Urban Forest Benefits Report

District 7-Thomas-Dale, City of Saint Paul, Minnesota

Prepared by Brett Stadsvold and Zach Jorgensen

Street trees are an important portion of the city's green infrastructure that provides shade to homes and buildings, reduces energy consumption, cleans the air, and intercepts and stores rainwater. Trees provide beauty to the landscape that forms unique character to neighborhoods, creates a sense of place and increases home values. This report provides an economic and environmental look at the value street trees provide in the Thomas-Dale Planning District (District 7) of Saint Paul, Minnesota. Residents of Thomas-Dale are encouraged to use this report as a tool for planning and management for their neighborhood and individual land.

In 2011, Saint Paul Forestry staff completed the street tree inventory for Thomas-Dale, cataloging species type, DBH (diameter at breast height), boulevard widths, utility wire conflicts, geographic location and the overall condition of the trees. Street tree data is stored in Davey Treekeeper software with real-time work orders and tree maintenance requests created and stored in the inventory. The economic and environmental benefits of boulevard trees are quantified with iTree Streets software.

Structural changes will occur in Thomas-Dale from EAB with the loss of ash trees. Two Alternate population scenarios highlight the reduction in economic and environmental benefits from the loss of all boulevard ash trees, and adjusts the benefits for ash replacement. These scenarios will be discussed later in this report.

Geographic Characteristics

Thomas-Dale is located in the west central portion of Saint Paul bounded by Lexington Parkway on the west, the Burlington Northern Santa Fe (BNSF) railroad to the north, University Avenue to the south and Interstate 35E to the east. With approximately 1,905 acres, District 7 comprises 5.5% of Saint Paul's land area.

District landmarks include the historic Saint Agnes Church, West Minnehaha Recreation Center and athletic fields, Scheffer Recreation Center and Ryan Park. The bur oak stand located on the Amherst H. Wilder Foundation property on Minnehaha Avenue and the tree lined Lexington Parkway represent two key sources for trees in District 7.

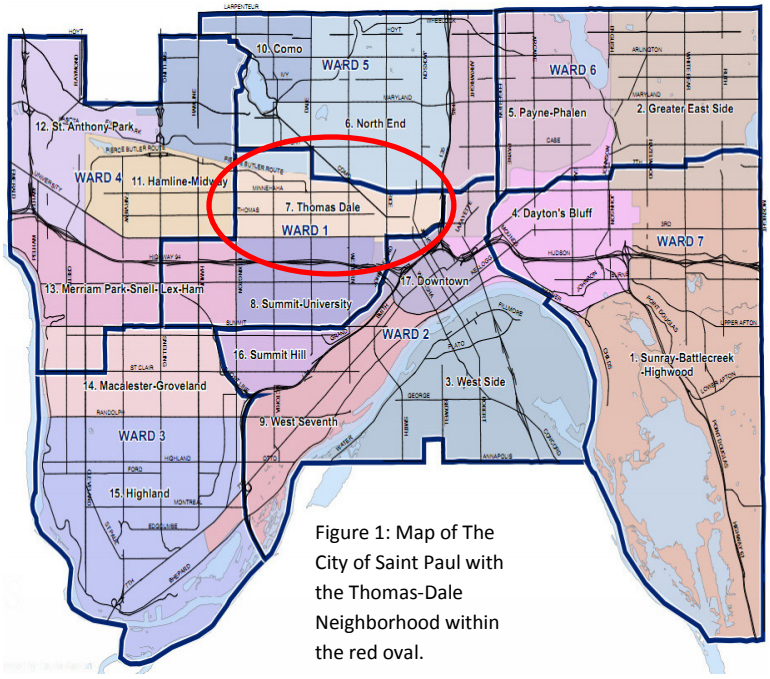

Figure 1: Map of The City of Saint Paul with the Thomas-Dale Neighborhood within the red oval.

Boulevards within residential areas typically provide generous planting areas with boulevards averaging six to eight feet in width. Smaller planting sites of three to six feet wide exist along transportation corridors of Rice and Marion Streets, Minnehaha and Thomas Avenue. The large park-lined Pierce-Butler Route provides large tree planting areas with some existing trees planted as noise barriers.

The University Avenue corridor is a regional commercial hub of restaurants, bars and service providers with a focus on individual motorists. However, construction of the central corridor light rail was underway during the writing of this report with proposed zoning changes that will create more walkable and public transit oriented areas with mixed use, high density development.

Currently, high amounts of impervious surfaces, compacted soils and lack of planting sites define University Avenue. Very few trees exist, but the Central Corridor Light Rail plans include planting trees along the entire stretch of the light rail corridor with structural soil as the planting medium, providing substantially more room for root growth and water infiltration. Stormwater will enter the root zone from the street as well as through permeable pavers placed over the root zone providing stormwater treatment and water infiltration sites.

Land Use

Similar to other neighborhoods, Thomas-Dale is comprised of a high percentage of residential land (38.9%) and public right-of-way (R.O.W.) at 30.1%. Parks and open space, commercial, educational and government land account for a smaller portion of Thomas-Dale's land area. The BNSF railroad corridor, along the northern border of Thomas-Dale lacks tree cover, but has great potential for additional trees. Trees can grow in a variety of locations, but residential land and the public R.O.W. offer the largest percentage and most easily plantable areas.

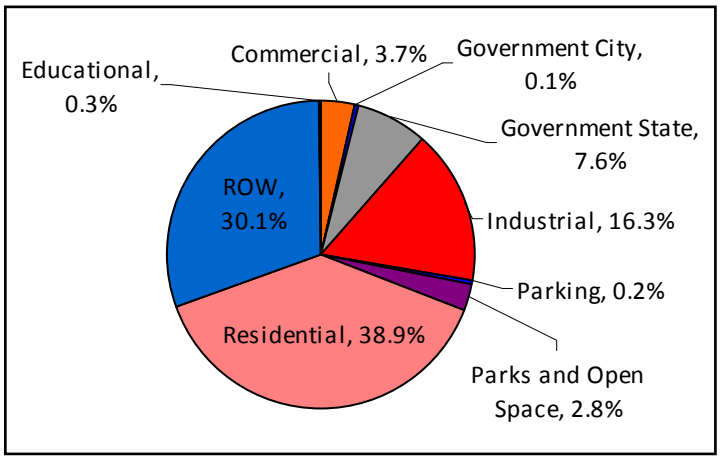

Figure 2: Thomas-Dale land use percentages. (iTree)

Forest Structure

In 2010, the City of Saint Paul contracted the University of Minnesota Spatial Analysis Laboratory (SAL) to perform a land cover classification to find the total canopy cover of trees in Saint Paul. The SAL combined 2007 LiDAR (Light Detection and Ranging) data with 2009 Quickbird satellite imagery to construct the classification. Saint Paul has a canopy cover of 32.5%, with canopy covering 23.4% of the Thomas-Dale District, the lowest percentage by planning district, other than Downtown Saint Paul (Figure 3).

Land Cover	Saint Paul	Thomas-Dale
Tree Canopy	32.5	23.4
Grass/Shrub	22.6	21.0
Impervious	23.9	36.4
Buildings	13.7	19.0
Water	7.1	0.0
Bare Soil	0.2	0.2
	100%	100.0%

Table 1: Land cover percentages for Saint Paul and Thomas-Dale. (Jorgensen 2011)

The R.O.W. of Thomas-Dale has a canopy cover of 30.1%, 5.1% higher than recommended levels for urban residential areas by American Forests. However, later discussion will show how population densities will shift with declines in the ash population. Saint Paul Forestry plants and manages trees in the right-of-way, while homeowners and private land owners manage their land. Figure 4 shows the greatest area for additional tree canopy exists within residential land of Thomas-Dale.

The median tree canopy cover over the right-of-way for all districts in Saint Paul is 36.1%. American Forests recommends 25% for urban residential areas.

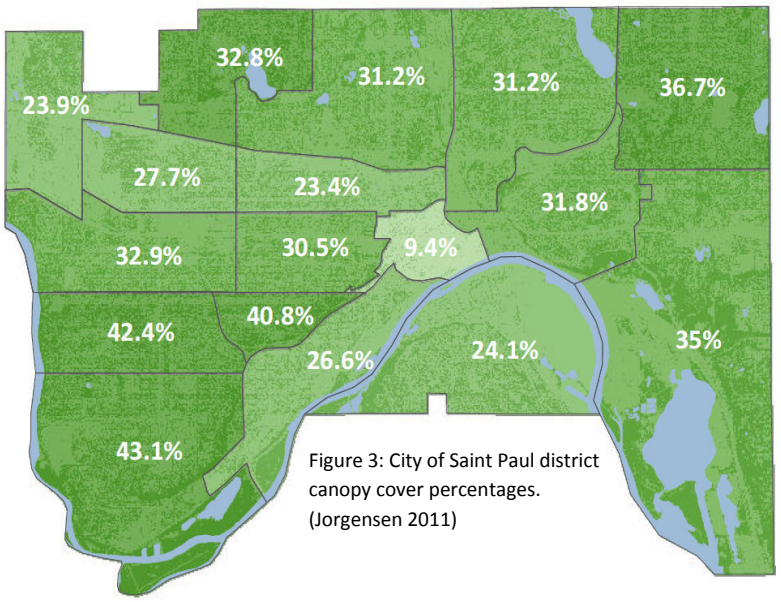

Figure 3: City of Saint Paul district canopy cover percentages. (Jorgensen 2011)

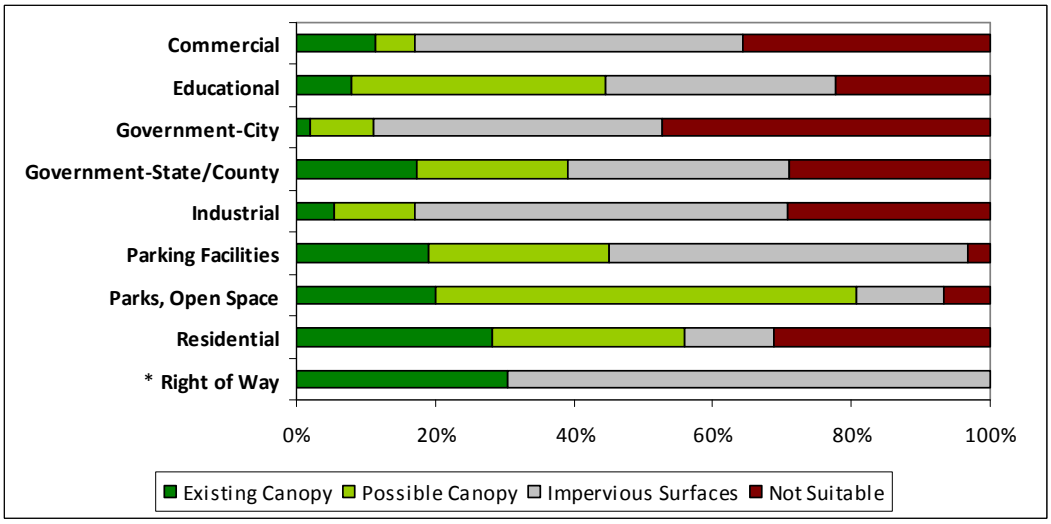

Figure 4: Possible canopy cover by land use in the Thomas-Dale District. (Jorgensen 2011)
*Vacant sites in the right-of-way are unknown.

Genus Distribution:

Thomas-Dale has 4,836 boulevard trees (Figure 5) with three genus comprising 60% of the boulevard tree population (maple 25%, ash 19%, and linden 16%). Honeylocust, oak, hackberry, elm, gingko and other trees make up smaller individual percentages, but help diversify the population.

Planning for increased diversity will be vital to the long term stability of the urban forest and will reduce future threats from widespread canopy loss. Current recommendations for diversity suggest the use of no more than 10% of any specie, 20% of any genus and 30% of any family to guard against wide-spread devastation similar to the elm decline from Dutch elm disease in the 1970's. Maple is currently the only genus with a population greater than 20%. Later discussion will show the effects of EAB on genus distribution.

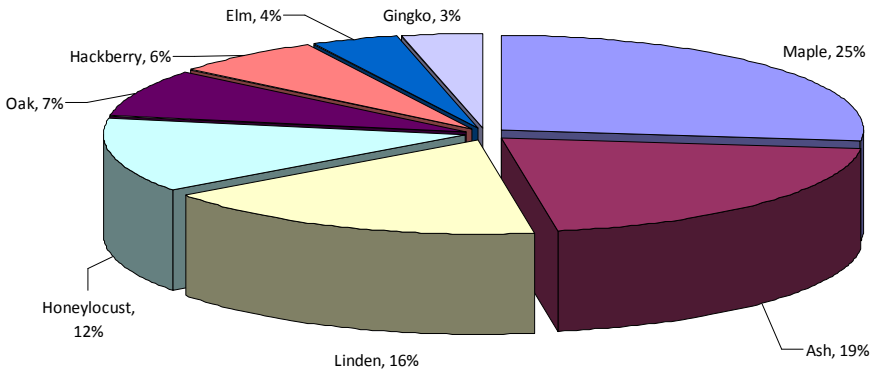

Figure 5: Genus distribution of boulevard trees in Thomas-Dale. (iTree)

The loss of ash trees due to the emerald ash borer would shift forest diversity, increasing the maple population to 32% of the street tree canopy.

Species Distribution:

A species level analysis (Figure 6) displays a population weighted heavily upon green ash, Norway maple, and honeylocust, all with populations higher than 10%. Populations of Norway maple and green ash will decline with threats from EAB and stem girdling roots in Norway maple. Saint Paul foresters are currently replanting vacant boulevard sites with Dutch elm disease resistant varieties of American elm and hybrid elms. Under utilized species in the district such as river birch, swamp-white oak, Japanese tree lilac are proven performers in urban landscapes that are also used. Additional species are planted more closely related to the characteristics of the planting site.

Photo by: Brett Stadsvold

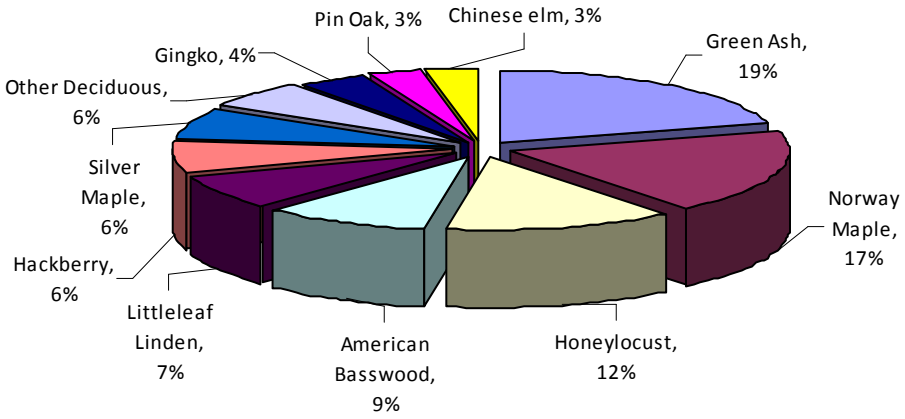

Figure 6: Species distribution of boulevard trees in Thomas-Dale. (iTree)

Size Distribution

The relative age structure (figure 7) of boulevard trees measured in diameter size reveals a population dominated by 13 to 18 inches (DBH) trees. Street trees ranging from 7 to 18 inches account for over half of the population. Trees greater than 18 inches represent 19 percent with trees greater than 24 inches comprising only four percent of the population. Boulevard trees across the city have followed a similar trend of limited presence of larger trees greater than 18 inches (DBH).

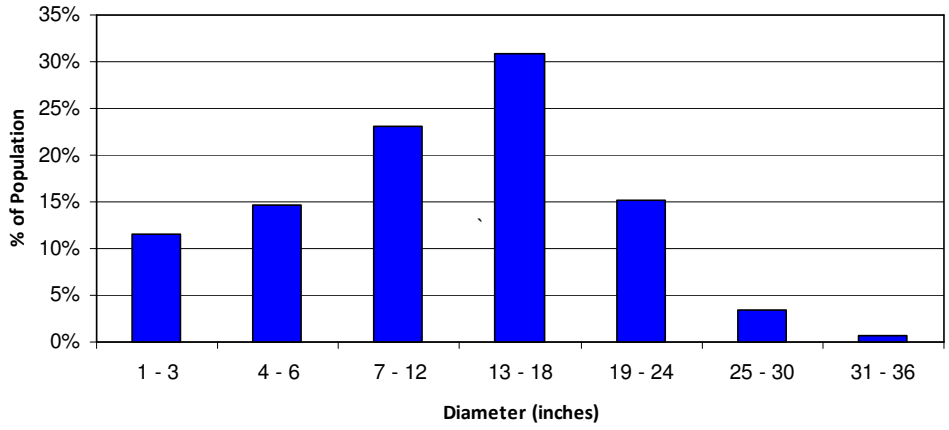

Figure 7: Relative age distribution of Thomas-Dale boulevard trees. (iTree)

Further examination of the 7 most common species shows an uneven distribution of boulevard trees in relative age and the size distribution by species (figure 8). Over half of the large boulevard trees (25 inches DBH and greater) are green ash, which will be effected by EAB in the future and reduce the presence of large diameter boulevard trees.

Future street tree plantings should focus on selecting under-utilized varieties of Dutch elm disease resistant elms, hackberry, American basswood and smaller varieties of Japanese tree lilac, crabapple, and maple where space is limited.

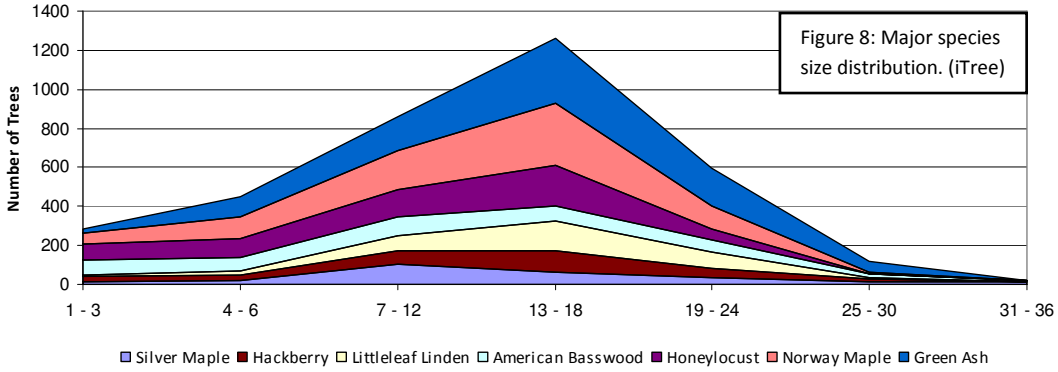

Figure 8: Major species size distribution. (iTree)

Thomas-Dale Total Annual Benefits of Street Trees

District land area	1,905 acres
Number of street trees	4,836
Canopy area for Right of Way	100.85 acres (30.1%)
Energy reduction	$128,036
Carbon sequestered	1.5 million pounds
Total carbon stored	15.7 million pounds
Air pollutants removed	2,085.1 pounds
Air pollutants avoided	7,975.11 pounds
Stormwater runoff avoided	5.6 mllion gallons
Aesthetic/Other benefits	$79,935
Total annual benefit	$404,649

Table 2: Average annual street tree benefits for Thomas-Dale: Benefits are calculated in iTree Streets software, derived from the 2010 Thomas-Dale street tree survey.

Planting trees that provide afternoon shade and reduce winter winds can reduce energy demand in buildings. While street trees provide less direct shading, they reduce urban air temperatures and wind speeds.

Annual Benefits

Street trees annually provide $404,649 of environmental services to Thomas-Dale, forming an important part of the green infrastructure network of Saint Paul. This value is substantial considering that it accounts for trees found only along the right-of-way and does not include the large population of trees planted in parks or on private property. This represents an average annual economic value of $83.67 per tree.

iTree quantifies benefits with five primary criteria including energy, air quality, carbon, stormwater and aesthetics. The clear winner for the most valuable tree in Thomas-Dale is pin oak at $141.54 per tree, followed by silver maple ($122.67/tree), green ash ($105.02/tree), littleleaf linden ($100.43/tree) and hackberry ($96.69/tree). Silver maples are rapid growers that can attain great height, but require intensive management that limits their use in an urban environment.

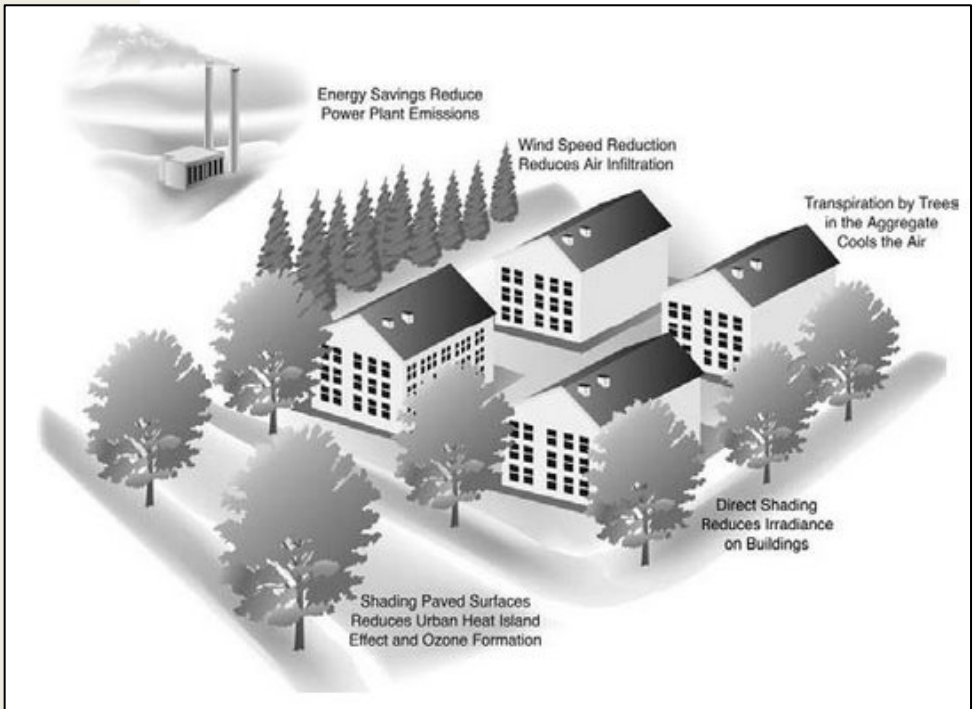

Figure 9: The right tree in the right place will reduce energy requirements and reduce power plant emissions. (graphic courtesy of National Tree Benefits Calculator)

Energy Savings

The most direct benefit of urban trees is the ability to mitigate microclimate conditions within the metropolitan region and reduce energy expenses for property owners. Trees reduce cooling and heating services by providing shade in the summer months and reducing wind speeds in the winter.

The Trees of Thomas-Dale reduce electrical usage by 749 MWh and gas consumption by 100,845 Therms, resulting in annual savings of $128,035. These numbers are estimates, but keep in mind that carbon releases into the atmosphere from coal fired power plants and the burning of natural gas for heat are substantially reduced with the presence of large shade trees in the community.

It may be common sense that trees with the largest canopies provide the greatest benefits, but do not overlook the importance of smaller trees in the landscape like Japanese tree lilac. Smaller trees provide shade, beauty, and habitat in areas where larger shade trees do not have room to grow.

Air Quality

Urban air quality is often reduced 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.

Photo by: Brett Stadsvold

Boulevard trees in Thomas-Dale remove 1,257 pounds of air pollutants through deposition while also eliminating the release of 7,945 pounds of emissions annually at an estimated value of $24,978. Hackberry ($6.90/tree), pin oak ($6.67/tree), and Amur corktree ($6.45/tree) provide the greatest environmental and economic benefit.

Trees do release Biological Volatile Organic Compounds (BVOC) that increases urban ozone levels and the presence of particulate matter (Owen). However, while BVOC emissions from trees may cause increases in ozone production, their presence is beneficial 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.

Street trees in Thomas-Dale are storing 15.7 million pounds (7,840 tons) of carbon with an estimated economic value of $117,595. Thomas-Dale currently benefits from green ash storing 2,091 tons of carbon, followed by Norway maple with 1,225 tons, both trees combining to store 42.3% of all carbon stored. Individually, pin oak ($52.75/tree) and silver maple ($44.52/tree) provide the greatest amount of storage per tree due to their large size at maturity.

Species	Energy ($)	CO2 ($)	Air Quality ($)	Stormwater ($)	Aesthetic/ Other ($)	Total ($)
Pin oak	41.47	8.45	6.67	54.42	30.52	141.54
Silver maple	31.38	6.48	6.25	53.22	25.35	122.67
Green ash	32.50	5.38	6.43	42.11	18.60	105.02
Littleleaf linden	29.04	5.71	5.72	35.83	24.14	100.43
Northern hackberry	34.94	3.86	6.90	35.80	15.20	96.69
Honeylocust	29.19	4.48	5.57	28.14	29.04	96.41
Amur corktree	31.84	4.66	6.45	34.07	15.12	92.15
Northern pin oak	28.39	3.97	6.11	37.10	12.12	87.69
Norway maple	28.33	4.14	5.74	30.22	13.51	81.94
American basswood	20.96	3.25	3.82	24.21	9.45	61.68
Ginkgo	16.70	1.84	3.23	12.55	3.73	38.05
Swamp white oak	11.30	1.83	2.11	9.26	7.73	32.23
Northern red oak	8.98	1.13	1.57	9.41	3.33	24.42
Freeman maple	5.37	0.47	0.88	4.24	2.82	13.79
Chinese elm	2.36	0.42	0.42	2.26	4.14	9.59
Japanese tree lilac	1.97	0.29	0.36	0.90	0.37	3.88

Table 3: Summary of average annual benefits per street tree in Thomas-Dale (itree).

Total Street Tree Benefits

Table 3 provides an overview of the average annual benefits per tree. Pin oak is large, rapid grower that captures a high quantity of carbon, provides large amounts shade and scores the highest per tree value of $141.54/ tree for Thomas-Dale. Keep in mind that this data only represents the street tree population of Thomas-Dale and is based on tree count and tree size. Other districts in Saint Paul will have varied results for per tree benefits.

Emerald Ash Borer

Emerald ash borer (EAB) was discovered in the South Saint Anthony Park neighborhood in May of 2009 and has begun to impact the urban forest of Saint Paul. Prior experience from communities in Michigan, Ohio and Illinois suggest that continued infestations, tree senescence and tree removal for community safety will reduce and potentially eliminate the ash tree population in this neighborhood. Saint Paul Forestry is using various tactics for managing EAB by removing infested trees, selectively removing low value ash trees and treatment of high value boulevard ash trees in the two infested areas in the city.

To better understand the potential impacts, two alternative scenarios are discussed to calculate the effects EAB will have on the environmental benefits provided by the street trees of Thomas-Dale. The first scenario removed all ash trees from the inventory representing a complete loss of boulevard ash. The second scenario also removes all ash trees, but includes the replacement of a diverse selection of two inch caliper trees, representing a situation similar to the structured removal program currently utilized across the city to reduce the ash population in advance of the borer.

Emerald ash borer has the potential to reduce the environmental benefits provided by the street trees of District 7 by 23%, or $92,475 annually (iTree).

Results (table 4) suggest that ash trees play a significant role in providing ecological benefits to the Thomas-Dale District and their potential loss would considerably reduce the environmental and economic value of the street trees including:

- Annual economic benefits would potentially decrease from $894,856 to $705,108, or about 21% with only a slight increase with the initial planting of new trees, with the exception of aesthetics.
- Total carbon stored in woody biomass would decrease by 2,491 tons and the amount of carbon sequestered by street trees annually could decline by 259 tons.
- Annual stormwater interception would be reduced by 1.8 million gallons.
- Removal of air pollutants would decrease by 268 pounds per year.
- Annual aesthetic and other factors would decline by approximately $61,012

Accompanying a reduction in economic and environmental benefits will be a structural change in the urban forest. Maple will account for 44% of the street tree population of Thomas-Dale, significantly higher than the 20% recommended genus level supporting canopy diversity and providing an opportunity for insect or disease problems in the future. One such threat is the Asian longhorn beetle, currently established in the eastern United States. This species is known to cause significant damage to maple trees and could heavily impact Thomas-Dale. Planned reforestation is critical in maintaining and increasing species diversity and the benefits provide to the urban ecosystem.

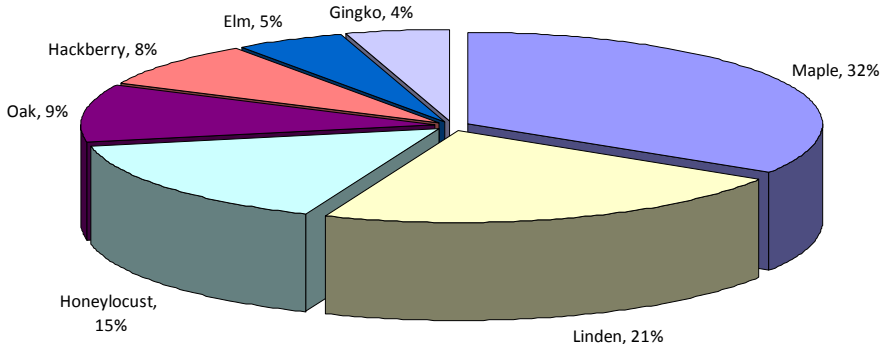

Figure 10: Thomas-Dale tree populations without ash trees. (iTree)

Thomas-Dale
Street Tree Benefits Results

	Current	Ash Trees Removed	With Ash Replacement
District Land Area (acres)	1,099	1,099	1,099
Number of Street Trees	4,836	3,906	4,836
Canopy Area of Right of Way (acres)	100.9	81.5	81.5
% Canopy of Right of Way (ROW)	30.5%	24.6%	24.6%
Annual Energy Reductions			
Electricity (MWh)	749.07	576.86	579.86
Natural Gas (Therms)	100,844.52	78,321.22	78,863.22
Annual Economic Value	$128,036	$98,723	$99,261
Carbon Reductions			
Stored in Street Trees (lbs.)	15,679,300.23	11,443,941.31	11,456,270.52
Sequestered Annually (lbs.)	1,540,836.75	1,161,551.76	1,167,839.23
Avoided Annually (lbs.)	1,256,462.22	967,599.34	972,629.19
Annual Economic Value	$20,358	$18,191	$18,274
Annual Removal of Air Pollutants			
Ozone (lbs.)	717.84	588.61	588.66
Nitrogen dioxide (lbs.)	121.61	100.94	100.95
Particulate matter (lbs.)	385.86	315.66	316.05
Sulfer dioxide (lbs.)	32.30	26.50	26.51
Annual Air Pollutants Avoided			
Nitrogen dioxide (lbs.)	3,562.79	2,750.10	2,765.64
Particulate matter (lbs.)	519.86	400.83	403.01
VOC's (lbs.)	495.90	382.25	384.31
Sulfer dioxide (lbs.)	3,396.55	2,615.94	2,629.56
Annual Economic Value	$24,978	$19,180	$19,274
Stormwater Mitigation			
Runoff reductions (gallons)	5,584,179.56	$4,185,775	$4,197,091
Annual Economic Value	$151,342	$113,442	$113,749
Aesthetic/Other Benefits			
Annual Economic Value	$79,935	$63,034	$64,294
Total Annual Benefit	$404,649	$309,892	$312,174
Benefits per person	**$26.90**	**$20.60**	**$20.75**

Table 4: Comparison of annual benefits of current Thomas-Dale street tree population to the loss of all boulevard ash trees and ash replacement. (iTree and Ramsey County)

Recommendations

This report is an initial measurement of the environmental and economic benefits provided by the street trees of Thomas-Dale. The data found within this report can assist with coordinating species selection and planning of tree planting activities to maximize future benefits. Future benefit reports will be based on this report for means of comparison and to measure progress.

Goals for Thomas-Dale:

- Increase tree cover in industrial and commercial areas whenever possible. Industrial and commercial areas account for 20% of the districts land area with few trees in theses areas.
- Encourage creating partnerships with property owners and the use of innovative planting methods within existing boulevards including engineered soils to mitigate pollution, stormwater runoff, and carbon emissions produced in these areas.
- Track the efficacy of the structural soil planting beds in supporting healthy trees in a highly urban environment along the Central Corridor Light Rail Project and implement similar design elements in other redevelopment projects in Saint Paul.

District 7 . 2011

- Improve boulevard soil conditions when planting by amending existing soils with compost and consider planting practices that loosen compacted soils including the use of spading machines and frost picks where practical. Improved soil conditions increase tree establishment success by promoting a supportive root zone.

- Continue planting a diverse selection of tree species, but also take into account total benefits per tree when selecting a tree species. For instance, honeylocust provides significantly more benefits annually than any other tree as they increase in size (figure 11). Underutilized species mentioned above should be planted more readily, while avoiding use of large quantities of maple that currently form 25% of the street tree canopy.

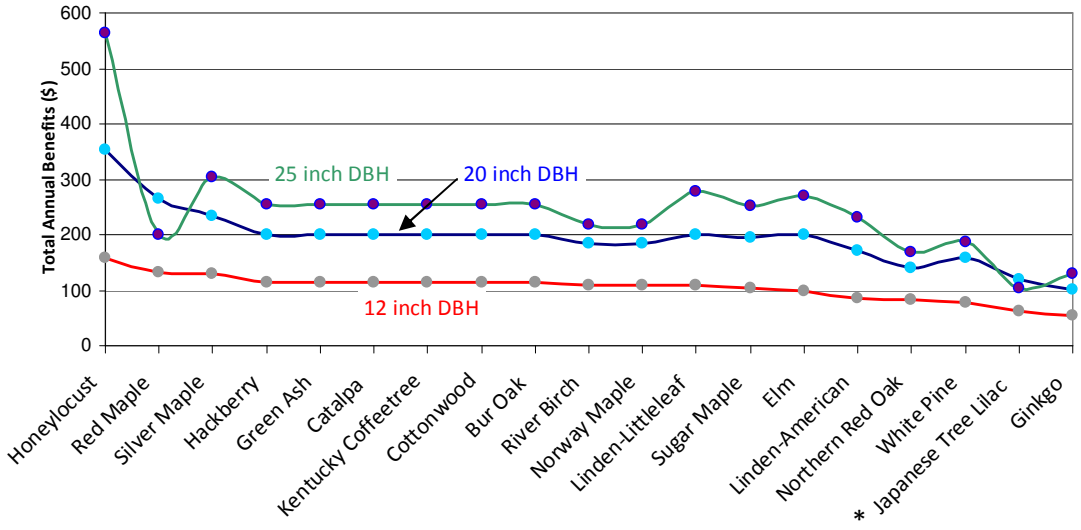

Figure 11: Comparison of total average annual benefits by species for 12", 20" and 25" diameter trees in Saint Paul. (National Tree Benefits Calculator)
*Japanese tree lilac rarely grow to diameters of 20-25", but are included as a comparison for 12" diameter trees.

District 7 . 2011

Appendix

Values used to determine the value of the street tree canopy in Thomas-Dale are as follows:

- Electricity rates are $0.1459/kWh based on weighted averages for 2011 summer and winter rates.
- Natural gas rates are $0.1859/therm based on weighted averages for 2011 summer and winter rates.
- Median home value of $97,100 is based on August 1, 2011 Zillow.com home value index data for May 2011.
- Values for air pollution and stormwater interception is based on the default information in loaded in iTree, calibrated to the Midwest. 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

- Population for Thomas-Dale of 15,041 (2010 Census, American FactFinder, U.S. Census Bureau)
- Operational costs of city tree management were not entered into iTree due to fluctuating budgets from year-to-year. This report is limited to only the benefits derived from the street trees of Thomas-Dale and does not balance out the costs of managing the street trees.

References

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

Setting Urban Tree Canopy Goals. American Forests. 2010.
http://ftp.americanforests.org/resources/urbanforests/treedeficit.php

Jorgensen, Z. "City of Saint Paul Urban Canopy Assessment 2011: Atlas. City of Saint Paul. 2011"

Casey Trees and Davey Tree Expert Co. National Tree Benefits Calculator. 2011.
http://www.treebenefits.com/calculator/.

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

2010 Population - St. Paul Planning Districts. Ramsey County, Minnesota March 29, 2011.
http://www.co.ramsey.mn.us/NR/rdonlyres/B4144AE3-AB23-42F6-9265-FCEB4F0E62E9/23084/2010districtcouncilpopulation.pdf

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Prepared by Brett Stadsvold and Zach Jorgensen. City of Saint Paul. October 2011.