Urban Forest Benefits Report

District 15-Highland

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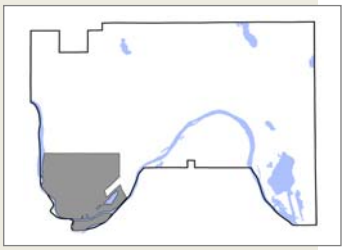


The Highland neighborhood is located in the southwest corner of Saint Paul and is a mix of residential neighborhoods, community scale commercial districts, and vibrant outdoor park lands overlooking the Mississippi river valley. At 3,872 acres the district covers slightly more than 10% of the city's 35,931 acre land area.

Residential neighborhoods and park land including Highland Park and Hidden Falls-Crosby Farm Regional Park account for the largest percentage of land use in Highland and support a significant level of urban tree cover. A 2011 canopy assessment found that District 15 has the highest canopy cover of any district at 43.1% of land area, 10.6% 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 support tree growth as well as an extensive network of park land that supports diverse forest plant communities. Community support for tree canopy is also strong and contributes to the ongoing development and care of Highland's urban forest.

During 2011/12, a comprehensive street tree inventory was completed cataloging the boulevard trees of District 15. 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 Highland, 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:

Highland Benefits Summary

District area	3,872 acres
Number of street trees	11,203
Canopy area	155*/350** acres
Energy reduction	$251,540
Carbon sequestered	3.1 million pounds
Total carbon stored	37.3 million pounds
Avoided carbon emissions	2.7 million pounds
Air pollutants removed	2,772 pounds
Air pollutants avoided	16,965 pounds
Stormwater runoff avoided	12.6 million gallons
Aesthetic/Other benefits	$378,447
Total annual benefit	$1,066,024

Table 1: Benefits summary

*Boulevard trees included in the street tree inventory provide an estimated 155 acres of tree canopy
**Total right of way canopy cover identified by the 2011 canopy assessment approaches 350 acres

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

Forest Structure

Genera Distribution

Inventory data collected in 2011-2012 reveals that the Highland neighborhood has 11,203 street trees growing along nearly 72 miles of boulevards. Three genera including maple (27%), ash (23%), and linden (12%) account for 62% of all street trees in Highland limiting overall species diversity. Interestingly, Norway maple varieties, which are planted for their ability to tolerate difficult urban conditions, account for 54% of the maple tree population. Species including oak, hackberry, disease resistant elm, 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 Highland'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 35% of the existing street tree population.

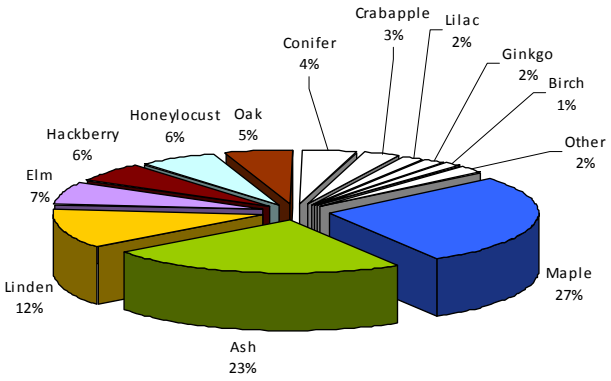


Figure 1: Genera Diversity

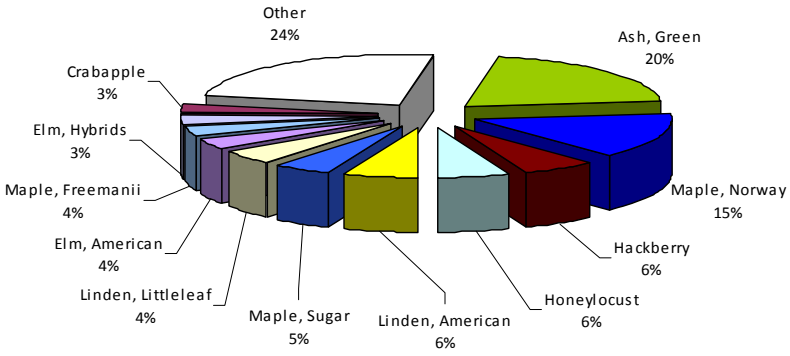


Figure 2: Species Diversity

Size Distribution

The size distribution of trees, represented by trunk diameter measured 4.5' above ground level (DBH), reveals that the boulevard tree population in Highland is composed largely of younger trees with nearly 64% of street trees at or below 12" in diameter. Large canopy trees that measure over 24" in diameter represent only 6% of the

population. Over 1,100 new trees were planted in District 15 in 2011 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.

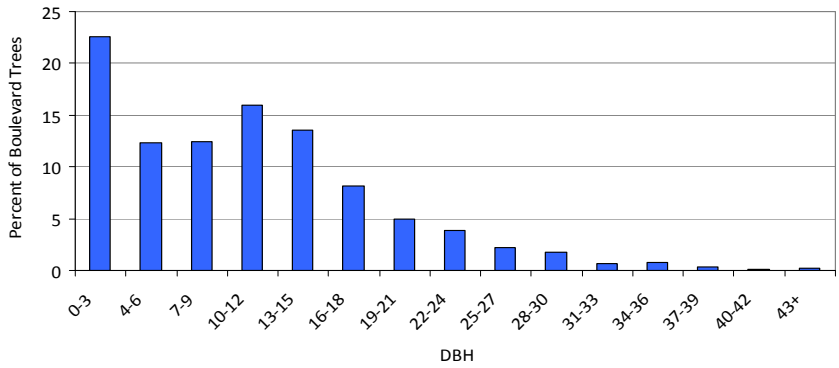


Figure 2: Size distribution as measured by tree diameter 4.5 feet above ground (DBH)

Further analysis of the size distribution for the seven most abundant tree genera reveals that current diversity ratios at this level will remain relatively stable over time based on recent species selections for new tree planting projects. Elm and ash trees represent notable exceptions to this trend. Dutch elm disease caused wide spread losses of elm trees in Saint Paul and new varieties of DED resistant elms continue to be developed and planted. This has lead to a marked increase in the percentage of elm trees within the urban forest. Elm varieties represent 20% of all trees 0"-3" in diameter versus 1%-4% of trees greater than 4" in diameter. Conversely, ash trees are no longer being planted due to the discovery of emerald ash borer in Saint Paul in 2009 and continued canopy losses as these trees decline will significantly reduce the ash population as a percentage of the total tree inventory.

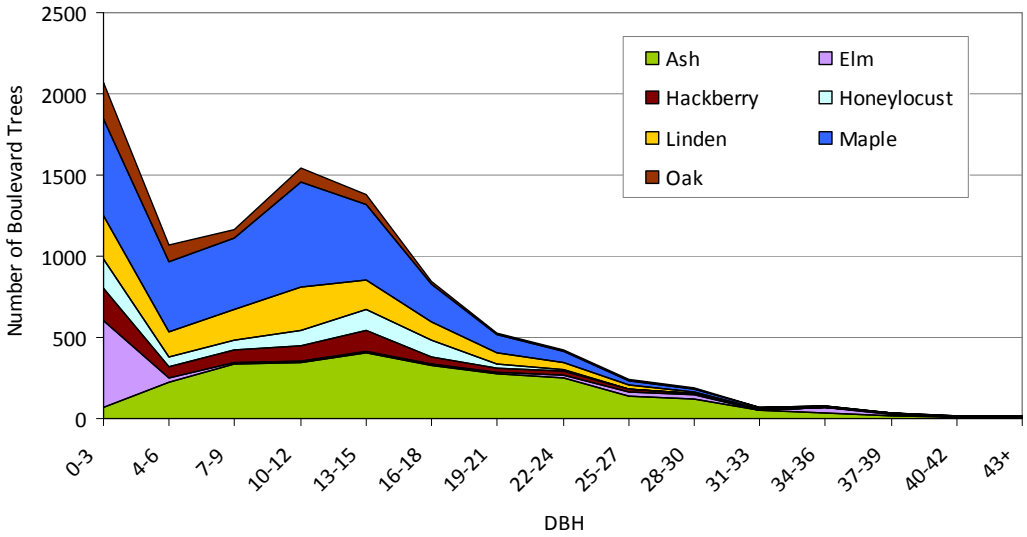
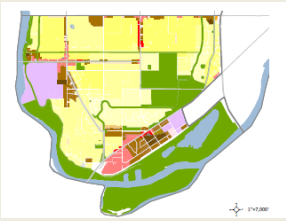


Figure 3: Primary Species Distribution

Maple trees are widely planted in Highland and represent 27% of all trees growing in District 15. Measured by category, maples represent 23% of trees 0”-3” in diameter and over 30% of trees in each diameter class up to 15” and will remain a substantial portion of the canopy moving forward. While these trees provide significant environmental and social benefits, the continued wide spread planting of maples will limit overall species diversity and forest resiliency.

Tree condition ratings in Highland are favorable with 66% of boulevard trees rated in good condition, 30% rated in fair condition, and 3.5% considered to be in poor condition. Ash trees rated lower in overall condition than the district average with 18% found to be in good condition, 75.5% rated in fair condition, and 6.5% rated in poor condition.



Residential land use, represented in yellow, accounts for 54% of district land area and contains over 92% of city managed boulevard trees.

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

Land Use

Detailed land use analysis within District 15 has measured land area as 34% residential, 22.5% park land, 5% industrial, 3% commercial, and 19.6% public right of way (streets) with the remaining defined as other land uses or water (2011 Canopy Assessment). The existing street tree populations are highest in residential areas (93%) followed by commercial (6%) and industrial lands (1%).

Tree planting sites in the district’s residential neighborhoods are located primarily on turf covered boulevards while commercial corridors located along Ford Parkway, Snelling Avenue, and West 7th Street 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 with residential turf boulevards ranging in size from as little as 4 feet wide to 12 feet or more while commercial districts range from 3 foot cutouts along West 7th to more generous planting beds and boulevards along Snelling Avenue and Ford Parkway. Wider boulevards provide greater soil volumes and better soil conditions that typically support larger tree canopies and tree growth.

Canopy Cover

District 15 covers approximately 3,872 acres of land area and has a total tree canopy cover of 43.1% as determined by the 2011 canopy assessment. The city right of way, which includes tree planting boulevards, represents 19% of district area and has a canopy cover of 46%, or 350 acres of tree canopy of which, 155 acres is provided by public boulevard trees. Boulevard trees account for 9% of the district’s 1,646 acres of overall canopy cover.

Tree cover exists primarily in the extensive residential neighborhoods and park lands that cover nearly two thirds of the district and is less prominent in the industrial areas where large buildings, storage, and transportation infrastructure limit tree planting. Nearly 93% of boulevard trees are planted in residential neighborhoods where boulevards are wide and provide adequate soil volumes that support mature tree establishment and growth.

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

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 stormwater, improve air quality, shade buildings, and provide other benefits.

Within District 15, ash received the highest importance value rating of 33.7 points due to their large presence in the urban canopy comprised of 2,599 trees representing 36% of the total canopy cover and 8.04 million square feet of leaf surface area. Norway maple was rated second with an RI value of 13.9 and a leaf area of 2.3 million square feet.

Japanese tree lilacs and river birch trees received the lowest importance ratings of 0.8 and 0.6 respectively. This is primarily due to the relatively small leaf surface area and structure of Japanese tree lilacs and the small population size of river birch in District 15 which reduces the ability of these tree species as a whole to intercept large volumes of stormwater or sequester and store large amounts of carbon. Neither tree should be over looked for use in the urban landscape as each brings important characteristics to city boulevards. Japanese tree lilacs 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
Ash	2,599	23.2	8,042,879	41.6	2,448,475	36.4	33.7
Norway Maple	1,653	14.8	2,307,080	11.9	1,014,743	15.1	13.9
Linden	1,211	10.9	1,390,224	7.2	634,945	9.4	9.1
Honeylocust	667	6	1,181,220	6.1	506,802	7.5	6.5
Elm	570	5.1	1,571,956	8.1	366,141	5.4	6.2
Hackberry	679	6.1	832,254	4.3	421,076	6.3	5.5
Sugar Maple	536	4.8	653,979	3.4	282,272	4.2	4.1
Silver Maple	175	1.6	683,989	3.5	201,884	3	2.7

Table 2: Trees with the highest relative importance value

Canopy Benefits

Reference page 9 for a complete list of the environmental and economic benefits provided by the street trees in Highland

Annual Benefits:

The 11,203 street trees planted in Highland provide an estimated $1,066,024 worth of environmental services to residents in District 15 and form an important part of Saint Paul's green infrastructure nework. This represents an average annual economic value of $95.15 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 economic benefit are silver maple ($197.93/tree), green ash ($152.49/tree), and honeylocust ($147.10/tree). Japanese Tree Lilacs contribute the smallest environmental benefit at $14.74/tree. As a genera, ash and maple trees provide the largest contribution of environmental benefits to the Highland neighborhood due to the significant number of these trees planted in District 15.

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 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 15 this environmental service totals $251,540 per year in energy and natural gas savings, reducing energy demand by 1,593 MWh per year and natural gas usage by 144,987 Therms. While these are estimates, the savings provided are substantial and reduce the amount of carbon released into the atmosphere from these energy sources.

Trees with large canopies including silver maples ($35.57/tree) and green ash ($34.31) provide the largest per tree benefit. As a group, ash provide the largest cumulative benefit ($80,323) followed by Norway maple ($42,801), two trees that are widely planted across District 15. 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 deposition and by altering local microclimates, reducing energy demand and the emissions associated with its production.

Boulevard trees in Highland remove an estimated 2,772 pounds of air pollutants through deposition. The shade these trees provide also reduces energy demand helping avoid the release of 18,481 pounds of emissions annually at an estimated value of $47,300 per year. Silver maple ($8.06/tree) and green ash ($7.63/tree) provide the greatest environmental and economic benefit followed by honeylocust ($5.73/tree) and Norway maple ($5.58 /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

Boulevard trees in District 15 store an estimated 37.3 million pounds of carbon and sequester 3.1 million pounds each year.

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.

Currently, street trees in District 15 are storing 37.3 million pounds (18,650 tons) of carbon with an estimated economic value of $279,888. Ash tree biomass comprises the largest share of carbon storage within the district at nearly 16.4 million pounds, or 46% of total stored carbon followed by Norway maple at 4.7 million pounds, or 12.6% of the total. Individually, silver maple ($63.79/tree) and green ash ($52.48/tree) provide the greatest amount of carbon storage per tree due to the ability of these species to grow to a large size at maturity.

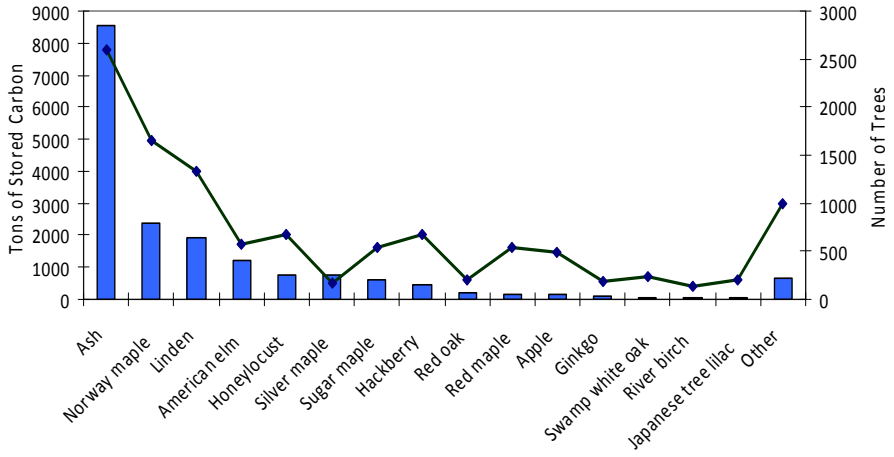


Figure 4: Carbon storage per species

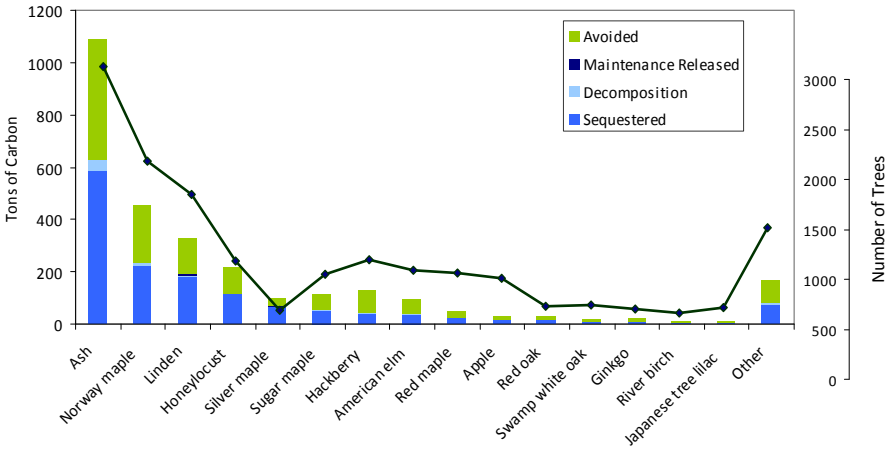


Figure 5: Carbon sequestration per species population
Dark blue represents annual carbon removed from the atmosphere while light blue represents carbon emissions to the atmosphere from the decomposition of plant biomass

Annual uptake of atmospheric carbon in District 15 sequesters 3,092,077 pounds of carbon each year with an estimated economic value of $23,191. Most of this is stored as woody biomass though 179,619 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 1.17 million pounds of carbon annually, more than 40% 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 2.67 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 15 reduce atmospheric carbon by nearly 5.6 million pounds annually through sequestration and pollution avoidance at an economic value of $43,228.

Stormwater

Highland's street trees intercept 12.6 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 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 through stormwater runoff, increased infiltration rates, and volume load reductions on stormwater infrastructure. Tree canopies are most effective at reducing runoff from small rain events as well as the initial rainfall of larger storm events.

Currently, boulevard trees in Highland intercept an estimated 12.6 million gallons of stormwater annually with an estimated economic value of $340,465. Tree species with a large canopy including silver maple ($71.56/tree) and green ash ($54.89/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 over 5 million gallons, or 40%, of the total volume captured by the street tree canopy.

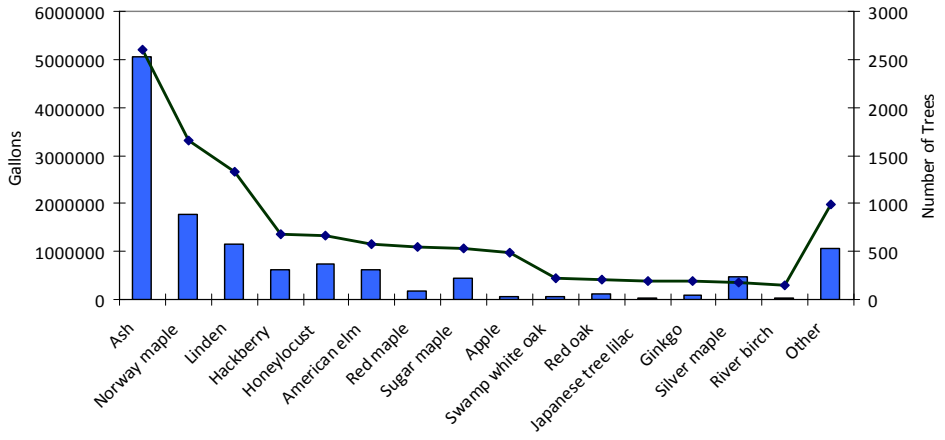


Figure 6: Stormwater runoff reductions per species population

District 15-Highland
Street Tree Canopy Assessment Results

	Current Benefits	Ash Tree Population**	Ash as % of Total Benefits
District Land Area (does not include water surface area)	3,493 acres	3,493 acres	100%
Number of Street Trees	11,203	2,599	23.2%
Street Tree Canopy Area*	155 acres	56 acres	36.1%
Percentage of Land Cover	4.4%	1.6%	36.4%
Annual Energy Reductions			
Electricity	1,593 MWh	551 MWh	34.6%
Natural Gas	215,434 Therms	73,473 Therms	34.1%
Annual Economic Value	$251,540	$86,305	26.7%
Carbon Reductions			
Stored in Street Trees	37.3 million pounds	17.1 million pounds	45.9%
Sequestered Annually	3.1 million pounds	1.26 million pounds	40.7%
Avoided Annually	2.67 million pounds	924,116 pounds	29.9%
Annual Economic Value	$323,116	$144,239	44.6%
Annual Removal of Air Pollutants			
Ozone	1,580 pounds	532 pounds	33.7%
Nitrogen dioxide	265 pounds	85 pounds	32.1%
Particulate matter	852 pounds	273 pounds	32%
Sulfer dioxide	75 pounds	24 pounds	31.2%
Annual Air Pollutants Avoided			
Nitrogen dioxide	7,583 pounds	2,613 pounds	34.5%
Particulate matter	1,106 pounds	382 pounds	34.5%
VOC's	1,055 pounds	364 pounds	34.5%
Sulfer dioxide	7,221 pounds	2,497 pounds	34.6%
Annual Economic Value	$53,816	$19,206	35.7%
Stormwater Mitigation			
Runoff reductions	12.56 million gallons	5,059,362 gallons	40.3%
Annual Economic Value	$340,465	$137,119	40.3%
Aesthetic/Other Benefits			
Annual Economic Value	$378,447	$128,458	36.9%
Total Net Annual Benefit	$1,066,024	$386,801	36.3%

*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 effected 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 15 contribute an estimated $378,447 annually to the economic value of the neighborhood with honeylocust ($78.97/tree) and silver maple ($74.34 /tree) identified as the top two trees followed closely behind by green ash ($49.42) and white ash ($49.47). 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 15 by 36%, or nearly $387,000 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. This issue is concerning as ash trees comprise 23% of all street trees in the Highland neighborhood and were identified as the primary tree of importance in District 15. The loss of these trees without a planned response will 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 may have in District 15, 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 Highland 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 $386,801 or 36%
- Carbon stored in woody biomass would decrease by 17.1 million pounds and the amount of carbon sequestered by street trees annually could decline by 1.26 million pounds
- Annual stormwater interception would decrease by 5.06 million gallons
- Removal of air pollutants would decrease by 914 pounds a year
- Property values and other benefits would decline by approximately $128,458 annually

Thus far, the spread of EAB in Saint Paul has been limited to two areas and management strategies are focusing on the replacement of monocultures of ash trees as well as those in poor condition to increase species diversity and reduce the potential long term risks and costs associated with EAB.

Goals

This report is an initial measurement of the environmental and economic benefits provided by the street trees in District 15. 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 Highland 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 to Highland.

- 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 tree species diversity within the public right of way, selecting trees that are both appropriate for the growing conditions found at each site and species that, ideally, do not represent more than 10% of the street tree population. Species selection should be coordinated with the Street and Park Tree Master Plan to support species diversity goals.

- 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 of District 15

- 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 $232,600 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 August 2012 based on inventory data collected during 2011-2012.