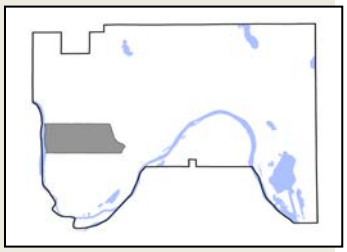
Urban Forest Benefits Report

District 14-Macalester | Groveland

Zachary Jorgensen



The Macalester-Groveland neighborhood is located along the western boundary of Saint Paul and is a mix of residential neighborhoods, community scale commercial districts, educational campuses, and bluff top park land overlooking the Mississippi river valley. At 1,564 acres the district accounts for about 4.5% of the city's 35,931 acre land area.

Single and multi-family residential land accounts for the largest percentage of land use in Macalester-Groveland supporting a significant level of urban tree cover. A 2011 canopy assessment found that District 14 has the second highest canopy cover of any district at 42.4% of land area, almost 10% 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. Community support for tree canopy is also strong and contributes to the ongoing development and care of Macalester-Groveland's urban forest.

During 2011/12, a comprehensive street tree inventory was completed cataloging the boulevard trees of District 14. Inventory data including the species, size, and condition of each tree was entered into i-Tree Streets[1] 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 Macalester-Groveland 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:

Macalester-Groveland Benefits Summary

District area	1,564 acres
Number of street trees	10,147
Canopy area	152*/242** acres
Energy reduction	$246,229
Carbon sequestered	3 million pounds
Total carbon stored	36.1 million pounds
Avoided carbon emissions	2.6 million pounds
Air pollutants removed	2,945 pounds
Air pollutants avoided	16,719 pounds
Stormwater runoff avoided	12 million gallons
Aesthetic/Other benefits	$400,755
Total annual benefit	$1,066,434

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

Tree species diversity levels in Macalester Groveland are well distributed with the exception of maple trees which currently comprise 1/3rd of all street trees.

Analysis of the 10,147 street trees cataloged as part of the 2011-2012 Macalester-Groveland street tree inventory reveals that, with the exception of maple trees, genera and species distribution is well balanced across the district due to a planned approach to the selection and planting of boulevard trees. Maples are a dominant part of the tree canopy and as a genera comprise 34% of the street tree population followed by ash (14%) and linden (10%). Norway maple, which includes a number of cultivars and varieties, is the primary species comprising 17% of the street tree population followed by green ash (11%) and sugar maple (7%). Species including river birch, oak, hackberry, honeylocust, and other canopy trees are currently underutilized and could be more widely planted to support species diversity goals.

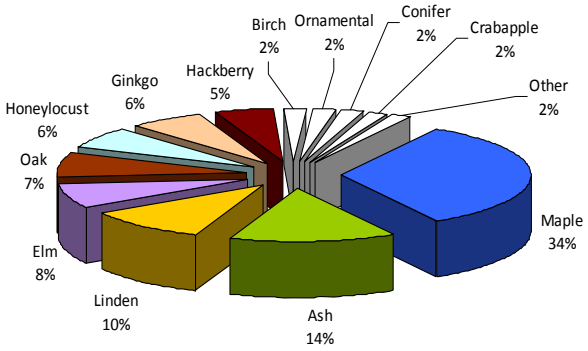


Figure 1: Genera Diversity

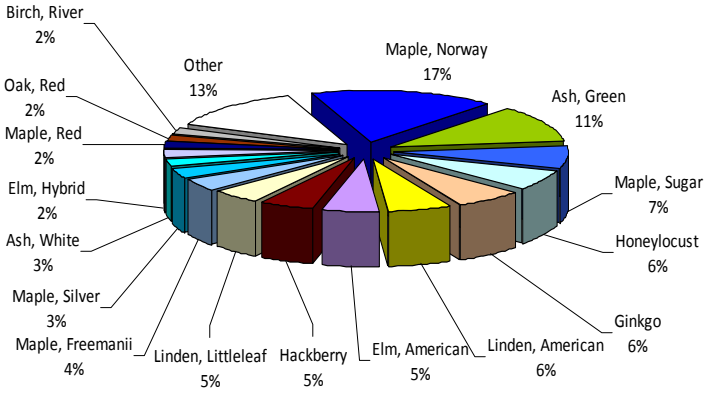


Figure 2: Species Diversity

Size Distribution

The size distribution of trees, determined by measuring the trunk diameter 4.5' above ground level (DBH), shows that the street tree population in Macalester-Groveland is balanced, but trends slightly smaller with 57% of street trees 12" in diameter or smaller. Over 600 new trees were planted in District 14 in 2011 as part of the city's street tree planting program elevating the number of 2" diameter trees in this assessment. Trees 13"-24" in diameter represent 36% of the street tree population while large canopy trees that measure over 24" in diameter represent 6% of the population.

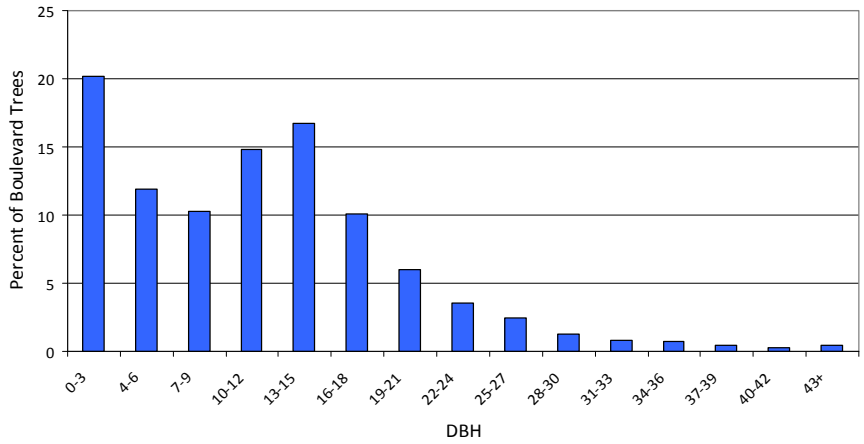


Figure 3: Size distribution as measured by tree diameter 4.5 feet above ground (DBH)

Further analysis of the eight most widely planted tree genera reveals that current diversity ratios will remain relatively stable over time with three exceptions: elm, ginkgo, and ash trees.

- 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 5.5% of the district's street trees while all other elms account for only 2.2% 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 14% of the street tree population.

- At this time, ginkgo trees are not planted on city boulevards due to the potential production of nuisance fruit.

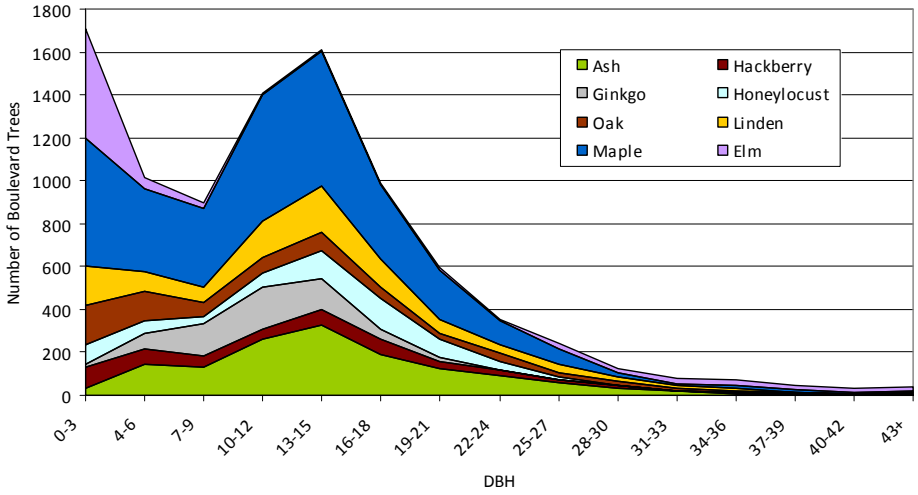


Figure 4: Primary Species Distribution

Maple trees are widely planted in Macalester-Groveland representing 34% of all trees growing in District 14. Calculated by size category, maples represent 30% of all trees 0”-3” in diameter, 18% of all trees 4”-9”, 30% of all trees 10”-15”, and 17% 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 Macalester-Groveland are high with 84% of boulevard trees rated in good condition, 15% rated in fair condition, and 1% considered to be in poor condition. Ash trees rated less favorably in overall condition with 60.8% in good, 37.7% in fair, and 1.5% rated in poor condition.

Land Use + Planting Site Locations

Residential land use, represented in yellow, accounts for 59% of district land area and contains over 92% of city managed boulevard trees.

Land use analysis within District 14 measured land area as 59% residential, 3% educational, 2% park land, 2% commercial, and 30% public right of way (streets, sidewalks, and boulevards) with the remaining defined as other land uses or water (2011 Canopy Assessment). The existing street tree populations are highest in single family residential areas (92.4%) followed by multi-family residential (6.5%) and commercial land (1.1%).

Tree planting sites in the district’s residential neighborhoods are located primarily on wide turf covered boulevards while commercial corridors located along Snelling Avenue and 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 14 has a land area of approximately 1,564 acres and a total tree canopy cover of 42.4% as measured by a 2011 city wide canopy assessment. Canopy cover over the public right of way, which includes street trees, is slightly higher at 50%, or 242 acres of tree cover on 486 acres of right of way land, 152 canopy acres of which is provided directly by street trees. Street trees contribute 22% 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

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 14, Norway maple received the highest importance value rating of 17.1 points. Norway maples are the most widely planted tree in Macalester-Groveland with 1,749 trees, or 17% of the population, and provide the largest amount of canopy cover at 1.22 million square feet with nearly 3 million square feet of leaf surface area. Green ash, which has the highest percentage of leaf area at 3.18 million square feet, was rated second with an RI value of 14.6. A substantial number of large elm trees are still present in District 14 and the large leaf area provided by these vestige sentinels gives them the 3rd highest RI value of 9.6.

Crabapple trees (RI value of 1), Japanese tree lilacs, 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
Norway Maple	1,749	17.2	2,977,777	15.8	1,221,813	18.4	17.1
Green Ash	1,183	11.7	3,176,903	16.8	1,024,091	15.4	14.6
Elm	788	7.8	2,435,654	12.9	539,497	8.1	9.6
Honeylocust	652	6.4	1,662,857	8.8	633,427	9.5	8.3
Sugar Maple	698	6.9	1,090,725	5.8	435,287	6.6	6.4
Linden, American	589	5.8	1,066,018	5.7	323,572	4.9	5.4
Hackberry	512	5	907,654	4.8	408,654	6.2	5.3
Silver Maple	304	3	1,281,791	6.8	384,843	5.8	5.2

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

Canopy Benefits

Refer to page 9 for a complete list of the environmental and economic benefits provided by the street trees in Macalester-Groveland.

Annual Benefits:

The 10,147 street trees planted in District 14 provide an estimated $1,066,434 worth of environmental services to the residents of Macalester-Groveland and form an important part of Saint Paul's green infrastructure network. This represents an average annual economic value of $105.10 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 ($220.24/tree), honeylocust ($202.16/tree), and green ash ($141.82/tree). Ornamental crabapple trees contribute the smallest environmental benefit at $14.23/tree. As genera, maple and ash trees are

the most widely planted and provide the largest overall contribution of environmental benefits to the Macalester-Groveland neighborhood.

Energy Savings

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.

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 14 this environmental service totals $246,229 per year in energy and natural gas savings, reducing energy demand by 1,573 MWh per year and natural gas usage by 209,551 Therms, or nearly 21 million cubic feet. 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 ($39.27/tree) and honeylocust ($33.33) provide the largest per tree benefit. As a group, Norway maple provide the largest cumulative benefit ($50,515) followed by green ash ($37,767), two trees that are widely planted across District 14. 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 Macalester-Groveland remove an estimated 2,945 pounds of air pollutants. The shade these trees provide also reduces energy consumption, avoiding the release of 16,719 pounds of emissions annually. The estimated economic value of these services is $55,890. Silver maple ($8.88/tree), honeylocust ($7.12), and green ash ($7.01/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).

Carbon Sequestration and Storage

Boulevard trees in District 14 store an estimated 18,050 tons of carbon and sequester 1,506 tons each year.

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 14 are storing 36.1 million pounds (18,050 tons) of carbon with an estimated economic value of $271,091. The biomass of green ash trees comprises the largest share of carbon storage within the district at 6.5 million pounds, or 18% of total stored carbon followed by Norway maple at 6.2 million pounds, or 17% of the total. Individually, silver maple ($68.22/tree) and green ash ($41.35/tree) provide the greatest amount of carbon storage per tree in district 14 due to the relative mature size of these species within the street tree population.

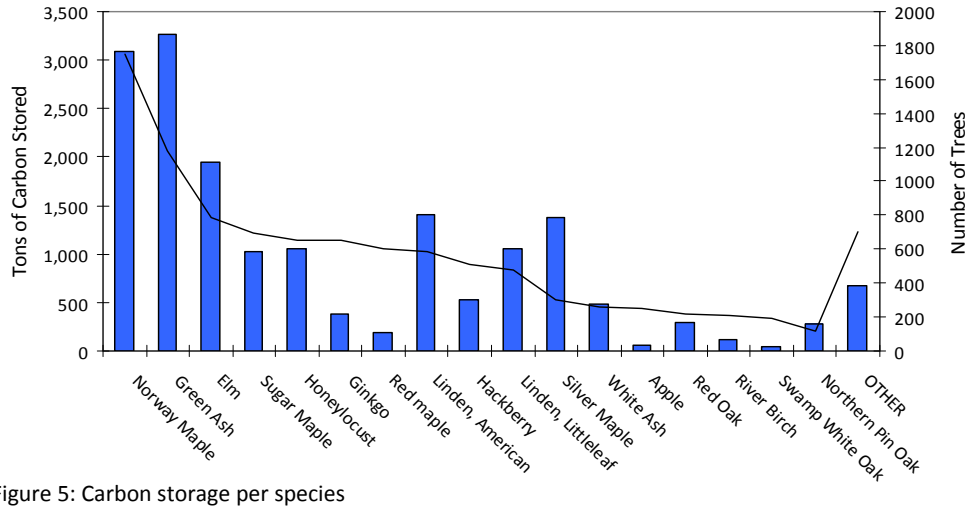


Figure 5: Carbon storage per species

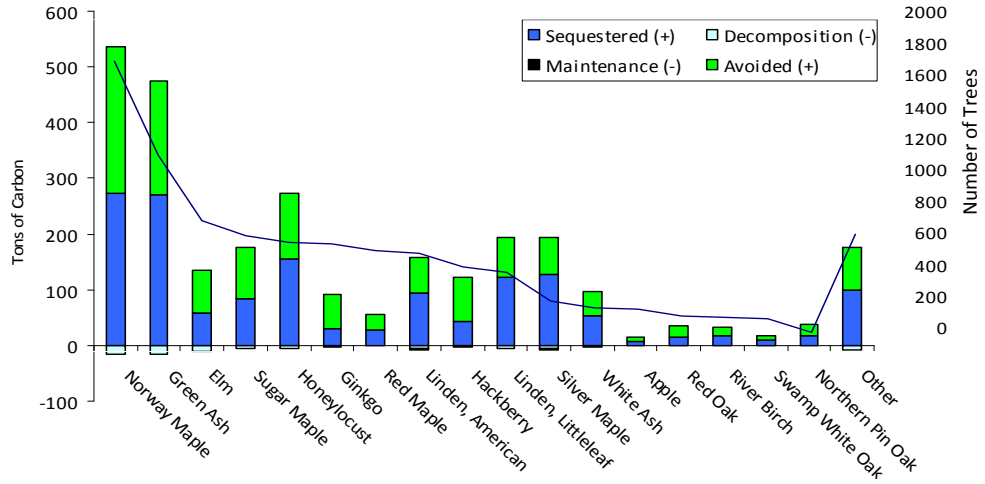


Figure 6: Carbon sequestration per species population
Dark blue represents annual carbon removed from the atmosphere while light blue represents carbon emissions to the atmosphere from the decomposition of plant biomass

Annual uptake of atmospheric carbon in Macalester-Groveland through sequestration captures over 3 million pounds of carbon each year with an estimated economic value of $22,590. Most of this is stored as woody biomass though 174,026 pounds, or nearly 6%, 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 639,913 pounds of carbon annually, or about 21% 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 2.6 million pounds of carbon emissions that would otherwise be released to produce the energy required to heat and cool buildings. In total the trees in District 14 reduce atmospheric carbon by nearly 5.5 million pounds annually through sequestration and pollution avoidance at an economic value of $40,948.

Stormwater

Street trees in District 14 intercept 12 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.

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 stormwater sewer infrastructure. Tree canopies are most effective at reducing runoff from small rain events and mitigating the peak flow volumes of large events.

Currently, boulevard trees in Macalester-Groveland intercept an estimated 12 million gallons of stormwater annually with an estimated economic value of $325,037. Tree species with a large canopy including silver maple ($78.04/tree) and green ash ($46.97/tree) provide the greatest per tree benefit due to the amount of leaf surface area and canopy spread available to capture rainfall. Norway maple trees provide the greatest contribution to stormwater reductions intercepting over 2.2 million gallons, or 18%, of the total volume captured by the street tree canopy.

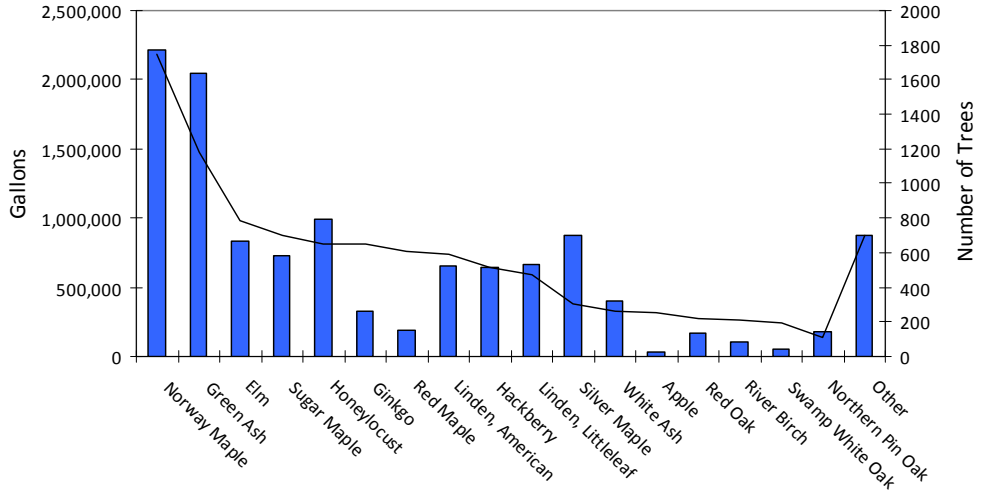


Figure 7: Stormwater runoff reductions per species population

District 14-Macalester | Groveland
Street Tree Canopy Assessment Results

	Current Benefits	Ash Tree Population**	% Ash
District Land Area (does not include water surface area)	1,564 acres	1,564 acres	100%
Number of Street Trees	10,147	1,426	14%
Street Tree Canopy Area*	152 acres	28 acres	18.4%
Percentage of Land Cover	9.7%	1.8%	18.6%
Annual Energy Reductions			
Electricity	1,573 MWh	293 MWh	18.6%
Natural Gas	209,551 Therms	37,629 Therms	17.9%
Annual Economic Value	$246,229	$44,921	18.2%
Carbon Reductions			
Stored in Street Trees	36.1 million pounds	7.4 million pounds	20.5%
Sequestered Annually	3 million pounds	639,913 pounds	21.3%
Avoided Annually	2.6 million pounds	491,357 pounds	18.9%
Annual Economic Value	$313,464	$64,252	20.5%
Annual Removal of Air Pollutants			
Ozone	1,693 pounds	237 pounds	33.7%
Nitrogen dioxide	286 pounds	38 pounds	32.1%
Particulate matter	890 pounds	126 pounds	32%
Sulfer dioxide	77 pounds	11 pounds	31.2%
Annual Air Pollutants Avoided			
Nitrogen dioxide	7,459 pounds	1,376 pounds	18.4%
Particulate matter	1,090 pounds	202 pounds	18.5%
VOC's	1,040 pounds	193 pounds	18.5%
Sulfer dioxide	7,130 pounds	1,328 pounds	18.6%
Annual Economic Value	$53,465	$9,924	18.6%
Stormwater Mitigation			
Runoff reductions	12 million gallons	2.43 million gallons	20.3%
Annual Economic Value	$325,037	$65,906	20.3%
Aesthetic/Other Benefits			
Annual Economic Value	$400,755	$74,347	18.5%
Total Net Annual Benefit	$1,066,434	$203,294	19%

*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 14 contribute an estimated $400,755 annually to the economic value of the neighborhood with honeylocust ($114.26/tree) and silver maple ($84.88/tree) identified as the top two trees followed closely behind by linden ($63.15/tree) and white ash ($60.40/tree). The overall economic benefit of forest cover on 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 has the potential to reduce the environmental benefits provided by the street trees of District 14 by 19%, or nearly $203,294 annually.

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 14% of all street trees in the Macalester-Groveland neighborhood. While the percentage of ash trees in the street tree population is lower than other areas of Saint Paul, many of the ash trees are mature with large canopies that provide significant benefits to the community but may also begin to decline due to the trees' age and size. 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 14, 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 Macalester-Groveland 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 $203,294 or 19%
- Carbon stored in woody biomass would decrease by 7.4 million pounds and the carbon sequestered by street trees annually would decline by 639,913 pounds
- Annual stormwater interception would decrease by 2.43 million gallons
- Removal of air pollutants would decrease by 412 pounds a year
- Property/other benefits would decline by approximately $74,347 annually

To date, the spread of EAB in Saint Paul has been limited and management strategies are focusing on the removal of infested trees and the replacement of ash tree monocultures and those in poor condition to increase species diversity and reduce the potential long term risks and costs associated with EAB. The borer is spreading and EAB management will continue to monitor and respond to new finds.

Goals

This report is an initial measurement of the environmental and economic benefits provided by the street trees in District 14. 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 including emerald ash borer. Additionally, it provides a baseline data set to measure changes in subsequent environmental benefit studies.

Goals for the Macalester-Groveland community forest include:

- Promote the proactive replacement of declining 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 34% 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 14

- 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 $0.673/therm representing the 24 month average cost of natural gas based on data available from CenterPoint Energy on May 23, 2012. www.centerpointenergy.com
- Median home value was calculated as $247,500 based on real estate estimates quoted on Saint Paul Real-Estate/ReMax Results, Trulia, and Zillow on May 23, 2012.
- 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 December 2012 based on inventory data collected during 2011-2012.