pounds	72 pounds	22%
VOC's	319 pounds	68 pounds	21%
Sulfur dioxide	2186 pounds	470 pounds	22%
Annual Economic Value	\$16,784	\$3,446	21%
Stormwater Mitigation			
Runoff reductions	3.5 million gallons	801,675 gallons	23%
Annual Economic Value	\$95,172	\$21,727	23%
Aesthetic/Other Benefits			
Annual Economic Value	\$119,732	\$25,286	21%
Total Net Annual Benefit	\$318,993	\$69,247	22%
*Measures inventoried boulevard tree canopy and does not include all right of way canopy cover as measured by the 2011 canopy assessment **Figures represent the number of ash trees and associated benefits that could be affected by the emerald ash borer.			

Aesthetic and Other Benefits

Trees provide a myriad of social, environmental, and economic benefits, many of which are difficult to quantify through standard economic measures. iTree accounts for these less tangible benefits in the aesthetic/other benefits category which measures tree canopy effects on property values and neighborhood aesthetics. Street trees in District 16 contribute an estimated \$119,732 annually to the economic value of the neighborhood with silver maple (\$86.71/tree) and honeylocust (\$73.40/tree) identified as the top two trees followed by pin oak (\$71.18/tree) and littleleaf linden (\$60.91/tree). The overall economic benefit of forest cover to property values including that on private property is likely much greater as tree canopy has been shown to increase home prices up to 6% of market value (Dwyer 1992, Sander 2010).

Emerald Ash Borer

Emerald ash borer (EAB) was discovered in the Saint Anthony Park neighborhood of Saint Paul in May of 2009 with a subsequent discovery near the intersection of Summit Avenue and Dale Street in 2011. Prior experience from communities in Michigan, Ohio, and Illinois suggest that once EAB is found it cannot be eliminated. Continued infestations and subsequent tree removal will reduce, and potentially eliminate ash trees from the urban forest.

Ash trees comprise 18% of all street trees in the Summit Hill neighborhood. The majority of ash trees are between 10"-18" DBH with canopies that provide significant benefits to the community. The loss of these trees without a planned response to EAB will have a noticeable impact on the capacity of the urban forest to provide ecosystem benefits to the community and will alter the structure and character of the streetscape.

To better understand the potential impact EAB may have in District 16, the economic benefits that ash trees provide were analyzed and compared to those of the complete street tree population. Results suggest that ash trees play a significant role in providing ecological benefits to the Summit Hill neighborhood and the unmitigated loss of ash trees would reduce the environmental and economic value of the street canopy.

- Annual economic benefits would decrease by \$69,247 or 22%
- Carbon stored in woody biomass would decrease by 2.3 million pounds and the carbon sequestered by street trees annually would decline by 223,470 pounds
- Annual stormwater interception would decrease by 801,675 gallons
- Removal of air pollutants would decrease by 123 pounds a year



Emerald ash borer has the potential to reduce the environmental benefits provided by the street trees of District 16 by 22%, or nearly \$69,247 annually.

Goals

This report is an initial measurement of the environmental and economic benefits provided by the street trees in District 16. The data found within can assist with the coordination of species selection and planning of tree planting projects to maximize future benefits while mitigating short term changes that may be caused by forest pests such as emerald ash borer. Additionally, it provides a baseline data set to measure changes in subsequent environmental benefit studies.

Goals for the Summit Hill community forest include:

- Promote the proactive replacement of ash trees with a diverse mix of species to build urban forest resiliency and maintain canopy cover in anticipation of the spread of emerald ash borer and loss of mature ash trees.
- Encourage property owners to plant trees on their property, expanding urban tree cover and the associated benefits that the community forest provides to residents. Residential yards often provide improved growing conditions over those found on city boulevards and are able to support a diverse variety of tree species not typically planted as street trees including fruit and nut bearing varieties.
- Enhance species diversity within the public right of way by limiting the number of maple trees (currently 41% of the district's boulevard tree population) planted while selecting alternative tree species that are appropriate for the growing conditions found at each site. Current recommendations, reflected in the Saint Paul Street and Park Tree Master Plan tree selection criteria, suggest that any one tree genera comprise no more than 20%, and no one tree species comprise more than 10% of the street tree population (Santamour).
- Promote the long term health and survival of the existing canopy through routine maintenance and by encouraging residents to water trees during dry periods as large trees provide the greatest environmental and economic benefit to the community.

Appendix

The following values were used to determine the economic benefits provided by the street tree canopy of District 16

- Electricity was calculated at \$0.0669/kWh based on the average of summer and winter rates quoted by Xcel Energy on May 23, 2012. www.xcelenergy.com
- Natural gas was calculated at \$0.513/therm representing the average cost of natural gas based on data available from CenterPoint Energy on March 26, 2013. www.centerpointenergy.com
- Median home value was calculated as \$273,000 based on real estate estimates from Saint Paul Real-Estate/ReMax Results, Trulia, and Zillow on March 26, 2013.
- Economic values for air pollution and stormwater interception were based on data available in iTree, calibrated to conditions found in the Midwest by the software. These values are:

CO2 (\$/lb)	0.0075
PM10 (\$/lb)	2.84
NO2 (\$/lb)	3.34
SO2 (\$/lb)	2.06
VOC (\$/lb)	3.75
Stormwater interception (\$/gallon)	0.0271

- Operational costs of city tree management were not entered into iTree due to the multi-year rotational nature of tree care across the city and the inaccuracy of dividing the total annual budget to one individual district. This necessarily limits this report to quantifying only the benefits received from the urban forest without balancing against the costs. Once the city wide inventory is complete a full cost/benefit study will be generated.

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This report was prepared by Zachary Jorgensen, Natural Resource Technician with Saint Paul Forestry. It was completed in April 2013 based on inventory data collected during 2011-2013.
