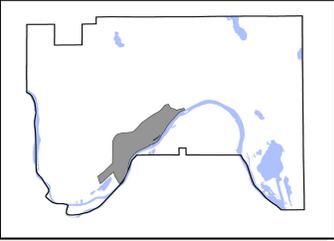# Urban Forest Benefits Report

District 9-West Seventh

Zachary Jorgensen

The West Seventh neighborhood is located southwest of downtown Saint Paul along the Mississippi River and is a mix of historic residential neighborhoods, active commercial districts, industry, and vibrant outdoor park land within the river valley. At 1,589 acres the district covers 4.5% of the city's 35,931 acre land area.

The 2011 canopy assessment found that District 9 ranks 13th out of 17 districts with an overall canopy cover of 26.6%, or 6% below the city average of 32.5%. This level of canopy cover can be attributed to the large industrial and commercial land uses that developed historically and continue to operate in District 9 as well as the significant regional transportation corridors that connect Saint Paul following the Mississippi River. Canopy cover on the city right of way was identified as 29%.

During 2011/12, a comprehensive street tree inventory was completed cataloging the boulevard trees of District 9. 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 West Seventh, 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:

West Seventh Benefits Summary	
District area	1,589 acres
Number of street trees	5,323
Canopy area	79*/141** acres
Energy reduction	$132,262
Carbon sequestered	1.7 million pounds
Total carbon stored	16.8 million pounds
Avoided carbon emissions	1.4 million pounds
Air pollutants removed	1,407 pounds
Air pollutants avoided	8,988 pounds
Stormwater runoff avoided	6 million gallons
Aesthetic/Other benefits	$132,419
Total annual benefit	$478,094

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.

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[1] Tree benefit model developed by the USDA Forest Service

Forest Structure

Tree Genera and Species Distribution

A 2011-2012 inventory of the West Seventh neighborhood identified 5,323 street trees comprised largely of 4 genera including maple (29%), ash (17%), linden (13%), and honeylocust (12%) which account for 73% of all street trees in District 9. Norway maple varieties, which are planted for their ability to tolerate difficult urban conditions, are the most widely planted species and account for 15% of the street tree population and 53% of the maple tree population. 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 in line with recommendations that tree canopies contain no more than 30% of a single family, 20% of a single genus, or 10% of a single species (Santamour).

With the arrival of emerald ash borer, significant shifts in species distribution may occur as ash trees, which account for 17% of boulevard trees, are replaced with other species.

Maple trees comprise a significant portion of District 9'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 39% of the remaining street tree population.
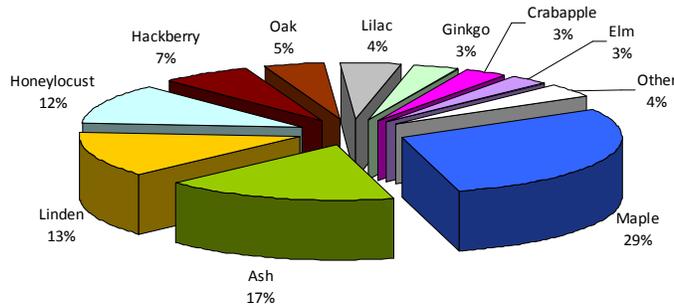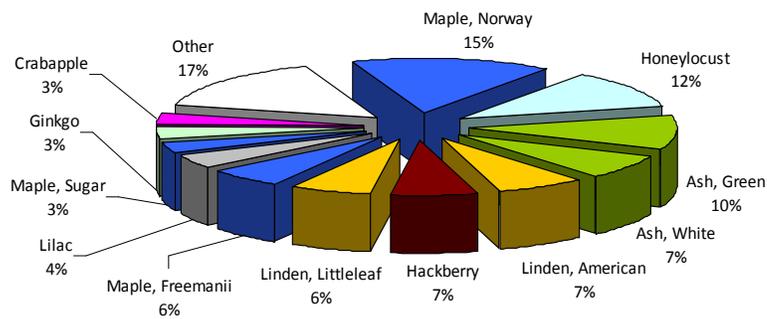

Figure 1: Genera Diversity

Figure 2: Species Diversity

Size Distribution

The size distribution of trees, determined by measuring the trunk diameter 4.5' above ground level (DBH), shows that the street tree population in District 9 is well distributed across the six size groups between 0" and 18" in diameter which represents 88.1% of the street tree population. Trees between 19" and 24" comprise 8.4% of the street tree population while those above 24" (typically oak, ash, maple, or linden) comprise 3.5% of the population. In 2012, 204 new 2" trees were planted in the district.
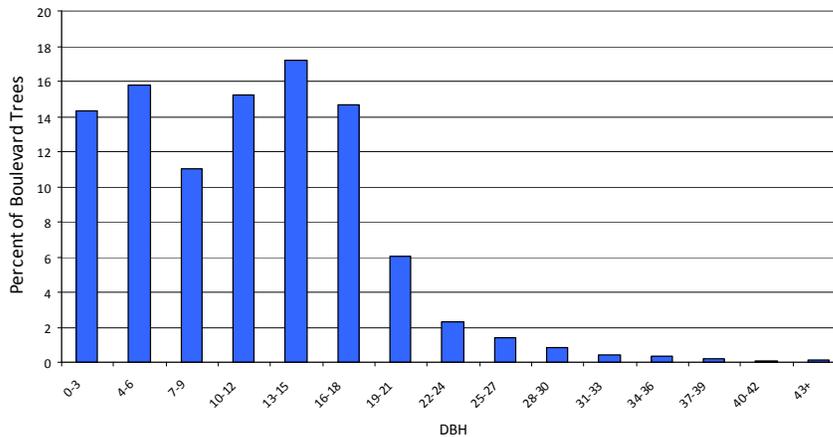
Figure 3: Size distribution as measured by trunk diameter 4.5 feet above ground (DBH)

Further analysis of the eight most widely planted tree genera reveals that current diversity ratios will remain relatively stable over time with relative increases in the number of elms, oaks, and hackberry while ash and ginkgo trees will become less prevelant. A number of additional tree species ('Other' in figure 4) are being planted, to increase species diversity.

- 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 a modest increase in the percentage of elm trees within the urban forest. Recently planted elm trees 0"-6" in diameter represent 2.3% of the district's street trees while all other elms account for only 0.6% 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 17% of the street tree population.

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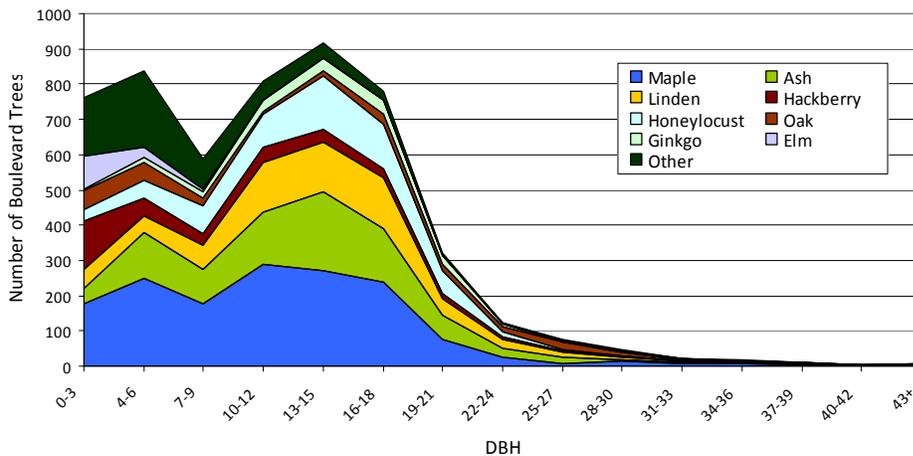

Figure 4: Primary Species Distribution

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- Maple trees are widely planted in the West Seventh neighborhood and represent 29% of all trees growing in District 9. Measured by category, maples represent 23% of trees 0"-3" in diameter and 30% or more of trees in each diameter class up to 18" 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 on public and private property can limit overall species diversity and may reduce forest resiliency.

Tree condition ratings in District 9 show that street trees are largely identified as good to fair condition with 71.5% of boulevard trees rated in good condition, 20.3% rated in fair condition, and 7.2% considered to be in poor condition. Ash trees rated slightly lower in overall condition than the district average with 53% found to be in good condition, 37% rated in fair condition, and 10% rated in poor condition.

Land Use and Site Conditions

Land use analysis within District 9 measured land area as 37% residential, 18% industrial, 7% park land, 6% commercial, and 31% 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 found primarily in residential neighborhoods (87.4%) followed by commercial (10.2%) and industrial lands (2.4%).

Tree planting sites in the district's residential neighborhoods are located on turf covered boulevards that range in width from as little as 3 feet wide up to 15 feet or more. Planting boulevards located along the commercial corridors of West 7th Street and the industrial areas between West 7th and Shepard Road are a mix of sidewalk cutouts and turf. Boulevard width and soil volumes available for tree growth in District 9 are influenced by the surrounding land use and development patterns as well as the shallow bedrock found in much of the neighborhood. Wider boulevards provide greater soil volumes and better soil conditions that typically support more vigorous tree growth and larger tree canopies.

Canopy Cover

District 9 covers approximately 1,589 acres of land area and has a total tree canopy cover of 26.6% as determined by the 2011 canopy assessment. The public right of way (tree planting boulevards, streets, and sidewalks) accounts for 30% of district land area and has a canopy cover of 29%, or 141 acres of tree canopy of which, 79 acres is provided by public boulevard trees. Boulevard trees account for 17% of the district's 456 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. The total number of trees, total leaf surface area, and overall canopy cover of each species are averaged to calculate the RI value. The RI value indicates the tree population's ability to mitigate

87% of street trees are found in residential neighborhoods, 10% in commercial areas, and only 2.4% in industrial areas.

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

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

stormwater runoff, improve air quality, promote energy conservation, and provide other benefits in relation to the other tree species populations.

Within District 9, Norway maple received the highest single species importance value rating of 15.5 points due to their large presence in the urban canopy comprised of 822 trees, or 15% of street tree population, and 1.3 million square feet of leaf surface area. Together, green and white ash have an importance value of 20.3, contributing a significant portion of the districts benefits with 935 trees and over 2 million square feet of leaf surface area.

Small stature trees including crabapple (RI<0.5) and Japanese tree lilacs (RI=1.8) will maintain small RI values compared to large canopy trees regardless of population size due to the small canopy and leaf area these trees produce. As a group however, these trees should not be overlooked as they are able to be planted under utility lines and other locations larger trees cannot while contributing aesthetic value to city boulevards.

	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	822	15.4	1,296,072	14.7	562,529	16.3	15.5
Honeylocust	615	11.6	1,494,858	16.9	616,073	17.8	15.4
Green Ash	549	10.3	1,401,850	15.9	469,430	13.6	13.3
White Ash	386	7.3	612,361	6.9	236,849	6.9	7.0
Linden, American	362	6.8	653,823	7.4	228,073	6.6	6.9
Linden, Littleleaf	342	6.4	677,768	7.7	214,242	6.2	6.8
Hackberry	352	6.6	365,629	4.1	186,848	5.4	5.4
Red Maple	370	7.0	184,397	2.1	120,832	3.5	4.2

Table 2: Trees with the a relative importance value over 4 on a 100 point scale

Canopy Benefits

Annual Benefits:

The 5,323 street trees planted in the West Seventh neighborhood provide an estimated $478,094 worth of environmental services to the community and form an important part of Saint Paul's green infrastructure network. This represents an average annual economic value of $89.82 per tree and is significant considering that these values only account for trees found along the public right of way and do not include 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 ($221.45/tree), pin oak ($196.90/tree), and honeylocust ($152.40/tree). Japanese Tree Lilacs contribute the smallest environmental benefit at $13.08/tree. As a genera, ash and maple trees provide the largest contribution of environmental and economic benefits to the neighborhood due to the significant number of these trees planted in District 9.

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 mitigate microclimates within the urban landscape 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 9 this environmental service totals $132,262 per year in energy and natural gas savings, reducing energy demand by 846 MWh per year and natural gas usage by 112,465 Therms, or slightly more than 11 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 production of these energy sources.

Trees with large canopies including pin oak ($46.07/tree) and silver maple ($44.52) provide the largest per tree benefit. Norway maple ($23,744) and honeylocust ($21,569) are widely planted in District 9 and provide the largest cumulative benefit. Unsurprisingly, small trees such as Japanese tree lilac ($6.15) provide a smaller level of energy savings. Their role should not be overlooked as they provide shade in areas where larger species may not have room to grow including over residential air conditioner units (shade improves efficiency) and under 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 improve air quality by removing pollutants through deposition and altering local microclimates, reducing energy demand and the emissions associated with its production.

Boulevard trees in the West Seventh neighborhood remove an estimated 1,407 pounds of air pollutants through deposition. The shade these trees provide also reduces energy demand helping avoid the release of 8,616 pounds of emissions annually for a projected total value of $28,093 per year. Silver maple ($10.45) and honeylocust ($7.45) provide the greatest per tree environmental and economic benefit with Norway maple ($5,169) and honeylocust ($4,579) providing the greatest overall species level benefit. 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

Reducing carbon emissions from urban areas is a critical component of developing a sustainable city. A well maintained urban forest is able to reduce carbon emissions by sequestering carbon and storing it in plant biomass and soils.

Boulevard trees in District 9 store an estimated 16.76 million pounds of carbon and sequester 1.7 million pounds each year.

Currently, street trees in District 9 are storing 16.76 million pounds (8,380 tons) of carbon with an estimated economic value of $125,728. Green ash tree biomass comprises the largest share of carbon storage within the district at nearly 2.8 million pounds, or 16.7% of total stored carbon followed by Norway maple at 2.6 million pounds, or 15.8% of the total. Individually, silver maple ($94.97/tree) and pin oak ($80.06/tree) provide the greatest amount of carbon storage per tree due to the relatively mature size of these trees in District 9.
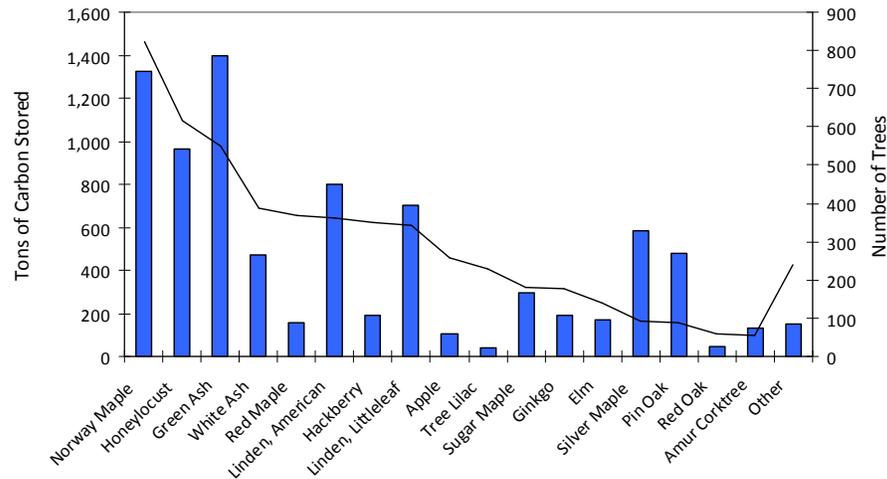

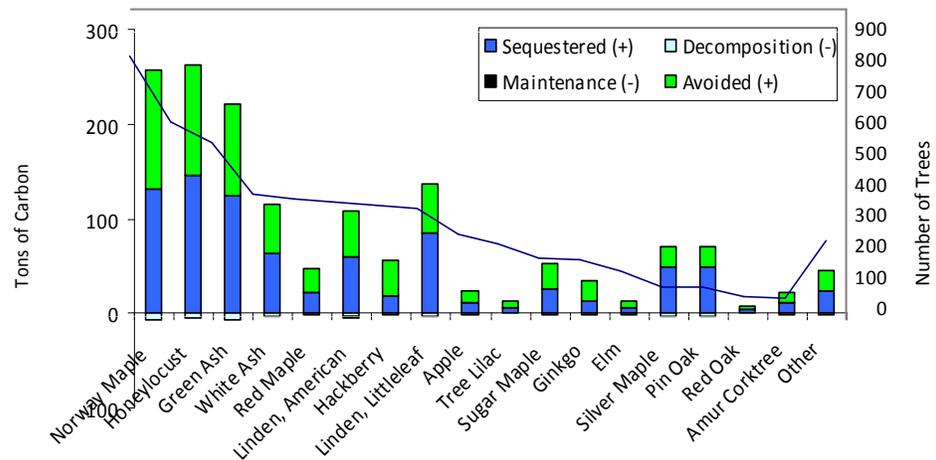Figure 5: Carbon storage per species

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 District 9 sequesters 1,697,385 pounds of carbon each year with an estimated economic value of $12,730. Most of this is stored as woody biomass though 80,720 pounds, or nearly 5%, is returned to the atmosphere via decomposition. Pin oaks ($11.40) and silver maple ($11.04) again provide the largest per tree benefit due to their fast growth rate and large size. Honeylocust (292,247

pounds), Norway maple (262,283 pounds), and green ash (249,133 pounds) sequester 47% of all carbon captured in the district.

In addition to sequestering carbon directly from the atmosphere, trees provide shade and mitigate local microclimates reducing energy demand and avoiding an estimated 1.4 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 9 reduce atmospheric carbon by nearly 3.1 million pounds annually through sequestration and pollution avoidance at an economic value of $22,701.

Stormwater

Trees are an important part of Saint Paul's green infrastructure system and have the ability to intercept significant amounts of rainfall before it falls on impervious surfaces and becomes runoff. Preventing runoff has multiple economic and environmental benefits that include water quality improvements by reducing pollutants entering local water bodies, increased infiltration rates, and volume load reductions on stormwater infrastructure. Tree canopies are most effective at reducing runoff from small rain events and lowering peak runoff rates for larger storm events.

Currently, boulevard trees in District 9 intercept an estimated 6 million gallons of stormwater annually with an estimated economic value of $162,620. Tree species with a large canopy including silver maple ($100.04/tree) and pin oak ($74.17/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 and as a species intercept 990,369 gallons followed by honeylocust (933,325 gallons) and green ash (920,338 gallons). These three tree species account for 47%, of the total volume captured by the street tree canopy.

Figure 7: Stormwater runoff reductions per species population

District 9's street trees intercept 6 million gallons of rainfall, reducing runoff and improving local water quality. Used in combination with other stormwater best management practices to capture and infiltrate rain fall, trees are an integral part of an effective green infrastructure system.
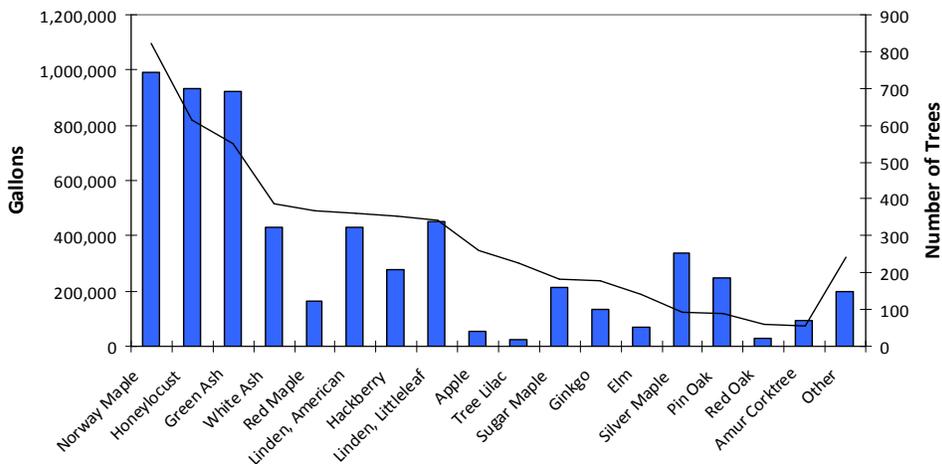
District 9-West Seventh Neighborhood
Street Tree Canopy Assessment Results

	Current Benefits	Ash Tree Population**	% Ash
District Land Area (does not include water surface area)	1,589 acres	1,589 acres	100%
Number of Street Trees	5,323	921	17.3%
Street Tree Canopy Area*	79 acres	16 acres	20.3%
Percentage of Land Cover	5%	1%	---
Annual Energy Reductions			
Electricity	846 MWh	175 MWh	20.7%
Natural Gas	112,465 Therms	21,870 Therms	19.4%
Annual Economic Value	$132,262	$23,391	17.7%
Carbon Reductions			
Stored in Street Trees	16.76 million pounds	3.67 million pounds	21.9%
Sequestered Annually	1.7 million pounds	368,015 pounds	21.7%
Avoided Annually	1.4 million pounds	292,659 pounds	20.6%
Annual Economic Value	$148,429	$32,343	21.8%
Annual Removal of Air Pollutants			
Ozone	807 pounds	114 pounds	14.1%
Nitrogen dioxide	136 pounds	18 pounds	13.2%
Particulate matter	428 pounds	64 pounds	15%
Sulfer dioxide	36 pounds	5 pounds	13.9%
Annual Air Pollutants Avoided			
Nitrogen dioxide	4,009 pounds	815 pounds	20.3%
Particulate matter	586 pounds	120 pounds	20.5%
VOC's	559 pounds	115 pounds	20.5%
Sulfer dioxide	3,834 pounds	791 pounds	20.6%
Annual Economic Value	$28,093	$5,753	20.5%
Stormwater Mitigation			
Runoff reductions	6 million gallons	1.33 million gallons	22.1%
Annual Economic Value	$162,620	$35,974	22.1%
Aesthetic/Other Benefits			
Annual Economic Value	$132,419	$26,000	19.6%
Total Net Annual Benefit	$478,094	$98,928	20.7%

*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 9 contribute an estimated $132,419 annually to the economic value of the neighborhood with honeylocust ($62.46/tree) and pin oak ($57.29/tree) identified as the top two trees followed by silver maple ($55.41) and littleleaf linden ($34.00). 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 9 by 21%, or $98,928 annually.

Emerald ash borer (EAB) was first discovered in the Saint Anthony Park neighborhood of Saint Paul in May of 2009 with subsequent discoveries outside of the primary infestation area in 2011 and 2013 (see www.stpaul.gov/forestry for the current information). 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 17% of all street trees in the West Seventh neighborhood. The loss of these trees without a managed response will have a noticeable impact on the capacity of the urban forest to provide ecosystem services to the community.

To better understand the potential impact EAB may have in District 9, 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 West Seventh neighborhood and the potential loss of ash trees would reduce the environmental and economic value of the street canopy.

- Annual economic benefits would decrease by $98,928 or 21%

- Carbon stored in woody biomass would decrease by 3.7 million pounds and the amount of carbon sequestered by street trees annually could decline by 368,015 pounds

- Annual stormwater interception would decrease by 1.3 million gallons

- Removal of air pollutants would decrease by 201 pounds a year

- Property values and other benefits would decline by approximately $26,000 annually

Thus far, EAB management has kept pace with the beetle's spread and strategies are focusing on the removal and replacement of infested ash trees, ash monocultures, and those in poor condition to increase species diversity and reduce the potential long term risks and costs associated with EAB. EAB management priorities and strategies may shift as the beetle continues to spread to new areas.

Recommendations

This report is an initial measurement of the environmental and economic benefits provided by the street trees in District 9. 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 EAB. Additionally, it provides a baseline data set to measure changes in subsequent environmental benefit studies.

Recommendations for the West Seventh 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 land currently has a canopy cover of 29%. Private yards often provide better growing conditions than city boulevards and able to support a wide variety of tree species not typically planted as street trees including fruit and nut bearing trees.

- Enhance species diversity within the public right of way by limiting the number of maples (currently 29% of the district's boulevard tree population) planted in District 9 while selecting alternative tree species that are appropriate for the growing conditions found at each site. Species selection should be coordinated with the Street and Park Tree Master Plan to support species diversity goals. Hackberry, oak, elm, birch, Kentucky coffeetree, and other underutilized trees can be more widely planted to support this recommendation.

- 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.

- Examine opportunities to enhance the planting conditions found along West Seventh where small sidewalk cutouts currently exist to support future canopy establishment and tree growth.

Appendix

The following values were used to determine the economic benefits provided by the street tree canopy of District 9

- 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 $137,233 based on real estate estimates quoted on Saint Paul Real-Estate/ReMax Results, Trulia, and Zillow on October 16, 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:

CO_2 ($/lb)	0.0075
$PM10$ ($/lb)	2.84
NO_2 ($/lb)	3.34
SO_2 ($/lb)	2.06
VOC ($/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 February 2013 based on inventory data collected during 2011-2012.