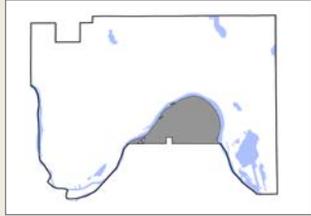


Urban Forest Benefits Report

District 3-West Side

Zachary Jorgensen



The West Side neighborhood is located south of the Mississippi River directly across from downtown Saint Paul. At 2,998 acres, the neighborhood covers approximately 8% of the city's 35,931 acre land area. Development within the district is divided topographically with residential neighborhoods established on the elevated ground above the river bluffs while industrial land uses occur on the Mississippi plain where river, rail, and highway connections provide access to the regional transportation network.

Residential and industrial lands account for the greatest share of the district's land use, directly influencing the extent of urban canopy cover through changes in development density and pattern. Significant land use features include the downtown airport as well as the large regional park lands along the river at Harriet Island and on the bluffs at Cherokee Park. A 2011 canopy assessment study indicated that District 3 has a total canopy cover of 24.1%, eight percent below the average city canopy cover of 32.5%.

In 2010, a complete tree inventory was collected cataloging the boulevard trees of district 3 recording the species type, size, and condition of each tree with subsequent updates entered as trees were either planted or removed. Inventory data was entered into i-Tree Streets¹ to calculate the current environmental services being provided by the urban forest and the associated economic value of these benefits. With potential structural changes resulting from the spread of emerald ash borer, the environmental benefits of the district's ash tree population were calculated to determine the potential impact on the overall benefits of District 3.

The following results are a summary of the findings.

<u>West Side Benefits Summary</u>	
District land area	2,998 acres
Number of street trees	6,895
Canopy area	112 acres
Energy reduction	\$194,470
Carbon sequestered	2.2 million pounds
Total carbon stored	25.6 million pounds
Avoided carbon emissions	1.99 million pounds
Air pollutants removed	2,065 pounds
Air pollutants avoided	12,622 pounds
Stormwater runoff avoided	8.85 million gallons
Aesthetic/Other benefits	\$181,090
Total annual benefit	\$687,091

Table 1: Benefits summary

¹ Tree benefit model developed by the USDA Forest Service

Forest Structure

Species Distribution:

Inventory data collected in 2010-2011 reveals that the West Side has 6,895 street trees growing along nearly 72 miles of boulevards. Maple (30%), ash (22%), honeylocust (12%), and linden (11%) account for 75% of all street trees, limiting overall species diversity. Most significantly, Norway maple varieties, which are planted for their ability to tolerate difficult urban conditions, account for 23% of the street 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 22% of boulevard trees, are replaced with other species.

The systemic loss of ash trees due to the emerald ash borer would shift species diversity, increasing maples to 39% of the street tree population

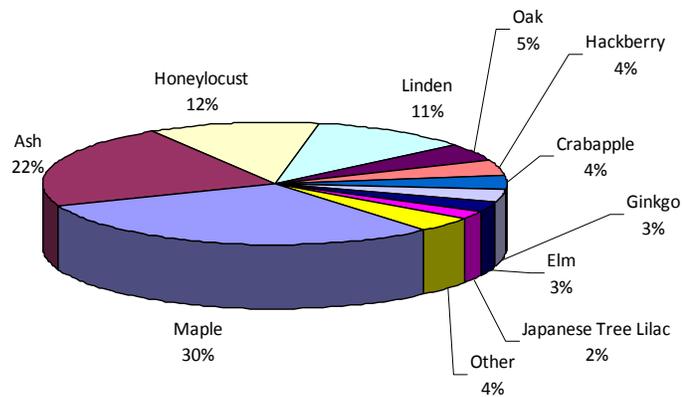


Figure 1: Species Diversity

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 District 3 is trending toward a mature canopy with a slight population depression around 8" caliper size. Trees 10"-18" in diameter represent 51% of boulevard trees while those under 10" diameter represent 34% of boulevard trees.

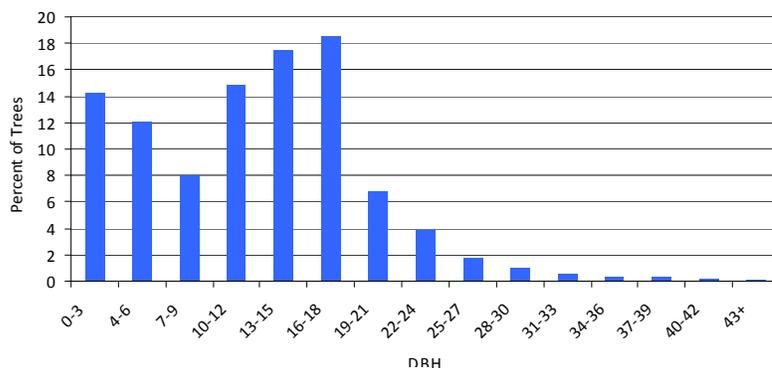


Figure 2: District 3 Diameter Distribution

Further analysis of the 8 most common tree types reveals that current species diversity ratios will remain relatively stable with a few notable exceptions. Elm tree numbers will increase due to the availability of new cultivars resistant to Dutch elm disease. Two species in particular are likely to see significant declines due to biotic factors and social preference. Most significantly, ash trees are no longer planted in Saint Paul and will likely become a minor contingent of the urban forest due to the introduction of emerald ash borer. Ginkgo trees are also no longer planted due to fruit production on unreliably propagated tree stock. This fruit is often considered a nuisance due to its strong odor. Conversely, residents maintain a strong preference for maple trees which will likely remain a large percentage of the urban canopy. While maple trees provide many aesthetic and environmental benefits, planting in large numbers will limit the overall diversity of the urban forest.

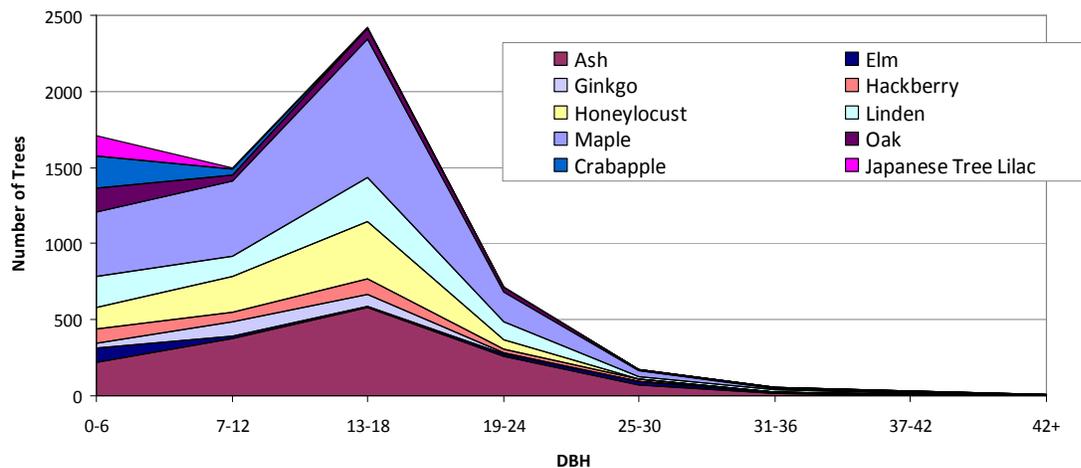


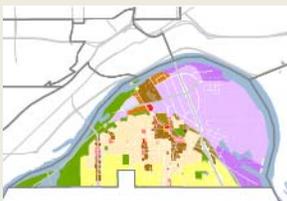
Figure 3: Primary Species Distribution

Trees on the West Side are in good condition with 94.85% rated as fair to excellent, 5.1% considered in poor condition, and .04% identified as dead.

Land Use:

Land use within District 3 has been identified as 26.4% industrial, 25.6% residential, 8% commercial, 8% park land, and 19.2% public right of way with the remaining 12.8% water or other land uses (2011 Canopy Assessment). Street tree populations are highest in residential areas (88%) followed by large commercial/industrial land (8.6%) and small commercial (4.1%). A significant amount of land east of Highway 52 is currently being used as the downtown airport which reduces canopy cover in that area and limits canopy establishment on lands within air traffic flight paths.

Tree planting sites are located primarily on turf covered boulevards in both residential and industrial areas with the exception of the commercial corridors along Wabasha Street, Cesar Chavez Street, and Robert Street where sidewalk cutouts exist. Boulevards vary in the amount of soil volume and planting lawn width with most boulevards between 6-10 feet wide supporting good tree growth. Where narrow boulevards and intensive land use exist, proper species selection will be important for long term tree establishment and survival.



Residential land use, represented in yellow, accounts for 25.6% of the district's land area while supporting 88% of the street tree cover. In comparison, industrial land, represented in purple, accounts for 26.4% of the land area but only 8.6% of the street tree canopy.

Canopy Cover:

District 3 covers approximately 2,998 acres of land with a total tree canopy cover of 24.1%. The city right of way, which includes tree planting boulevards, represents 19% of district land area and has a canopy cover of 35.5%, or 204 acres of tree canopy of which, 112 acres is provided by publicly managed boulevard trees contributing 16% of the district’s overall canopy cover.

Tree cover exists primarily in the residential neighborhoods and park land of the district and is less prominent in the industrial areas where large buildings and a heavy transportation infrastructure restrict tree planting. Nearly 88% of boulevard trees are planted in residential neighborhoods with only 12% located in industrial or commercial areas despite a relatively equal divide in land use.

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 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 environmental benefits.

Within District 3, ash received the highest importance value rating of 25.4 points due to their large presence in the urban canopy comprised of 1,519 trees representing 22% of the total canopy cover and 3.78 million square feet of leaf surface area. Norway maple was rated second with an RI value of 22.1 and a leaf area of 2.66 million square feet. Though not included in the table 2, silver maple and elm trees are noteworthy due to the large canopies mature trees develop resulting in RI values of 3.9 and 2.9 respectively. These values are significant considering the small population of these two species.

Japanese tree lilacs and red oak trees received the lowest importance ratings of 0.8 and 0.7 respectively. This is primarily due to the small leaf area and structure of Japanese tree lilacs and the immature size of the district’s red oak population which is less able to intercept large volumes of stormwater or sequester and store large amounts of carbon. Japanese tree lilacs should not be over looked in the landscape as they are able to be planted in locations larger trees cannot and provide additional aesthetic and design benefits.



Trees with a large total leaf surface area and broad canopy spread provide the greatest benefits. Ash trees are the most important tree species while maples are the most important genus in District 3 based on population size and canopy area.

	Number of Trees	Percent	Leaf Area (ft2)	Percent	Canopy Cover (ft2)	Percent	Importance Value
Ash	1,519	22.0	3,780,918	28.7	1,251,565	25.6	25.4
Norway Maple	1,603	23.2	2,658,140	20.1	1,123,621	23.0	22.1
Honeylocust	821	11.9	1,749,878	13.3	771,831	15.8	13.7
Linden	768	11.1	1,452,313	11.1	467,456	9.5	10.6
Tree Lilac	143	2.1	5,558	0.0	10,780	0.2	0.8
Red Oak	70	1.0	73,223	0.0	30,514	0.6	0.7

Table 2: Highest (4) and lowest (2) importance values

Canopy Benefits

Annual Benefits:

Street trees provide an estimated \$687,091 worth of environmental services to residents in District 3 and form an important part of the green infrastructure of Saint Paul. This represents an average annual economic value of \$99.65 per tree. This is significant considering that it accounts for trees found along the public right of way and does not include the 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 (\$218.31/tree), Honeylocust (\$144.52/tree), and Elm (\$126.80/tree). Japanese Tree Lilacs contribute the smallest environmental benefit valued at \$7.09/tree. As a general, maple and ash are the largest providers of environmental benefits due to their large population size.

Energy Savings:

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

In District 3 this environmental service totals \$194,470 per year in energy and natural gas savings, reducing energy demand by 1,187 MWh per year and natural gas usage by 158,338 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 honeylocust (\$35.09/tree) and silver maples (\$45.36/tree) provide the largest per tree benefit while maples provide the largest cumulative benefit due to their wide spread planting across the neighborhood. Unsurprisingly, small trees provide the smallest energy saving. Their role should not be overlooked as they provide effective shade in areas where larger species may not have room to grow including near residential air conditioner units adjacent to residential homes.

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 through deposition and by altering local microclimates, reducing energy demand and the emissions associated with its production.

Boulevard trees on the West Side remove 2,065 pounds of air pollutants through deposition while also reducing energy demand avoiding the release of 12,612 pounds of emissions annually at an estimated value of \$41,695 per year. Elm (\$8.21/tree) and silver maple (\$10.12/tree) provide the greatest environmental and economic benefit followed by pin oak (\$7.64/tree), honeylocust (\$7.13/tree), and ash (\$6.80/tree). Most of this value is generated by avoiding the generation of emissions.

Reference page 8 for a complete list of the environmental and economic benefits provided by the street trees of District 3

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 provide less direct shading, they reduce ambient urban air temperatures and wind speeds increasing energy savings across Saint Paul.

Trees do release Biological Volatile Organic Compounds (BVOC) which can increase urban ozone levels and 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 formation by lowering air temperatures and altering wind patterns which effect air pollution levels (Nowak).

Carbon Sequestration and Storage:

Reducing carbon emissions is one of the critical environmental issues facing urban areas. A well maintained urban forest is able to mitigate atmospheric carbon levels by sequestering carbon dioxide and storing it in plant biomass.

Currently, street trees in District 3 are storing 25.6 million pounds (12,822 tons) of carbon with an estimated economic value of \$192,324. Ash tree biomass comprises the largest share of carbon storage within the district at nearly 3,688 tons, or 29% of total stored carbon followed by Norway maple at 2,728 tons, or 21% of the total. Individually, silver maple (\$92.20/tree) and elm (\$58.68/tree) provide the greatest amount of storage per tree due to their large size at maturity.

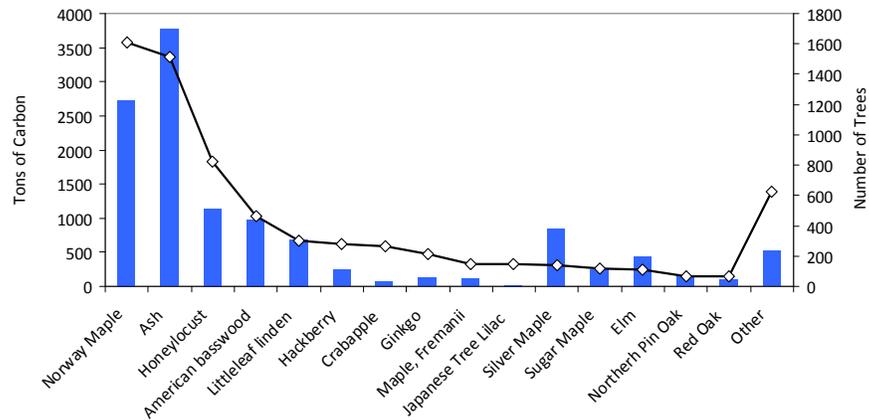


Figure 4: Carbon storage per species

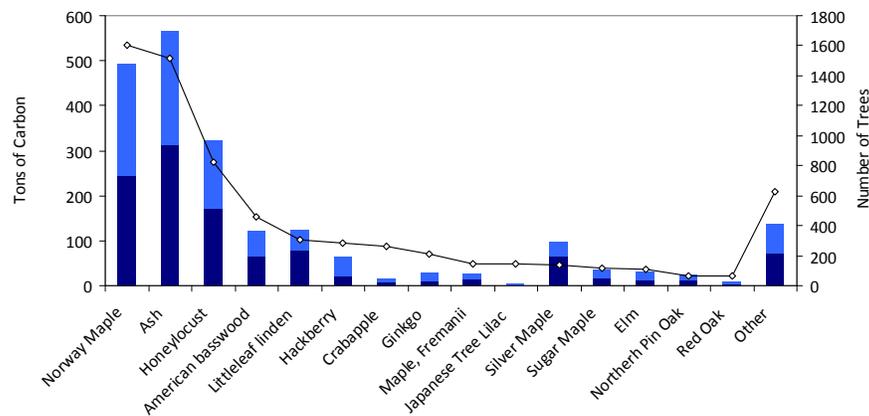


Figure 5: Carbon sequestration per species population
 Dark blue represents annual carbon removed from the atmosphere while light blue represents carbon emissions avoided due to energy savings

Boulevard trees in District 3 currently store 25.6 million pounds of carbon and annually sequester 2.4 million pounds.

Annual uptake of atmospheric carbon in District 3 sequesters 2,351,013 pounds of carbon each year with an estimated economic value of \$17,633. Most of this is stored as woody biomass though 123,334 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, as a group, sequester the most carbon at 640,362 pounds annually, or 27% of the district total.

In addition to sequestering carbon directly from the atmosphere, trees provide shade and mitigate local microclimates reducing energy demand, avoiding an estimated 1.99 million pounds of carbon emissions that would otherwise be released to produce this energy. In total the trees in District 3 reduce atmospheric carbon by nearly 4.2 million pounds annually through sequestration and pollution avoidance at an economic value of \$31,551.

With an increased awareness of the role carbon plays in global climate change and the potential ramifications extending from increased atmospheric carbon levels, these benefits should be considered in the development of a more sustainable Saint Paul.

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 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, trees on the West Side intercept an estimated 8.85 million gallons of stormwater annually with an estimated economic value of \$239,834. Trees with a large canopy including silver maple (\$95.83/tree) and elm (\$55.75/tree) provide the greatest per tree benefit due to the amount of leaf area and canopy spread available to capture rainfall. The greatest contribution to stormwater reductions are provided by ash trees (\$44.93/tree) which as a group intercept nearly 2.4 million gallons or 27% of the total volume intercepted.

Street trees intercept 8.85 million gallons of rainfall, improving regional water quality by reducing runoff which carries nutrients and pollutants. Combined with other stormwater best management practices including rain gardens, trees form an effective green infrastructure system.

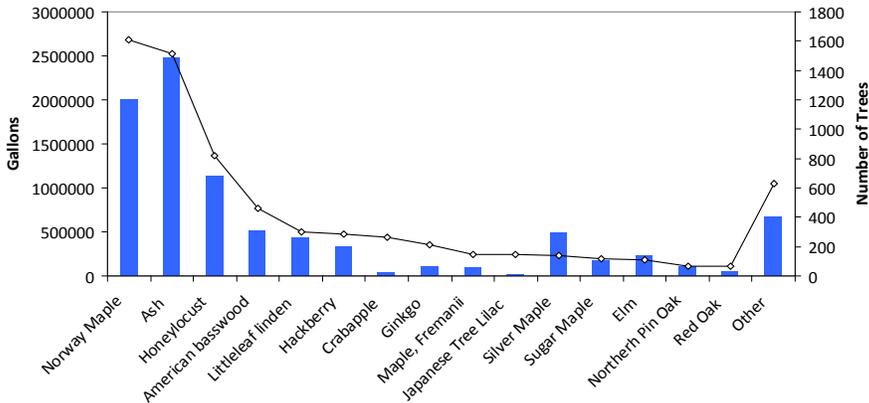


Figure 6: Stormwater runoff reductions per species population

**District 3-West Side
Street Tree Canopy Assessment Results**

	Current Benefits	Ash Tree Population**	% Ash
District Land Area	2,998 acres	2,998 acres	100%
Number of Street Trees	6,895	1,519	22%
Street Tree Canopy Area*	112 acres	26 acres	23.2%
Percentage of Land Cover	3.7%	1.2%	32.4%
Annual Energy Reductions			
Electricity	1,187 MWh	301.5 MWh	25.4%
Natural Gas	158,338 Therms	39,231 Therms	24.7%
Annual Economic Value	\$194,470	\$48,690	25%
Carbon Reductions			
Stored in Street Trees	25.6 million pounds	7.55 million pounds	29.4%
Sequestered Annually	2.2 million pounds	663,957 pounds	30.2%
Avoided Annually	1.99 million pounds	505,779 pounds	25.4%
Annual Economic Value	\$223,875	\$65,444	29.2%
Annual Removal of Air Pollutants			
Ozone	1,188 pounds	231.1 pounds	19.5%
Nitrogen dioxide	200 pounds	37 pounds	18.5%
Particulate matter	624 pounds	124.5 pounds	20%
Sulfur dioxide	53 pounds	10.4 pounds	19.6%
Annual Air Pollutants Avoided			
Nitrogen dioxide	5,632 pounds	1,457.3 pounds	25.9%
Particulate matter	823 pounds	208.3 pounds	25.3%
VOC's	785 pounds	198.9 pounds	25.3%
Sulfur dioxide	5,382 pounds	1,366.8 pounds	25.4%
Annual Economic Value	\$40,146	\$10,170	25.3%
Stormwater Mitigation			
Runoff reductions	8,849,329 gallons	2,470,844 gallons	28%
Annual Economic Value	\$239,834	\$66,965	28%
Aesthetic/Other Benefits			
Annual Economic Value	\$181,090	\$43,119	23.8%
Total Net Annual Benefit	\$687,091	\$123,752	18%

*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 typical measures. iTree accounts for these intangible benefits in the aesthetic/other benefits category which includes property values and neighborhood aesthetics. Street trees in District 3 contribute an estimated \$181,090 annually to the economic value of the neighborhood with honeylocust (\$58.90/tree) and silver maple (\$56.28/tree) identified as the top two trees according to this analysis.

Emerald Ash Borer

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 and continued infestations and tree removal will reduce, and potentially eliminate, ash trees from the urban forest. This issue is concerning as ash trees were identified as one of the primary trees of importance in the West Side and their loss 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 could have in District 3, the economic benefits that ash trees provide were analyzed and compared to those of the current street tree population. Results suggest that ash trees play a significant role in providing ecological benefits to the West Side 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 nearly \$124,000 or 18%
- Carbon stored in woody biomass would decrease by 3,775 tons and the amount of carbon sequestered by street trees annually could decline by 664,000 pounds
- Annual stormwater interception would decrease by 2.47 million gallons
- Removal of air pollutants would decrease by 400 pounds a year
- Property values and other benefits would decline by approximately \$43,000 annually

Thus far, the spread of EAB in Saint Paul has been minimal 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.



Emerald ash borer has the potential to reduce the environmental benefits provided by the street trees of District 3 by 18%, or nearly \$124,000 annually.

Recommendations

This report is an initial measurement of the environmental and economic benefits provided by the street trees of the West Side. The data found within can assist with coordinating species selection and planning of tree planting activities to maximize future benefits. Additionally, it provides a baseline data set to measure progress for subsequent environmental benefit studies including the city wide 2011 Canopy Assessment.

Recommendations include:

- Increase tree cover in industrial areas by encouraging property owners to plant additional trees and through the use of innovative planting methods within existing boulevards including engineered soils.
- Encourage residential property owners to plant additional trees on their property, expanding the benefits that the urban forest provides to residents on the West Side. Residential yards often provide superior growing conditions and are able to support many tree species that do not grow well on the boulevard including fruit and nut trees.
- Improve boulevard soil conditions when planting by amending existing soils and consider planting practices that loosen compacted soils including the use of spading machines where practical. Improved soil conditions increase tree establishment success by promoting a supportive root zone.
- Increase species diversity, reducing the use of maples which currently represent 30% of the district's boulevard trees, while selecting trees appropriate for each site and in line with the Street and Park Tree Master Plan.
- 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 value of the street tree canopy in District 3

- Electricity was calculated at \$0.0678/kWh based on the average of summer and winter rates quoted by Xcel Energy on July 27, 2010. www.xcelenergy.com
- Natural gas was calculated at \$0.72/therm based on the price available from CenterPoint Energy on July 27, 2010. www.centerpointenergy.com
- Median home value was calculated as \$143,000 based on local real estate estimated home values. This number is imperfect but represents a number that accounts for current resale values and estimated home values across the neighborhood.
- Values for air pollution and stormwater interception were based on the information in iTree which has been calibrated to the Midwest by the program. 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 inventory data is complete a full cost/benefit study can be generated.

References

City of Saint Paul, "Urban Canopy Assessment 2011: Atlas," stpaul.gov/index.aspx?NID=4581

Nowak, D.J. et al. "A modeling of the impact of urban trees on ozone," *Atmospheric Environment* 34 (2000) pp1601-1613

Owen, S.M. et al, "Biogenic volatile organic compounds (BVOC) emission estimates from an urban tree canopy," *Ecological Applications* 13(4) 2003 pp927-938

USDA Forest Service, iTree Tools for Assessing and Managing Community Forests, www.itreetools.org

This report was prepared by Zachary Jorgensen, Natural Resource Technician with Saint Paul Forestry. It was completed in November 2011 based on inventory data collected during 2010-2011.
