Urban Forest Benefits Report

District 2-Greater East Side

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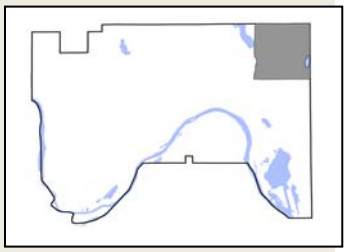


The Greater East Side (Planning District 2) is located in the northeast corner of Saint Paul and is composed of residential neighborhoods with commercial development located along White Bear Avenue and Maryland Avenue. A network of neighborhood parks provide green space and recreational opportunities. At 2,508 acres the district covers 7% of the city's 35,931 acre land area.

Single family residential neighborhoods account for the largest percentage of land use in the Greater East Side, 52%, and support a significant level of urban tree cover while providing significant opportunity for additional canopy growth through private tree planting. A 2011 canopy assessment found that District 2 has the 4th highest canopy cover of any district at 36.7% of land area, 4.2% higher than the city average of 32.5%. This canopy cover can be attributed to a pattern of low density residential development that includes large yards and wide boulevards that support public and private tree planting.

During 2011/12, a comprehensive street tree inventory was completed cataloging the boulevard trees of District 2. 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 a potential spread of emerald ash borer into the East Side, the environmental benefits of the ash tree population were calculated to determine the mid-term impact on forest benefits associated with the rapid loss of the district's ash trees.

The following results are a summary of the findings:

Greater East Side Benefits Summary

District area	2,508 acres
Number of street trees	9,655
Street Tree Canopy area	144*/263** acres
Energy reduction	$241,259
Carbon sequestered	3 million pounds
Total carbon stored	32.8 million pounds
Avoided carbon emissions	2.6 million pounds
Air pollutants removed	2,538 pounds
Air pollutants avoided	16,440 pounds
Stormwater runoff avoided	11.4 million gallons
Aesthetic/Other benefits	$159,264
Total annual benefit	$800,944

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

A 2011-2012 inventory of the Greater East Side neighborhood identified 9,655 street trees. Three genera including maple (26%), ash (23%), and linden (11%) account for 60% of all street trees, limiting overall species diversity. Interestingly, Norway maple varieties, which are planted for their ability to tolerate difficult urban conditions, account for 63% of the maple tree population and 16% of all street trees. Species including oak, hackberry, disease resistant elm, birch, and other underutilized canopy trees represent a smaller portion of the urban forest and could be more widely planted to improve species diversity levels where site conditions and boulevard width allow.

With the arrival of emerald ash borer, significant shifts in species distribution may occur as ash trees, which account for 23% of boulevard trees, are replaced with other species.

Maple trees comprise a significant portion of the Greater East Side's street tree population. A sudden system wide loss of ash trees if the emerald ash borer infestation becomes wide spread would shift species diversity, increasing maples to 34% of the remaining street tree population.

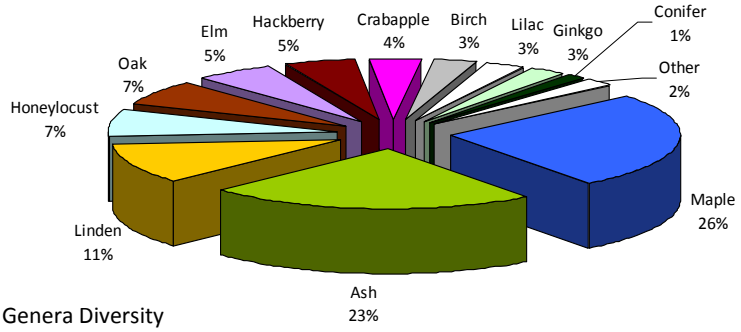


Figure 1: Genera Diversity

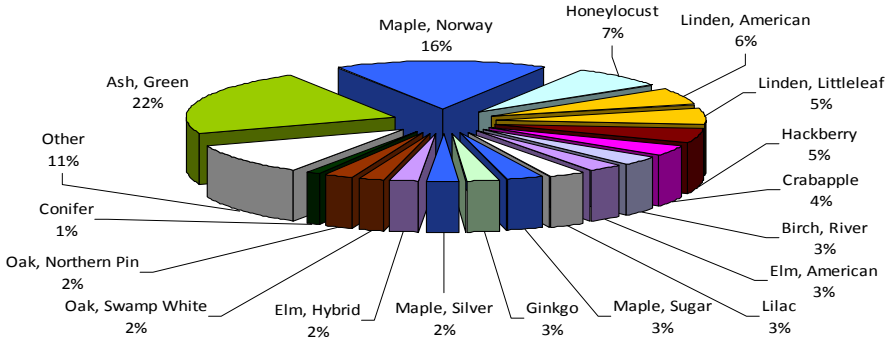


Figure 2: Species Diversity

Size Distribution

The size distribution of trees, represented by trunk diameter measured 4.5' above ground level (DBH), shows the population divided between trees 1"-3" DBH and 10"-18" with a decline in the number of trees between 7"-9". Large canopy trees with a DBH between 19"-24" represent 9% of the street tree population and trees over 24" in diameter 4% of the population. A total of 1,063 new trees were planted in District 2 in 2011 and 2012 as part of the city's street tree planting program resulting in a significant increase in the number of 2" diameter trees in the inventory.

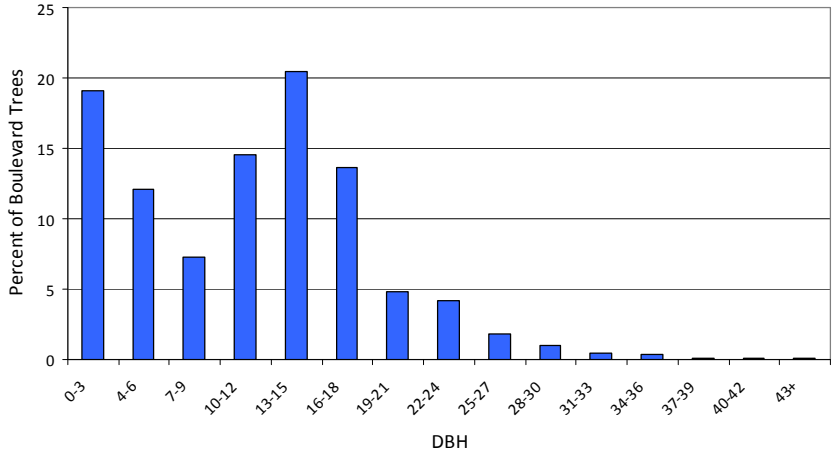


Figure 3: Size distribution as measured by tree diameter 4.5 feet above ground (DBH)

Further analysis of the seven most widely planted tree genera reveals that current diversity ratios will shift slightly with increases in the number of elms, oaks, and birch trees while ash trees will become less prevelant.

- 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 increase in the percentage of elm trees within the urban forest. Recently planted elm trees 0”-6” in diameter represent 5% of the district’s street trees while all other elms account for only 0.5%.

- Due to the 2009 discovery of emerald ash borer (EAB) in Saint Paul, ash trees are no longer planted on city boulevards. The replacement of ash trees with other tree types combined with the potential loss of mature ash trees as EAB spreads will reduce, and possibly eliminate ash trees from the district, currently 23% of the street tree population.

- A diverse pallet of tree types are being planted to enhance species diversity, reflected by the increase in the nuber of trees identified as ‘Other’.

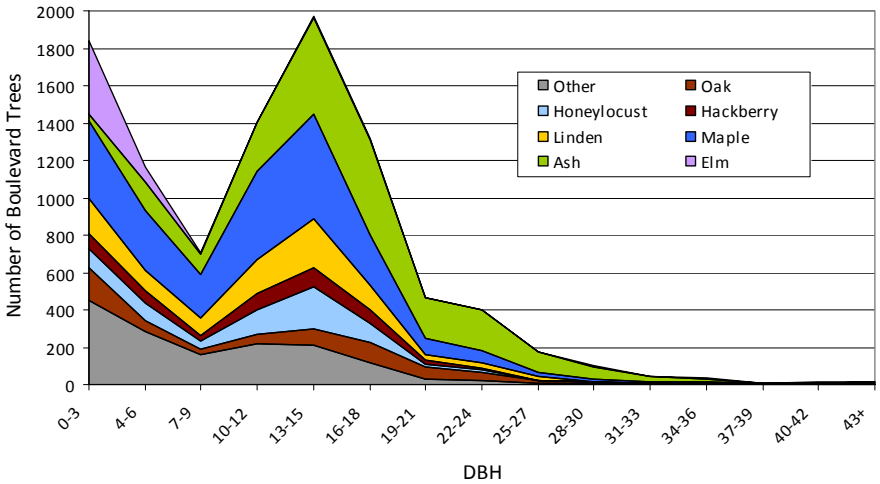
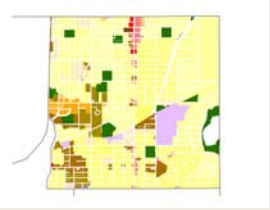


Figure 4: Primary Species Distribution

Maple and ash trees are widely planted in the East Side and represent 26% and 23% of all trees growing in District 2. Ash make up a significant portion of the mature tree population and as measured by category, represent 38% of trees 16”-18” DBH, 46% of trees 19”-21” DBH, and 53% of trees 22”-24” DBH. While these trees provide significant environmental and social benefits, the reliance on a limited pallet of tree types reduces overall species diversity and forest resiliency.

Tree condition ratings in District 2 are favorable with 64% of boulevard trees rated in good condition, 20% rated in fair condition, and 16% considered to be in poor condition. Ash trees rated slightly lower in overall condition than the district average with 45% found to be in good condition, 45% in fair condition, and 10% in poor condition.



Residential land use, represented in yellow, accounts for 63% of district land area and contains over 96% of city managed boulevard trees.

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

Land Use

Land use analysis within District 2 measured land area as 63% residential, 4.5% park land, 3.5% industrial, 1.7% commercial, and 23.7% 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 residential areas (96.7%) followed by commercial (2.7%) and industrial land (0.5%).

Tree planting sites in the district’s residential neighborhoods are located primarily on wide turf covered boulevards while commercial corridors located along White Bear Avenue and Maryland Avenue have narrower boulevards with a mix of sidewalk cutouts, pavers, 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 2 covers approximately 2,508 acres of land area and has a total tree canopy cover of 36.7% as determined by the 2011 canopy assessment. The public right of way, which includes tree planting boulevards, represents 24% of district area and has a canopy cover of 44%, or 263 acres of tree canopy of which, 144 acres is provided by public boulevard trees. Boulevard trees account for 16% of the district’s 920 acres of overall canopy cover.

Importance Value

iTree assigns a relative importance value (RI) to compare the relative economic value of the environmental and social benefits provided by each tree species population. The total number of trees, total leaf surface area, and overall canopy cover of each species are averaged to calculate the RI value.

Within District 2, green ash received the highest importance value rating of 31.7 points due to the large population and mature size of these trees in the urban canopy. Ash account for 2,167 trees representing 33% of the total tree cover and 6.5 million square

Trees with a large total leaf surface area and broad canopy spread provide the greatest benefits.

feet of leaf surface area. Norway maple was rated second with an RI value of 15.4 and a leaf area of 2.25 million square feet.

Many trees receive low relative importance values due to a low population size or small tree size which provide smaller leaf surface and canopy areas. This reduces the ability of these tree species as a whole to intercept large volumes of stormwater or mitigate large amounts of carbon. Small stature trees should not be overlooked for use in the urban landscape, however, as small trees impart important aesthetic and functional characteristics to city boulevards and are often able to be planted in locations larger trees cannot.

	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	2,167	22.4	6,531,394	39.5	2,081,787	33.3	31.7
Norway Maple	1,588	16.4	2,248,439	13.6	1,013,668	16.2	15.4
Honeylocust	719	7.4	1,301,588	7.9	617,922	9.9	8.4
Linden, Littleleaf	503	5.2	1,006,723	6.1	318,474	5.1	5.5
Hackberry	482	5.0	662,288	4.0	346,697	5.5	4.8
Silver Maple	219	2.3	1,046,560	6.3	300,568	4.8	4.5

Table 2: Trees with the a relative importance value over 4 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 of District 2.

Annual Benefits:

The 9,655 street trees growing in District 2 provide an estimated $800,944 worth of environmental services to neighborhood residents and form an important part of Saint Paul's green infrastructure network. This represents an average annual economic value of $82.96 per tree which is significant considering that these figures only account for trees found along the public right of way and do not include the thousands of trees planted in parks or on private property.

When accounting for the five primary benefits iTree uses to calculate tree benefit values including energy, air quality, carbon, stormwater, and aesthetics the trees with the largest economic benefit are silver maple ($184.60/tree), green ash ($124.48/tree), and pin oak ($119.11/tree). As a genera, ash and maple trees provide the largest contribution of environmental benefits to the Greater East Side neighborhood due to the significant number of these trees planted in District 2.

Energy Savings

One of the direct benefits urban trees provide to residents is the ability to mitigate 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.

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.

In District 2 this environmental service totals $241,259 per year in energy and natural gas savings, reducing energy demand by 1,547 MWh per year and natural gas usage by 204,653 Therms, or slightly more than 20 million cubic feet of natural gas. While these are estimates, the savings provided are substantial and reduce the amount of carbon released into the atmosphere from the use of these energy sources.

Trees with large canopies including silver maples ($41.09/tree), pin oak ($37.25/tree), and green ash ($35.26) provide the largest per tree benefit. As a group, ash provide the largest cumulative benefit ($76,404) followed by Norway maple ($43,552), two trees that are widely planted across District 2. Unsurprisingly, small trees provide smaller 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 by 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 deposition and by altering local microclimates, reducing energy demand and the emissions associated with its production.

Boulevard trees in District 2 remove an estimated 2,538 pounds of air pollutants through deposition. The shade these trees provide also reduces energy demand helping avoid the release of 16,440 pounds of emissions annually. The total estimated value of these services is $51,967 per year. Silver maple ($9.43/tree), pin oak ($8.48/tree), and green ash ($7.77/tree) provide the greatest environmental and economic benefit followed by honeylocust ($6.65/tree). The most significant portion of this value is derived from the urban forest's ability to reduce urban temperatures and the total volume of emissions generated to produce energy to cool and heat buildings.

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

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

Currently, street trees in District 2 are storing 32.75 million pounds (16,378 tons) of carbon with an estimated economic value of $245,670. Ash tree biomass comprises the largest share of carbon storage within the district at 13.5 million pounds, or 41% of total

stored carbon followed by Norway maple at 4.5 million pounds, or 14% of the total. Individually, silver maple ($80.04/tree) and green ash ($46.57/tree) provide the greatest amount of carbon storage per tree due to the relatively large size of these trees in the District 2 street tree population.

Boulevard trees in District 2 store an estimated 16,378 tons of carbon and sequester 1,514 tons each year.

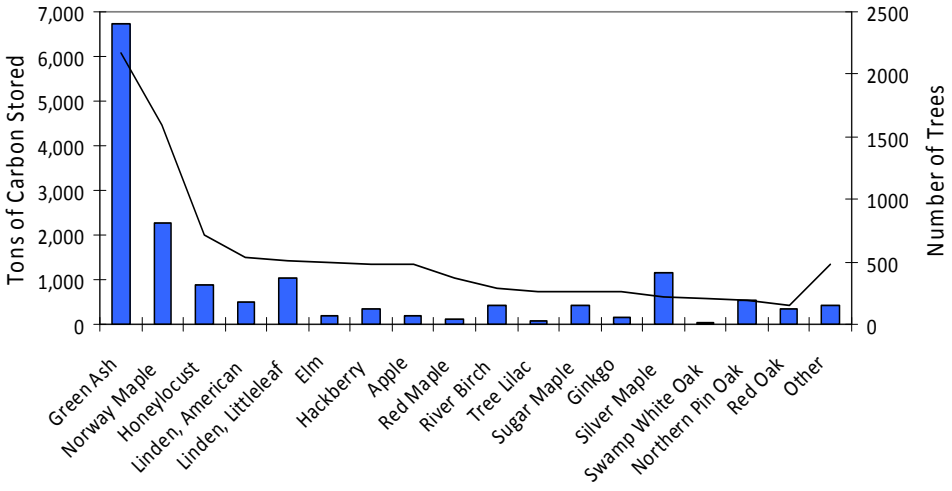


Figure 5: Carbon storage per species

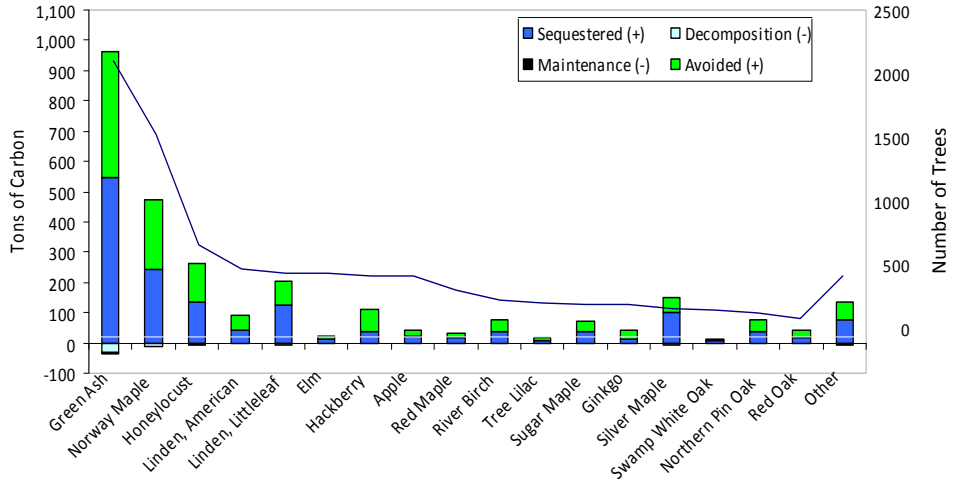


Figure 6: Carbon sequestration per species population
Dark blue represents annual carbon removed from the atmosphere while light blue represents carbon released through decomposition of plant biomass (below the x-axis)

Annual uptake of atmospheric carbon in District 2 sequesters 3,029,496 pounds of carbon each year with an estimated economic value of $22,721. Most of this is stored as woody biomass though 157,677 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 1.1 million pounds of carbon annually, more than 36% 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 area buildings. In total the trees in District 2 reduce

atmospheric carbon by nearly 5.45 million pounds annually through sequestration and pollution avoidance at an economic value of $40,892.

Stormwater

Street trees in District 2 intercept 11.3 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 District 2 intercept an estimated 11.3 million gallons of stormwater annually with an estimated economic value of $307,562. Tree species with large canopies including silver maple ($86.33/tree) and green ash ($52.49/tree) provide the greatest per tree benefit due to the amount of leaf surface area and canopy spread available to capture rainfall. Ash trees provide the greatest contribution to stormwater reductions and as a genera intercept 4.2 million gallons, or 37% of the total volume captured by the street tree canopy.

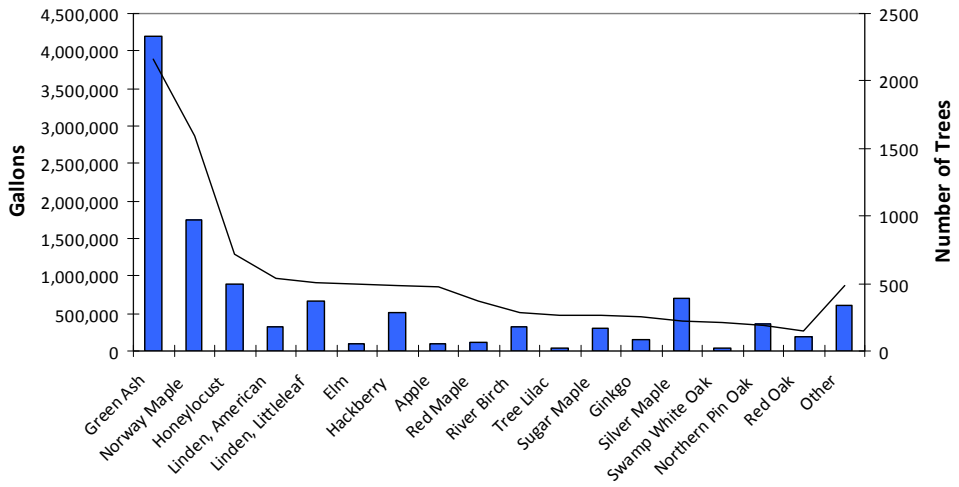


Figure 7: Stormwater runoff reductions per species population

District 2-Greater East Side
Street Tree Canopy Assessment Results

	Current Benefits	Ash Tree Population**	% Ash
District Land Area (does not include water surface area)	2,508 acres	2,508 acres	100%
Number of Street Trees	9,655	2,233	23%
Street Tree Canopy Area*	144 acres	49 acres	34%
Percentage of Land Cover	5.7%	2%	34%
Annual Energy Reductions			
Electricity	1,548 MWh	503 MWh	32.5%
Natural Gas	204,653 Therms	65,419 Therms	32%
Annual Economic Value	$241,259	$77,644	32.2%
Carbon Reductions			
Stored in Street Trees	32.8 million pounds	13.6 million pounds	41.5%
Sequestered Annually	3 million pounds	1.1 million pounds	36.8%
Avoided Annually	2.6 million pounds	842,865 pounds	32.5%
Annual Economic Value	$286,562	$116,338	40.6%
Annual Removal of Air Pollutants			
Ozone	1,454 pounds	420 pounds	28.9%
Nitrogen dioxide	244 pounds	67 pounds	23.4%
Particulate matter	774 pounds	221 pounds	28.6%
Sulfer dioxide	66 pounds	19 pounds	28.8%
Annual Air Pollutants Avoided			
Nitrogen dioxide	7,328 pounds	2,369 pounds	32.3%
Particulate matter	1,072 pounds	347 pounds	32.3%
VOC's	1,023 pounds	332 pounds	32.5%
Sulfer dioxide	7,017 pounds	2,278 pounds	32.5%
Annual Economic Value	$51,967	$17,129	33%
Stormwater Mitigation			
Runoff reductions	11.35 million gallons	4.27 million gallons	37.6%
Annual Economic Value	$307,562	$115,629	37.6%
Aesthetic/Other Benefits			
Annual Economic Value	$159,264	$50,018	31.4%
Total Net Annual Benefit	$800,944	$274,593	34.3%

*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, some of which are difficult to quantify through standard economic measures. iTree accounts for these intangible benefits in the aesthetic/other benefits category which includes property values and neighborhood aesthetics. Street trees in District 2 contribute an estimated $159,264 annually to the economic value of the neighborhood with honeylocust ($37.43/tree) and silver maple ($37.83/tree) identified as the top two trees followed by linden ($25.52) and green ash ($22.53). The economic benefit of forest cover on property values is likely much greater as tree canopy has been shown to increase home prices up to 6% of their 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 2 by 34%, or $274,593 annually.

Emerald ash borer (EAB) was discovered in the Saint Anthony Park neighborhood of Saint Paul in May of 2009. 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. This issue is concerning as ash trees comprise 23% of all street trees in the Greater East Side neighborhood and were identified as the primary tree of importance in District 2. The loss of these trees without a planned and proactive response would have a noticeable impact on the capacity of the urban forest to provide ecosystem services to the community as well as the experiential quality of the streetscape.

To better understand the potential impact EAB could have in District 2, 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 Greater East Side and the potential loss of ash trees would reduce the environmental and economic value of the street canopy.

- Annual economic benefits would decrease by $274,593 or 34%
- Carbon stored in woody biomass would decrease by 13.6 million pounds and the amount of carbon sequestered by street trees could decline by 1.1 million pounds annually
- Annual stormwater interception would decrease by 4.27 million gallons
- Removal of air pollutants would decrease by 727 pounds a year
- Aesthetic benefits would decline by approximately $50,018 annually

Goals

This report is an initial measurement of the environmental and economic benefits provided by the street trees in District 2. 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 EAB. Additionally, it provides a baseline data set to measure changes in subsequent environmental benefit studies.

Goals for the Greater East Side 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.

- 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 better growing conditions than city boulevards and are able to support a wide variety of tree species not typically planted as street trees including fruit and nut bearing species.

- Enhance species diversity within the public right of way by planting a mix of tree types. Species selection should be coordinated with the Street and Park Tree Master Plan and street tree inventory to support species diversity goals. 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 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.

- 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 $103,000 based on real estate estimates quoted on Saint Paul Real-Estate/ReMax Results, Trulia, and Zillow on October 18, 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 March 2013 based on inventory data collected during 2011-2012.