

Summary Report

Calculated Public Tree Values and Benefits for the City of Grand Rapids

City of Grand Rapids, Michigan

September, 2010



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Executive Summary

The City of Grand Rapids has a valuable resource in its street trees and is taking a proactive stance to ensure that these benefits are available for the community. Through Grand Rapids' staffing decisions and commitment to understanding the complexity of its urban forest, the City is creating a positive identity for the municipality and is fostering pride within the community. However, maintaining this resource can be costly, and the City has fallen slightly behind with required maintenance tasks. If left unattended, the benefits afforded by Grand Rapids' street trees will not be fully achieved, and priority maintenance concerns may create unwelcome liability issues in the future. There are a number of vacant planting sites that can be utilized; however, planned maintenance of these new trees should be considered before any resources are put toward planting. Planned maintenance will give this investment the best chance of paying off in the future through the increased benefits of mature trees.



Photograph 1. One of many newly planted trees in downtown Grand Rapids.

Resource Structure

i-Tree Streets, based on Grand Rapids' 4 percent sample tree inventory, estimates that there are 61,654 publicly managed street trees. In order to gain an understanding of the benefits these trees provide the community and the management needs involved, an analysis of Grand Rapids' street tree resource must be performed. Species, diversity, age distribution, condition, and canopy coverage can be used to characterize Grand Rapids' resource as follows:

- There are over 75 distinct species of street trees growing throughout the City of Grand Rapids. The predominant street tree species are Norway maple (*Acer platanoides*, 34.1%); thornless honeylocust (*Gleditsia triacanthos inermis*, 10.2%); green ash (*Fraxinus pennsylvanica*, 7.3%); sugar maple (*Acer saccharum*, 7.2%); and red maple (*Acer rubrum*, 7%).
- The age structure of Grand Rapids' street trees is properly imbalanced, with more trees considered young than mature. Of the street trees in Grand Rapids, 10 percent are considered mature (>24-inch DBH), while 31 percent are considered young (<6-inch DBH). Maintaining the flow of benefits provided by the City's urban forest will require a continued commitment to planting trees and maintaining the growing population of young trees to ensure that they reach maturity.
- The majority of street trees in Grand Rapids are in good condition (82%), with only 4 percent of inventoried trees classified as poor. Trees in fair condition comprise 14 percent of the inventory, while trees that are dead or dying account for just 1 percent of the population. The predominantly good condition of Grand Rapids' street trees can be attributed to the relatively young age distribution. These young trees will continue to provide increasing benefits as they mature, but will also require increasing maintenance in the future. Removing all dead and dying trees should be a priority.
- In Grand Rapids, the estimated street tree canopy covers approximately 953 acres of the total land area of 28,800 acres (45 square miles), or 3.3 percent of the City. When the canopy cover is expressed as a percentage of the total area of the streets and sidewalks only, the percentage is 36.74 percent.

Resource Function and Value

The cumulative value provided by Grand Rapids' street trees is averaged to be \$105 per tree annually, for a gross total of \$6.5 million annually. The City's street trees conserve and reduce energy, reduce carbon dioxide levels, improve air quality, mitigate stormwater runoff, and provide other benefits associated with aesthetics, increased property values, and quality of life. Grand Rapids' street trees are providing the community substantial benefits such as:

- Inventoried street trees reduce energy and natural gas use in Grand Rapids due to shading and climate effects equal to 9,598 MWh and 1,307,232 therms, for a total savings valued at approximately \$2,544,333, with a City-wide average of \$41.27 per street tree.
- Street trees in Grand Rapids reduce atmospheric CO₂ by a net of 9,688 tons per year, valued at \$145,318 for an average net benefit per tree of \$2.39.
- The net air quality improvement from the removal and avoidance of air pollutants is valued at \$323,084 per year, with an average net benefit per tree of \$5.24.
- Grand Rapids' street trees intercept 78.7 million gallons of stormwater annually. The total value of this benefit to the City is \$2.1 million per year, for an average value of \$34.60 per tree.
- The estimated total annual benefit associated with increased property values, aesthetics, and other less tangible improvements is \$1.2 million per year, for an average of \$20.14 per tree.
- When the City's annual tree-related expenditures are considered, approximately \$1,804,594 per year, the net annual benefit (benefits minus costs) to the City is \$4,694,139. The average net benefit for an individual street tree in Grand Rapids is \$76.14 per year. The City of Grand Rapids receives \$3.60 in benefits for every \$1 spent on its municipal forestry program.

Resource Management

Grand Rapids' street tree resource is rich in the benefits it provides the community. However, maintaining this resource requires constant attention and commitment to achieve sustainability. Urban stresses such as compacted soils, pollution, limited growing space, and insufficient nutrients lead to an increased need for an aggressive management program. To maximize the benefits of Grand Rapids' resource and ensure sustainability, the following management practices should be implemented:

- Sustain the existing street tree resource through comprehensive tree maintenance, including new tree establishment and cyclical pruning. Develop a replacement plan for the City's most mature trees (and top benefit producers) to replace them with trees of similar stature gradually before they must be removed.
- Adjust tree planting in the City to expand the extent of the resource and maintain the flow of benefits over time. Focus on large-stature trees where growing conditions permit and good-performing species to maximize benefits.
- Reduce dependence on Norway maple, sugar maple, and red maple through careful species selection to achieve greater diversity and guard against catastrophic losses. Currently, maples (*Acer* spp.) comprise approximately 52 percent of Grand Rapids' inventoried street trees.
- Cease to plant ash species as a street tree in response to the presence of emerald ash borer (*Agrilus planipennis*). The current population of ash trees (7.3 percent of the inventoried tree population) should be carefully monitored for signs of an EAB infestation, and infested trees should be removed immediately.
- Strengthen the City's network of partners and urban forest managers to work together towards the common goal of an improved, more functional, and sustainable street tree resource.

Introduction

The public trees growing on the rights-of-way of the City of Grand Rapids are valuable private property, neighborhood, and municipal resources. They provide tangible and intangible benefits for diverse services such as pollution control, energy reduction, stormwater management, property values, wildlife habitat, education, and aesthetics.

Previously, the services and benefits that trees provide in the urban and suburban setting were considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the City of Grand Rapids' current tree inventory data are summarized in this report. Although Grand Rapids' tree inventory is only a 4 percent sample, valuable insight can still be obtained regarding the overall health of the City's street trees and the benefits they provide the community.

The science behind this model and type of analysis is sound and has been published in peer-reviewed journals. The challenge now is to apply the science to enhance the quality of life in the City of Grand Rapids by improving the condition and extent of the urban forest.

i-Tree Streets Benefit Model Overview

The method used to determine the overall and net values and benefits is the U.S. Forest Service's i-Tree Streets v 3.0. i-Tree Streets is a component of i-Tree, a suite of free software tools recently released by the U.S. Forest Service that can be used to assess and manage community forests. With these tools, cities and urban forest managers can accurately quantify the benefits of urban forests, understand and balance the costs of managing an urban forest, and become better prepared for severe weather emergencies.

Specifically, i-Tree Streets is a tool that quantifies the benefits of street trees and compares them directly with the costs of urban forestry programs to produce accurate net benefit values. It is a statistically valid, financially sound, and defensible cost-benefit analysis tool for urban forestry that may be used with existing inventories, or with a sampling of streets in a community. Appendix A lists additional sources for further information.

i-Tree Streets Benefit Categories

Inventory data from the City of Grand Rapids sample inventory project were entered into the i-Tree Streets model by Davey Resource Group to assess and quantify the beneficial functions of the street tree resource, and to place a dollar value on the annual environmental benefits they provide. Data were collected between July 13-28, 2010. The analysis was performed to determine and quantify these benefits:

- **Energy Consumption Savings**—The energy savings that trees provide can be attributed to shading, the cooling effect of transpiration, and wind reduction. These key factors reduce the amount of radiant energy absorbed in buildings and other hardscapes, cooling the air around buildings in the summer and helping retain heat during cold winter months. The energy savings is realized by lower cooling and heating costs for any type of building.
- **Carbon Sequestering**—Carbon dioxide (CO₂) is used during a tree's photosynthesis process to produce the natural building blocks necessary for tree growth. This process takes carbon dioxide from the atmosphere and holds it as woody and foliar biomass. This is referred to as carbon sequestration.
- **Air Quality**—The air quality of Grand Rapids' urban environment greatly benefits from the presence of street and other public trees. Trees absorb gaseous pollutants in the form of ozone (O₃) and nitrogen dioxide (NO₂). Reduction in ozone can also be attributed to the tree shading effect on hardscape surfaces and the transpiration process. Trees intercept volatile organic compounds (VOCs), sulfur dioxide (SO₂), and small particulate matter (PM₁₀), such as dust, ash, dirt, pollen, and smoke from the air. Trees also emit biogenic volatile organic compounds (BVOCs), an air pollutant that contributes to the formation of ozone, a process which the i-Tree Streets' model takes into account.
- **Stormwater Mitigation**—The City of Grand Rapids' street tree population reduces the volume of stormwater runoff in its neighborhoods and, ultimately, City-wide. This function and benefit is especially important in developed settings with increased quantities of impervious surfaces (roads, driveways, homes, parking areas) and in areas in close proximity to surface waters. A tree's surface area, especially the leaf surfaces,



***Photograph 2.** Using i-Tree Streets analysis software, Grand Rapids' street tree resource returns an estimated \$6.5 million in benefits annually back to the community, for a net benefit of \$4.7 million per year. Large, mature species, such as this sugar maple, are responsible for producing much of the benefits.*

intercepts and stores rainfall. The root systems of trees increase soil infiltration, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, reducing soil compaction rates, and improving soil absorptive properties. In addition, trees intercept suburban contaminants, such as oils, solvents, pesticides, and fertilizers, which are often part of stormwater runoff, thus reducing pollutant discharges into the City's vital waterways.

- **Aesthetics and Other Public Values**—It may seem difficult to place a dollar value on the benefits Grand Rapids' street trees provide to the overall ambiance of the City and the well-being of neighborhood residents and visitors; however, trees provide beauty to the landscape, privacy to homeowners, and refuge for urban wildlife, and this can be quantified.

Since Grand Rapids' tree inventory is a 4 percent sample, and the City's network of parks and green space are absent from this analysis, a large portion of public trees are not represented in the report. As a result, the full extent and benefit of Grand Rapids' urban forest may be underestimated.

Grand Rapids' Municipal Tree Resource

Street Tree Numbers

Grand Rapids' street tree population is dominated by broadleaf-deciduous trees (98.7 percent of the total). Broadleaf-deciduous trees usually have larger canopies than coniferous street trees, and, because most of the benefits provided by trees are related to leaf surface area, broadleaf trees usually provide the highest level of benefit. There are an estimated 849 (1.3%) evergreen and coniferous trees rounding out the population (Appendix B).

Species Richness and Composition

Grand Rapids' inventoried street tree population includes a mix of more than 75 species (Appendix C). This level of diversity is to be commended, as a variety of species types can decrease the impact of species-specific pests and diseases by limiting the number of trees that are susceptible. This, in turn, reduces the time and money spent on mitigating problems resulting from any such episodes. Additionally, a wide variety of tree species may help to limit the impacts from a number of physical events, such as strong storms, wind, ice, flooding, drought, etc.

However, the top 10 occurring species account for approximately 84 percent of the inventoried street tree population.

The predominant species are Norway maple, (34.1%), thornless honeylocust (10.2%), green ash (7.3%), sugar maple (7.2%), and red maple (7.0%). Davey Resource Group recommends that no single species represents more than 10 percent of the total population, and no single genus represents more than 20 percent of the total population. Norway maples exceed this population guideline for species, while maples collectively exceed the guideline set for genus representation.

The threat of insect and disease makes species richness imperative throughout the City of Grand Rapids. One such insect that is currently impacting the street tree population is emerald ash borer (*Agrilus planipennis*). EAB is an invasive species that is native to Asia. It was discovered in Detroit, Michigan in the summer of 2002, and only attacks trees in the genus *Fraxinus*. In Grand Rapids, green and white ash trees comprise approximately 7.3 percent of Grand Rapids' street tree population and account for \$515,191 annually (7.9%) in benefits. The cost of replacing these two species, as they exist in their current state, is valued at \$4,412,749, illustrating the value of Grand Rapids' ash trees as a valuable resource worth additional attention in the presence of this pest. If treatment is not considered a viable option, then the cost of removing the infested ash trees must be considered, as well as the cost of replacing the lost ash trees with trees of comparable size and structure to replace the lost benefits.



Photograph 3. American elm (*Ulmus americana*), with its majestic form, was once the most recognized tree in Midwestern communities prior to Dutch elm disease. Today, it represents less than 0.5% of all street trees in Grand Rapids (stock photograph).

Species Importance

i-Tree Streets calculates the importance of any one species in a street tree inventory by assigning each species an Importance Value (IV). Importance Values enable urban forest managers to indicate which trees have the greatest functional capacity within a community. IV can be taken a step further to forecast the loss of benefits should a catastrophic event eliminate a single species.

The top five inventoried street trees in Grand Rapids have the following Importance Values: Norway maple, 29.9; thornless honeylocust, 12.3; green ash, 7.7; sugar maple, 10.8; and red maple 4.4. Grand Rapids relies heaviest on the functional capacity of Norway maple, which has a significantly higher IV than other species due to its maturity, greater size (78.62 percent are greater than 6-inch DBH), broader leaf area, and prevalence among the City's street trees. In fact, Norway maple constitutes an estimated 30.7 percent of inventoried tree canopy in the City. Conversely, red maple (fifth on the most inventoried list) has an IV of only 4.4, mostly due to the fact that 66.86 percent of the red maple population is considered young (<6-inch DBH). Appendix D provides IVs for the 14 most prevalent species.



Photograph 4. Norway maples have a reported Importance Value of 29.9 due in part to their increased presence among inventoried street trees (34.1%) (stock photograph).

Stocking Level

If a tree were to be planted every 50 ft, Grand Rapids' stocking level would include approximately 211 trees per linear street mile. Although the estimate of stocking level does not account for planting site conflicts, such as utility poles and right-of-way distances, linear street mileage can be used to estimate that there are approximately 125,405 trees and planting sites along City-maintained streets. However, as mentioned earlier, this figure may be significantly less due to the presence of planting site conflicts.

An estimation of stocking level can also be achieved based on the 4 percent sample inventory. As calculated by i-Tree streets, there are 70,772 total sites along the City's right-of-way. This includes 61,654 planted sites, and 9,118 unplanted sites for a stocking level of 87 percent. The unplanted sites are then broken down into small, medium, and large planting sites. Appendix E summarizes stocking level for current inventory data.

Calculating trees per capita is another important measure of tree stocking. Assuming that Grand Rapids has a human population of 193,710, and no other trees exist beyond the ones included in this study, then street trees per capita for the City is 0.32. This is approximately one tree for every three people.

Relative Age Distribution

The distribution of ages within a tree population influences present and future costs as well as the flow of benefits. An uneven-aged population allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy cover.

Grand Rapids has a properly imbalanced age distribution, with 31 percent of inventoried street trees considered young (<6-inch DBH); 19 percent established trees (6- to 12-inch DBH); 40 percent maturing trees (12- to 24-inch DBH); and 10 percent mature trees (>24-inch DBH). An ideal street tree population has an imbalanced age distribution, with higher percentages of young trees than mature trees to minimize fluctuations in functional benefits. As trees mature and begin to decline, a tree population skewed towards young trees will ensure that a flow of benefits continues to exist.

Relative age should also be considered between species (Figure 1). Norway maple, which has the highest Importance Value (29.9) of any street tree in Grand Rapids, is represented in the population as 47 percent mature (>24-inch DBH) or maturing (12- to 24-inch DBH), with 31 percent established (6- to 12-inch DBH), and 21 percent young (<6-inch DBH). If young trees of similar size and structure are not planted to improve the age distribution of this species, the return of valuable benefits may be disrupted for future generations. Appendix F displays the relative age distribution for the ten most inventoried street trees in Grand Rapids.

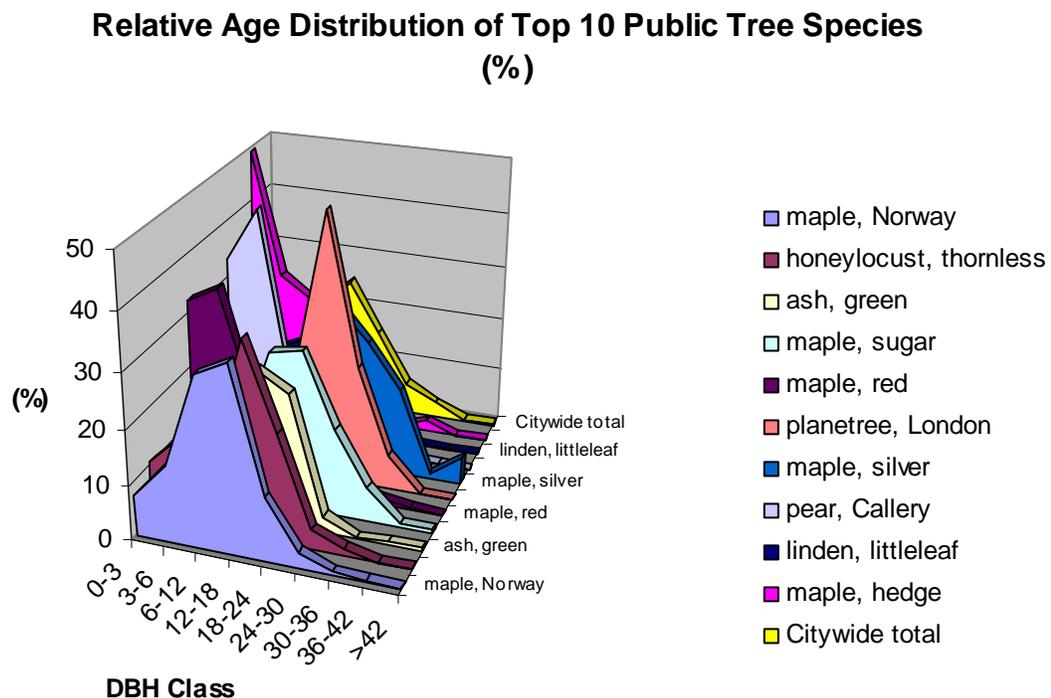


Figure 1. Relative Age Distribution of Grand Rapids' Top Ten Street Trees

Tree Condition

Tree condition indicates both how well trees are managed and how well they perform given site-specific conditions. The majority of Grand Rapids' street trees (82%) are in good condition. Trees rated good are performing at their peak and the benefits they provide are maximized. This is in line with the age distribution of the ten most occurring street trees (74.92% are under 12-inch DBH). Trees in poor condition account for 4 percent of the population, and about 0.5 percent of street trees are dead or dying. The goal for dead and dying trees should be zero. Figure 2 breaks down the condition rating of Grand Rapids' top ten most occurring street trees.

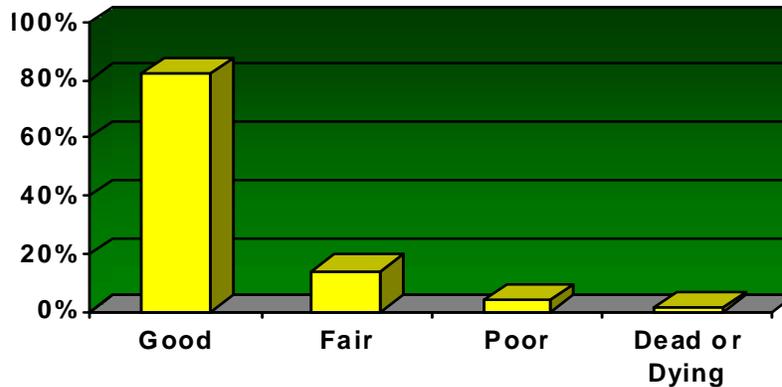


Figure 2. Condition of Grand Rapids' Top Ten Street Trees

Canopy Cover

Leaf surface area directly correlates with the benefits of street trees. The greater the leaf surface area exhibited by a tree, the greater the benefits a particular tree is likely to provide the community. In other words, trees with large leaves and spreading canopies tend to produce the most benefits. Seeking out planting sites that will accommodate the planting of large-growing species will most positively impact the canopy cover for future generations.

In Grand Rapids, the estimated street tree canopy covers approximately 953 acres of the total land area of 28,800 acres (45 square miles), or 3.3 percent of the City. When the canopy cover is expressed as a percentage of the total area of the streets and sidewalks only, the percentage is 36.7 percent (Figure 3) (Appendix H). Grand Rapids should always strive to improve the stocking level by planting additional trees. Planting the right species in the right place will increase canopy cover, leading to greater benefits in the community.

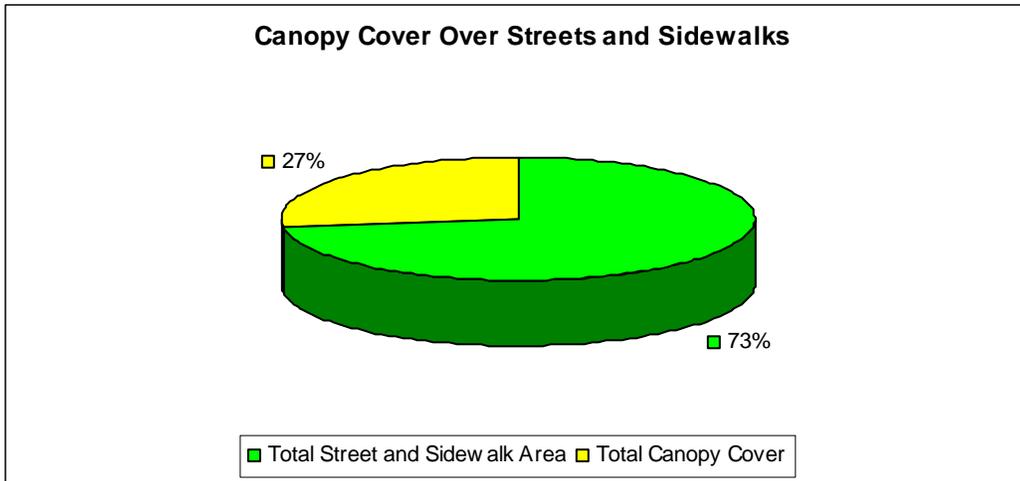
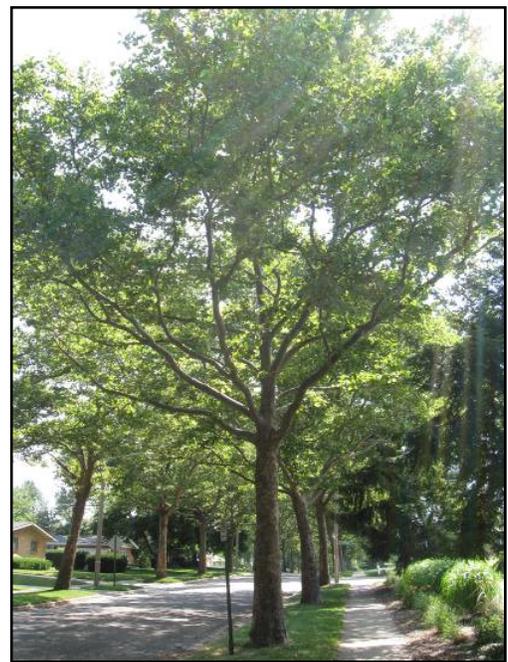


Figure 3. Canopy Cover over Streets and Sidewalks for the City of Grand Rapids

Replacement Value

Grand Rapids’ inventoried street tree resource is an asset valued at \$70,893,448 (Appendix I). This value is determined by considering the cost of replacing Grand Rapids’ inventory of 61,654 street trees with trees of a similar state.

Norway maples, the highest occurring street trees, have the highest replacement value of all species at \$19.5 million, representing 27.5 percent of the total replacement value. The second and third species on the replacement value list, sugar maple and London planetree, are only fourth and sixth, respectively, on the top ten most occurring species list. London planetree and sugar maple move up the replacement value list due to their age distribution. Of the London planetree population, 76.8 percent is greater than 18 inches in DBH, and 72.31 percent of the sugar maple population is greater than 12 inches in DBH. This is important in illustrating how the value and benefits of a large tree multiply as it matures and offset the increased cost of maintenance. It also serves to illustrate the importance of maintaining a planting scheme that strives to replace a maturing population, such as the London planetrees, with new trees that will attain similar size and structure at maturity in an attempt to keep a continuous benefit flow.



Photograph 5. A row of mature London planetrees (Platanus x acerifolia) shading a Grand Rapids street.

Costs of Managing Grand Rapids' Municipal Trees

Investing in Grand Rapids' street trees is well worth the cost. The City's trees provide numerous economical, environmental, psychological, and social benefits to the community. The current annual budget for street tree related expenditures is approximately \$1,804,594, 0.5 percent of the City's total municipal budget of \$346,000,000. (Appendix J).

Tree Planting and Establishment

Ensuring that the benefits of Grand Rapids' street trees are available for future generations requires quality nursery stock, proper planting techniques, and adequate follow-up care. Grand Rapids annually allocates approximately \$218,369 toward planting new trees. Of Grand Rapids' total expenditures for tree services, approximately 12 percent of costs can be attributed to tree planting. According to i-Tree Streets reporting on a 4 percent sample survey, Grand Rapids has an estimated 9,118 vacant planting spaces to be filled. Considering that Davey Resource Group conservatively estimates the cost of purchasing and planting a new tree at \$210 per tree, Grand Rapids could expect to spend \$1,914,780 to reach a stocking level of 100 percent in the inventoried area. However, this ballpark figure is only intended to highlight the attention needed to achieve stocking goals in the City, as regional and internal variances are not accounted for.



Photograph 6. *Planting new trees improves the age structure of urban forests and ensures that the flow of benefits is uninterrupted.*

Maintenance

Annually, planting, pruning, removals, disposal, and litter cleanup account for 86 percent of Grand Rapids' total street tree related expenditures. Removals account for approximately 28 percent of total expenditures, while pruning accounts for 34 percent. Approximately 11 percent of total expenditures are attributed to litter and storm clean-up.

Administration

Approximately 4 percent of total annual expenditures for managing street trees can be attributed to administration costs. These costs include forestry personnel salaries, clerical staff, summer help, supplies, training, inspection, and membership fees.

Additional Tree Related Expenditures

Expenditures related to infrastructure damage are an additional expense that Grand Rapids absorbs annually. The City is estimated to have contributed \$39,090, 2 percent of its total expenditures, to the repair or mitigation of tree related damages.

Benefits of Grand Rapids' Municipal Trees

Street trees provide a host of benefits to the City of Grand Rapids. Street trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. In addition, trees provide numerous economical, psychological, and social benefits. However, the intent of this study is to determine whether the benefits of street trees outweigh the costs of maintaining them.

This study uses data from a 4 percent sample street tree inventory collected in Grand Rapids and the i-Tree Streets model to assess and quantify the beneficial functions of the City's street tree resource, and to place a dollar value on the annual benefits they provide (Table 1).

Table 1. i-Streets Analysis Results for Total Annual Benefits per Species in the City of Grand Rapids

Average Annual Benefits of Public Trees by Species							
Species	Energy	CO₂	Air Quality	Stormwater	Aesthetic	Total (\$)	% of Total \$
maple, Norway	889,097.82	82,355.83	115,177.92	612,713.51	327,298.17	2,026,643.26	31.19
honeylocust, thornless	328,244.40	35,866.15	41,961.17	247,706.76	316,476.68	970,255.17	14.93
ash, green	201,563.60	21,832.05	26,033.80	171,074.90	94,622.19	515,126.54	7.93
maple, sugar	265,998.24	26,655.81	33,033.17	259,684.04	119,075.34	704,446.59	10.84
maple, red	90,047.54	7,798.65	11,985.02	63,695.91	39,429.04	212,956.16	3.28
planetree, London	181,243.30	15,051.00	20,318.30	176,694.55	39,662.12	432,969.26	6.66
maple, silver	189,382.14	27,847.52	26,402.51	248,469.31	118,951.06	611,052.53	9.40
pear, Callery	34,479.19	3,345.09	4,161.65	24,016.19	26,083.73	92,085.86	1.42
linden, littleleaf	61,158.46	7,786.94	7,789.35	47,153.13	40,361.70	164,249.58	2.53
maple, hedge	16,372.92	1,445.38	1,891.17	9,065.61	7,618.05	36,393.13	0.56
oak, northern red	44,843.66	2,367.73	4,926.52	50,992.18	3,203.13	106,333.22	1.64
zelkova, Japanese	8,535.05	725.96	1,004.47	3,998.05	4,400.83	18,664.36	0.29
Other street trees	233,366.95	23,394.32	28,398.57	217,909.63	104,486.23	607,555.70	9.35
TOTAL	2,544,333.28	256,472.43	323,083.61	2,133,173.76	1,241,668.28	6,498,731.36	100.00

Electricity and Natural Gas Results

Grand Rapids' street trees provide a savings of 9,598 MWh (\$961,798) and 1,307,232 therms (\$1,582,535) in shading and climate effects (Appendix K). The average savings per inventoried tree in the City is \$41.27, while Grand Rapids saves a total of \$2,544,333 per year over the whole inventory. Norway maple produces the largest electricity and natural gas savings at \$889,098, 34.9 percent of all energy savings. The energy benefits by species list follows the top five most occurring species list, with red maple being the exception. The number of red maples does not translate directly to benefits provided. This is due to the age distribution of red maples being heavily weighted toward younger trees, and young trees with less canopy cover provide fewer benefits.

Avoided and Sequestered Carbon Dioxide

Grand Rapids' street tree resource reduces a net 17,098 tons of CO₂ per year valued at \$256,472, with the average savings per tree at \$4.16. Norway maples account for 32.1 percent of these savings while constituting 34.1 percent of the total tree inventory. A comparison between red maple and silver maple benefits again illustrates the importance of maintaining a balanced relative age distribution. The relatively young red maple population (66.86 percent of the red maples are less than 6-inches DBH) represents 7 percent of the total tree population, yet only accounts for 3 percent of the net CO₂ benefits; whereas, the predominantly mature silver maple population (91 percent are greater than 12-inches DBH) represents only 4.1 percent of the total tree population yet provides 10.9 percent of the net CO₂ benefits.

Since carbon benefits directly correlate with woody biomass and leaf surface area, large mature trees are a big part of providing these benefits. Maintaining Grand Rapids' large mature tree population and planting new trees that will mature to similar size and structure will ensure that the flow of these benefits will not be interrupted in the future. Appendix L presents benefits associated with carbon sequestration by species.

Deposition and Avoided Pollutants

Grand Rapids' street trees improve air quality in two ways. The first way is by the deposition and interception of O₃, NO₂, PM₁₀, and SO₂. The second way is by the avoidance of NO₂, PM₁₀, VOCs, and SO₂. Avoidance is the indirect reduction of pollutant emissions by lowering dependence on energy consumption. Grand Rapids' street trees provide an annual savings of \$67,132 by means of deposition/interception and \$285,298 through avoidance. Norway maple and thornless honeylocust contribute the most benefits towards air quality due to their prevalence in the street tree population and size at maturity. The combined savings of these two species, 44 percent of street trees, is \$164,694 annually.

BVOC Emissions

Trees emit BVOCs that negatively affect air quality. Larger trees, such as silver maple, thornless honeylocust, and London planetree, tend to have higher BVOC emissions. In Grand Rapids, BVOC emissions offset total air quality benefits by \$29,347.

Net Air Quality Improvement

Grand Rapids experiences a net air quality improvement of \$323,084 per year, averaging \$5.24 per tree. Silver maples may be high BVOC emitters, but they provide the highest number of benefits per tree at an average of \$10.46. However, this tree is often considered an inferior landscape species because it tends to grow fast and is subject to breakage in high winds or under heavy loading events (ice, snow, etc.). Sugar maples are the second leading producer of air quality benefits per tree at \$7.47. Appendix M displays annual and net benefit values for air quality improvement by species.

Stormwater Runoff Reductions

Street trees in Grand Rapids intercept 78,709,427 gallons of stormwater annually, for a savings of \$2,133,174 (Appendix N). The average benefit per street tree is valued at \$34.60. Silver maple, red oak, and sugar maple intercept the greatest amounts of stormwater per tree due to their relatively mature age distribution. A comparison of Grand Rapids' silver maple and Norway maple population will illustrate the greatly increased stormwater benefits of large, mature trees. The Norway maple (34.1 percent of total tree population) intercepts 22.6 million gallons annually, while silver maple (only 4.1 percent of total tree population, but heavily mature) intercepts almost half of what Norway maple does at 9.1 million gallons annually.

Aesthetic, Property Value, Social, Economic, and Other Benefits

Aesthetic and other related benefits in Grand Rapids provide an estimate of \$1,241,668 annually to the City, for an average of \$20.14 per inventoried tree. Thornless honeylocust (\$50.47) and silver maple (\$47.14) return the highest benefit per tree (Appendix O).

Net Benefits and Benefit-Cost Ratio (BCR)

Grand Rapids receives substantial benefits from its street trees. However, the City must also consider the cost of maintaining this resource. Applying a benefit-cost ratio (BCR) is a useful way to evaluate the public investment in street trees. A BCR is an indicator used to summarize the overall value compared to the costs of a given project. Specifically in this analysis, BCR is the ratio of the cumulative benefits provided by the City's street trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms.

Not all of the benefits attributed to street trees are easily quantified; therefore, some intangible benefits are not included in this study. For example, benefits linked with human needs, such as increased public safety, are difficult to measure. Furthermore, variances within species and between sites often occur to make estimates less precise.

Grand Rapids' street trees provide significant benefits to the community and environment alike. Energy savings are the largest producers (39%) of quantifiable benefits to the City annually, with stormwater mitigation close behind at 32 percent. Aesthetic benefits account for 19 percent of the annual total, while air quality improvement and carbon dioxide reduction account for 10 percent of annual benefits. As determined throughout this analysis, larger-growing trees, such as silver maple, thornless honeylocust, green ash, and Norway maple, consistently supply the most benefits.

The sum of estimated benefits for the City of Grand Rapids (Table 2) is \$6.5 million annually at an average of \$105.41 per street tree and \$33.55 per capita. When Grand Rapids' annual expenditures are considered (\$1,804,594), the net annual benefit (benefits minus costs) returned by street trees to the City is \$4,694,139. The average net annual benefit for an individual street tree in Grand Rapids is \$76.14, nearly \$24.23 per capita. Based on the 4 percent sample inventory estimation of 61,654 trees, Grand Rapids receives \$3.60 in benefits for every \$1 that is spent on its municipal forestry program (Appendix P).

Table 2. i-Tree Streets Analysis Results for Annual Benefits, Net Benefits, and Cost for Public Trees

	Total (\$)	\$/Tree	\$/Capita
Total Benefits	6,498,731	105.41	33.55
Total Costs	1,804,592	29.27	9.32
Net Benefits	4,694,139	76.14	24.23
Benefit Cost Ratio	3.60	N/A	N/A

Management Implications

When cared for properly, Grand Rapids' street trees are worth investing in. Citizens of Grand Rapids can take comfort in knowing that the benefits produced by maintaining the urban forest outweigh the costs. In fact, for every \$1 spent on street tree management, street trees return an average net value of \$3.60 in benefits back to the community. Unfortunately, street trees can become a burden to any municipality if neglected. As trees grow larger and mature, those that are not adequately maintained become increasingly more costly to manage and may create liability issues. Meanwhile, valuable benefits are not fully achieved, lessening opportunities to encourage a safe, healthy, and more enjoyable environment in which to live.

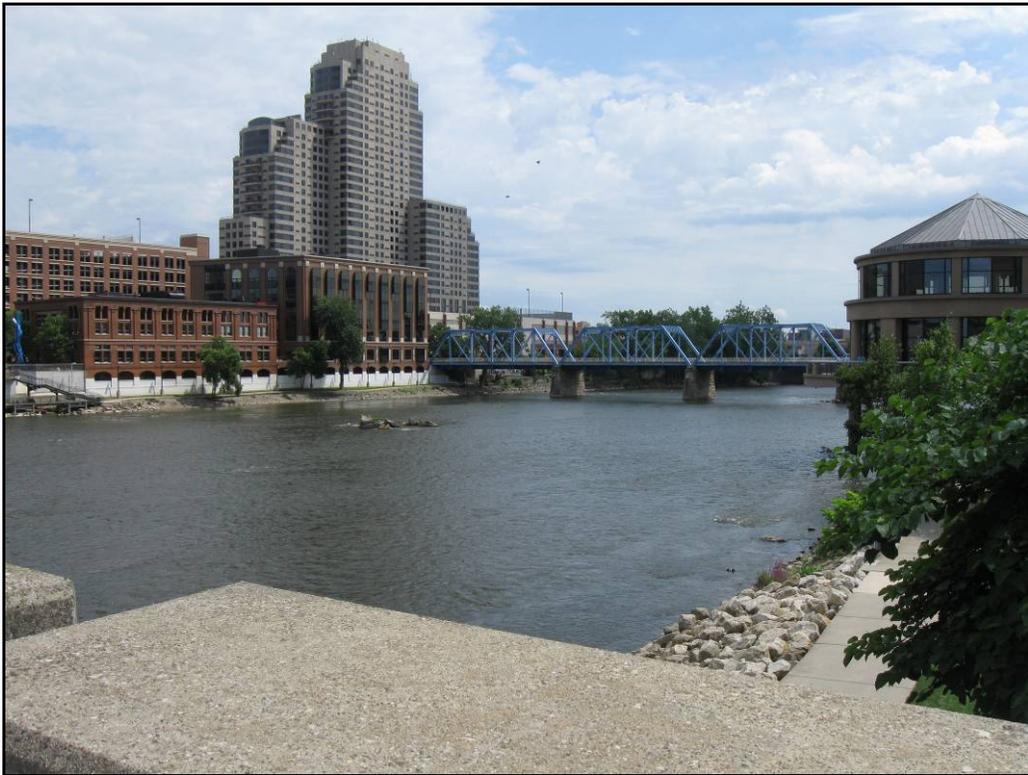
Implementing a comprehensive tree management program, including new tree establishment and cyclical pruning, is the first step in ensuring that benefits produced by the City's street trees surpass the cost of managing them. Currently, approximately 80 percent of Grand Rapids' inventoried street trees are considered to be in good condition. Trees in fair condition account for 14 percent of the population, with 4 percent of street trees recorded as poor and 0.5 percent inventoried as dead or dying. While these figures indicate a strong commitment to street tree management, Grand Rapids should strive to eliminate all dead and dying trees, replace poor performers, and maintain strong performing and large-growing species that provide the most benefits. Replacing overutilized species, such as maples (54%), should be considered to improve species diversity and reduce the impact of species-specific pests or disease. Northern red oak (*Quercus rubra*) (\$146.78) and London planetree (\$138.65) both have a high per-tree benefit, but represents only 6.2 percent of the total tree population. Planting large-growing and underutilized trees such as these two species will result in a more sustainable flow of benefits for future generations.

Ash trees are a valuable component of Grand Rapids' urban forest, as they represent 7.3 percent of all street trees. The replacement value of ash trees in the City is approximately \$4.3 million. Ash trees play a considerable role in Grand Rapids' urban forest, and the loss of these trees would be significant. Because emerald ash borer is already present in Grand Rapids, the City needs to remain proactive in its management strategies regarding this pest. Ash trees should be eliminated from Grand Rapids' planting program, pest monitoring should persist, treatment options should be considered, and an action plan should be established in preparation for the decline of the ash tree population.

The City of Grand Rapids is on the right path to a sustainable urban forest. This study can be used to hone the City's street tree management strategy, promoting a valuable asset with invaluable qualities. With a long-term plan, and the people in place to apply that plan to the City's trees, Grand Rapids will develop the resources it needs to achieve its urban forestry goals.

Conclusion

Grand Rapids' urban forest is a valuable resource. The street trees return an approximate annual net benefit of \$4,694,139 to the City at an average of \$76.14 per tree and \$24.23 per capita. Citizens of Grand Rapids see a return on their investment of \$3.60 for every \$1 spent on management. As a result, this i-Tree Streets analysis strongly suggests that there is justification for more attention and funding for urban forestry planning, design, management, and maintenance in the City of Grand Rapids. Planning for a greener and healthier city can begin by including urban forestry in all project discussions and considering creative ways in which to ensure the private and public tree canopy is kept healthy, well-maintained, safe, and is enhanced by well-planned planting projects.



Photograph 7. *The future development of green spaces and parks along the Grand River provides the opportunity to plant large growing species in a favorable environment, lowering maintenance needs and maximizing that tree's net benefits.*

Appendix A
Further Information

Further Information

www.itreetools.org

City of Minneapolis, Minnesota Municipal Tree Resource Analysis
McPherson, E.G., Simpson, J. R., Peper, P. J., Maco, S. E., Gardner,
S. L., Cozad, S. K., Xiao, Q (2005).

Midwest Community Tree Guide
Benefits, Costs, and Strategic Planning
McPherson, E.G., Simpson, J. R., Peper, P. J., Gardner, S. L.,
Vargas, K. E., Maco, S.E., Xiao, Q (2006).

Appendix B
Population Summary for the City of Grand Rapids

Population Summary of Public Trees

9/1/2010

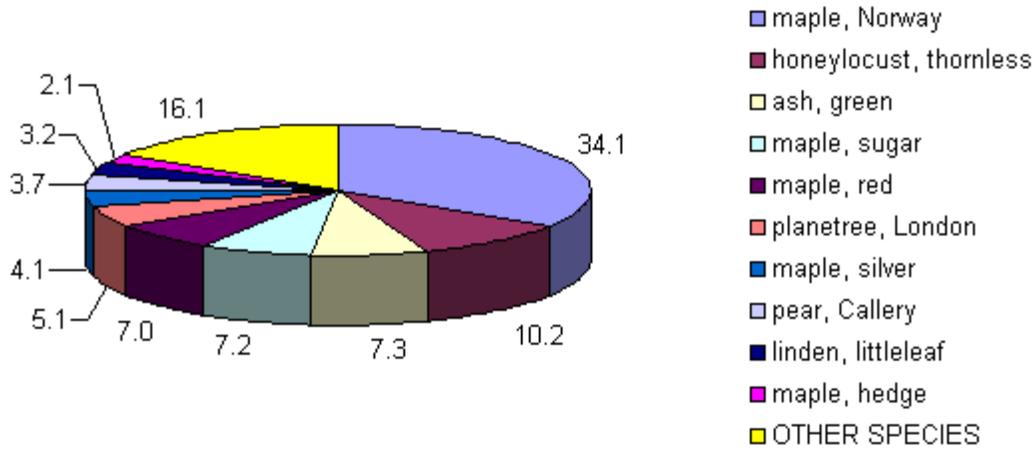
Species	DBH Class (in)									Total Standard Error
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	
Broadleaf Deciduous Large (BDL)										
ash, green	25	799	1,224	1,224	1,074	125	0	25	25	4,522 (±964)
maple, sugar	200	225	475	1,224	1,274	699	275	25	25	4,422 (±709)
maple, red	1,374	1,499	674	350	175	150	50	25	0	4,297 (±880)
planetree, London	50	25	25	625	1,524	674	200	0	0	3,123 (±837)
maple, silver	100	100	25	400	749	600	400	25	125	2,523 (±431)
oak, northern red	25	50	0	25	50	150	275	100	50	724 (±439)
BDL OTHER	799	325	475	475	600	375	300	100	75	3,522 (±503)
Total	2,573	3,023	2,898	4,322	5,446	2,773	1,499	300	300	23,133 (±2,009)
Broadleaf Deciduous Medium (BDM)										
maple, Norway	1,574	2,923	6,420	7,070	2,398	550	100	0	0	21,034 (±1,866)
honeylocust, thornless	650	999	899	2,198	1,224	225	75	0	0	6,270 (±1,329)
pear, Callery	749	974	275	275	0	0	0	0	0	2,273 (±563)
linden, littleleaf	400	275	325	650	275	25	0	0	0	1,949 (±631)
maple, hedge	650	350	300	0	0	0	25	0	0	1,324 (±237)
zelkova, Japanese	350	175	50	50	0	0	0	0	0	625 (±221)
BDM OTHER	1,174	250	275	350	100	25	75	0	0	2,248 (±406)
Total	5,546	5,946	8,544	10,592	3,997	824	275	0	0	35,723 (±2,538)
Broadleaf Deciduous Small (BDS)										
BDS OTHER	1,399	325	225	0	0	0	0	0	0	1,949 (±294)
Total	1,399	325	225	0	0	0	0	0	0	1,949 (±294)
Broadleaf Evergreen Large (BEL)										
BEL OTHER	0	0	50	0	0	0	0	0	0	50 (±49)
Total	0	0	50	0	0	0	0	0	0	50 (±49)
Broadleaf Evergreen Medium (BEM)										
BEM OTHER	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0 (±0)
Broadleaf Evergreen Small (BES)										
BES OTHER	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0 (±0)
Conifer Evergreen Large (CEL)										
CEL OTHER	0	0	0	25	25	0	0	0	0	50 (±35)
Total	0	0	0	25	25	0	0	0	0	50 (±35)
Conifer Evergreen Medium (CEM)										
CEM OTHER	225	75	225	125	0	25	0	0	0	674 (±239)
Total	225	75	225	125	0	25	0	0	0	674 (±239)
Conifer Evergreen Small (CES)										
CES OTHER	0	25	25	25	0	0	0	0	0	75 (±42)
Total	0	25	25	25	0	0	0	0	0	75 (±42)
Grand Total	9,743	9,393	11,966	15,089	9,468	3,622	1,774	300	300	61,654 (±3,420)

Appendix C
Species Distribution

Grand Rapids

Species Distribution of Public Trees (%)

9/1/2010



Species	Percent
maple, Norway	34.1
honeylocust, thornless	10.2
ash, green	7.3
maple, sugar	7.2
maple, red	7.0
planetree, London	5.1
maple, silver	4.1
pear, Callery	3.7
linden, littleleaf	3.2
maple, hedge	2.1
OTHER SPECIES	16.1
Total	100.0

Appendix D
Importance Value for Most Abundant Trees

Grand Rapids

Importance Values for Most Abundant Public Trees

9/1/2010

Species	Number of Trees	% of Total Trees	Leaf Area (ft ²)	% of Total Leaf Area	Canopy Cover (ft ²)	% of Total Canopy Cover	Importance Value
maple, Norway	21,034	34.1	29,880,620	24.8	12,744,595	30.7	29.9
honeylocust, thornless	6,270	10.2	15,610,230	13.0	5,764,866	13.9	12.3
ash, green	4,522	7.3	9,625,377	8.0	3,245,794	7.8	7.7
maple, sugar	4,422	7.2	16,809,574	13.9	4,740,172	11.4	10.8
maple, red	4,297	7.0	3,241,462	2.7	1,471,868	3.5	4.4
planetree, London	3,123	5.1	10,315,842	8.6	3,054,132	7.4	7.0
maple, silver	2,523	4.1	13,739,513	11.4	3,924,887	9.5	8.3
pear, Callery	2,273	3.7	1,189,036	1.0	524,861	1.3	2.0
linden, littleleaf	1,949	3.2	2,578,485	2.1	841,560	2.0	2.4
maple, hedge	1,324	2.1	380,655	0.3	221,726	0.5	1.0
oak, northern red	724	1.2	3,209,252	2.7	795,338	1.9	1.9
zelkova, Japanese	625	1.0	151,622	0.1	128,345	0.3	0.5
OTHER TREES	8,569	13.9	13,780,964	11.4	4,043,472	9.7	11.7
Total	61,654	100.0	120,512,633	100.0	41,501,615	100.0	100.0

Appendix E
Summary of Stocking Level

Grand Rapids

Summary of Available Planting Sites for Public Trees

9/1/2010

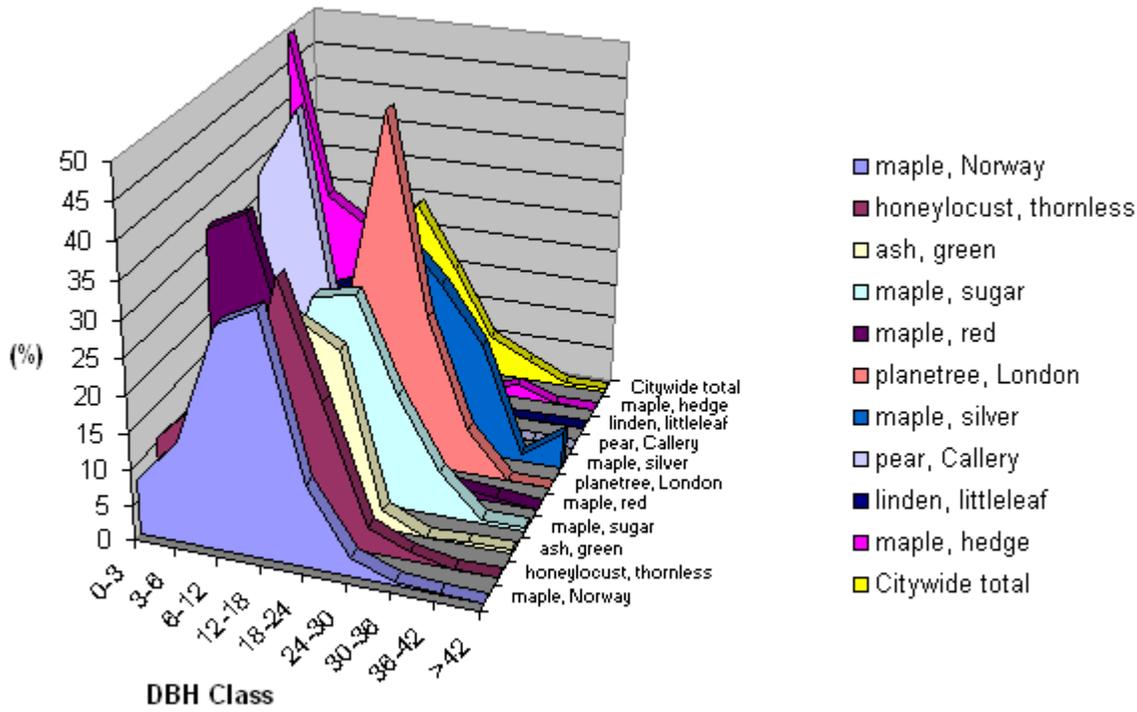
Zone	No. of Unplanted Sites	No. of Planted Sites	Total No. of Sites	Stocking (%)	No. of Unplanted Sites			
					Small	Medium	Large	Undefined
1	9,118	61,654	70,772	87	5,271	1,124	275	0
Citywide total	9,118	61,654	70,772	87	5,271	1,124	275	0

Appendix F
Relative Age Distribution

Grand Rapids

Relative Age Distribution of Top 10 Public Tree Species (%)

9/2/2010



Species	DBH class (in)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
maple, Norway	7.48	13.90	30.52	33.61	11.40	2.61	0.48	0.00	0.00
honeylocust, thornless	10.36	15.94	14.34	35.06	19.52	3.59	1.20	0.00	0.00
ash, green	0.55	17.68	27.07	27.07	23.76	2.76	0.00	0.55	0.55
maple, sugar	4.52	5.08	10.73	27.68	28.81	15.82	6.21	0.56	0.56
maple, red	31.98	34.88	15.70	8.14	4.07	3.49	1.16	0.58	0.00
planetree, London	1.60	0.80	0.80	20.00	48.80	21.60	6.40	0.00	0.00
maple, silver	3.96	3.96	0.99	15.84	29.70	23.76	15.84	0.99	4.95
pear, Callery	32.97	42.86	12.09	12.09	0.00	0.00	0.00	0.00	0.00
linden, littleleaf	20.51	14.10	16.67	33.33	14.10	1.28	0.00	0.00	0.00
maple, hedge	49.06	26.42	22.64	0.00	0.00	0.00	1.89	0.00	0.00
Citywide total	15.80	15.24	19.41	24.47	15.36	5.88	2.88	0.49	0.49

Appendix G
Structural (Woody) Condition of Trees

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
Amur corktree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
Amur maackia	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
arborvitae spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	175	(±112)	100.00	0.28
	Total	175	(±112)	100.00	0.28
arborvitae, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	100	(±77)	100.00	0.16
	Total	100	(±77)	100.00	0.16
ash, European	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	20.00	0.04
	Good	100	(±49)	80.00	0.16
	Total	125	(±54)	100.00	0.20
ash, green	Dead or Dying	50	(±49)	1.10	0.08
	Poor	125	(±81)	2.76	0.20
	Fair	325	(±111)	7.18	0.53
	Good	4,022	(±936)	88.95	6.52
	Total	4,522	(±964)	100.00	7.33
ash, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	12.50	0.04
	Good	175	(±127)	87.50	0.28
	Total	200	(±129)	100.00	0.32
beech, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±73)	100.00	0.12
	Total	75	(±73)	100.00	0.12
birch, European white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
birch, paper	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
birch, river	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
boxelder	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
buckeye, Ohio	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±42)	100.00	0.12
	Total	75	(±42)	100.00	0.12
catalpa, northern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	125	(±65)	100.00	0.20
	Total	125	(±65)	100.00	0.20
catalpa, southern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
cherry/plum, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	100	(±77)	33.33	0.16
	Good	200	(±77)	66.67	0.32
	Total	300	(±109)	100.00	0.49
cottonwood, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
crabapple, flowering	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	13.33	0.08
	Good	325	(±121)	86.67	0.53
	Total	375	(±126)	100.00	0.61
elm, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	8.33	0.04
	Fair	100	(±49)	33.33	0.16
	Good	175	(±64)	58.33	0.28
	Total	300	(±84)	100.00	0.49
elm, hybrid	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	125	(±65)	100.00	0.20
	Total	125	(±65)	100.00	0.20
elm, Siberian	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	200	(±115)	33.33	0.32
	Good	400	(±254)	66.67	0.65
	Total	600	(±278)	100.00	0.97
elm, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	33.33	0.04
	Good	50	(±35)	66.67	0.08
	Total	75	(±55)	100.00	0.12

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
filbert, Turkish	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	125	(±122)	55.56	0.20
	Good	100	(±69)	44.44	0.16
	Total	225	(±140)	100.00	0.36
ginkgo	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	5.56	0.04
	Good	425	(±177)	94.44	0.69
	Total	450	(±179)	100.00	0.73
goldenraintree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
hackberry, common	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	10.00	0.04
	Good	225	(±73)	90.00	0.36
	Total	250	(±76)	100.00	0.41
hawthorn, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	16.67	0.04
	Good	125	(±88)	83.33	0.20
	Total	150	(±91)	100.00	0.24
hemlock, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
hickory, shagbark	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
hickory, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
honeylocust	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
honeylocust, thornless	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	0.80	0.08
	Good	6,220	(±1328)	99.20	10.09
	Total	6,270	(±1329)	100.00	10.17
hophornbeam, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
hornbeam, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	25.00	0.04
	Good	75	(±42)	75.00	0.12
	Total	100	(±49)	100.00	0.16
horsechestnut, red	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
Japanese pagodatree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	200	(±109)	100.00	0.32
	Total	200	(±109)	100.00	0.32
juniper, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
katsuratree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
Kentucky coffeetree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
lilac, Japanese tree	Dead or Dying	25	(±24)	6.25	0.04
	Poor	0	(±0)	0.00	0.00
	Fair	75	(±42)	18.75	0.12
	Good	300	(±114)	75.00	0.49
	Total	400	(±150)	100.00	0.65
linden, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	400	(±141)	100.00	0.65
	Total	400	(±141)	100.00	0.65
linden, littleleaf	Dead or Dying	25	(±24)	1.28	0.04
	Poor	25	(±24)	1.28	0.04
	Fair	175	(±127)	8.97	0.28
	Good	1,724	(±576)	88.46	2.80
	Total	1,949	(±631)	100.00	3.16
linden, silver	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
locust, black	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	100	(±60)	100.00	0.16
	Total	100	(±60)	100.00	0.16

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
maple, hedge	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	1.89	0.04
	Good	1,299	(±236)	98.11	2.11
	Total	1,324	(±237)	100.00	2.15
maple, Norway	Dead or Dying	50	(±35)	0.24	0.08
	Poor	50	(±35)	0.24	0.08
	Fair	1,024	(±251)	4.87	1.66
	Good	19,885	(±1803)	94.54	32.25
	Total	21,009	(±1866)	99.88	34.08
maple, red	Dead or Dying	50	(±35)	1.16	0.08
	Poor	50	(±35)	1.16	0.08
	Fair	525	(±183)	12.21	0.85
	Good	3,672	(±856)	85.47	5.96
	Total	4,297	(±880)	100.00	6.97
maple, silver	Dead or Dying	75	(±42)	2.97	0.12
	Poor	50	(±35)	1.98	0.08
	Fair	325	(±148)	12.87	0.53
	Good	2,073	(±389)	82.18	3.36
	Total	2,523	(±431)	100.00	4.09
maple, sugar	Dead or Dying	25	(±24)	0.56	0.04
	Poor	0	(±0)	0.00	0.00
	Fair	275	(±87)	6.21	0.45
	Good	4,122	(±683)	93.22	6.69
	Total	4,422	(±709)	100.00	7.17
maple, sycamore	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
maple, Tatarian	Dead or Dying	25	(±24)	7.69	0.04
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	15.38	0.08
	Good	250	(±91)	76.92	0.41
	Total	325	(±100)	100.00	0.53
mountainash, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±42)	100.00	0.12
	Total	75	(±42)	100.00	0.12
mulberry, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	100	(±60)	100.00	0.16
	Total	100	(±60)	100.00	0.16
oak, bur	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	50.00	0.04
	Good	25	(±24)	50.00	0.04
	Total	50	(±35)	100.00	0.08
oak, cherrybark	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	100.00	0.04
	Good	0	(±0)	0.00	0.00
	Total	25	(±24)	100.00	0.04

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
oak, English	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±42)	100.00	0.12
	Total	75	(±42)	100.00	0.12
oak, northern red	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	175	(±149)	24.14	0.28
	Good	550	(±299)	75.86	0.89
	Total	724	(±439)	100.00	1.18
oak, pin	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	275	(±181)	100.00	0.45
	Total	275	(±181)	100.00	0.45
oak, swamp white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	40.00	0.08
	Good	75	(±42)	60.00	0.12
	Total	125	(±54)	100.00	0.20
oak, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	12.50	0.04
	Good	175	(±73)	87.50	0.28
	Total	200	(±77)	100.00	0.32
pear, Callery	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	1.10	0.04
	Fair	25	(±24)	1.10	0.04
	Good	2,223	(±558)	97.80	3.61
	Total	2,273	(±563)	100.00	3.69
persimmon, common	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
planetree, London	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	1.60	0.08
	Good	3,073	(±836)	98.40	4.98
	Total	3,123	(±837)	100.00	5.06
plum, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
plum, cherry	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
redbud, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
redcedar, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
Russian-olive	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	100.00	0.04
	Fair	0	(±0)	0.00	0.00
	Good	0	(±0)	0.00	0.00
	Total	25	(±24)	100.00	0.04
serviceberry, Allegheny	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
serviceberry, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
spruce, Colorado	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	400	(±141)	100.00	0.65
	Total	400	(±141)	100.00	0.65
spruce, Norway	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
sycamore, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	4.76	0.04
	Good	500	(±351)	95.24	0.81
	Total	525	(±352)	100.00	0.85
tree of heaven	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±42)	100.00	0.12
	Total	75	(±42)	100.00	0.12
walnut, black	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	125	(±65)	100.00	0.20
	Total	125	(±65)	100.00	0.20
walnut, English	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
yellowwood	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	175	(±73)	100.00	0.28
	Total	175	(±73)	100.00	0.28

Functional (Foliage) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
zelkova, Japanese	Dead or Dying	50	(±35)	8.00	0.08
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	4.00	0.04
	Good	550	(±188)	88.00	0.89
	Total	625	(±221)	100.00	1.01

Grand Rapids

Relative Performance Index for Public Trees

9/2/2010

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Standard Trees Error	% of Public
maple, Norway	0.24	4.22	12.18	83.36	1.01	21,034 (±1866)	34.12
honeylocust, thornless	0.00	0.60	11.95	87.45	1.03	6,270 (±1329)	10.17
ash, green	0.55	7.18	13.81	78.45	0.98	4,522 (±964)	7.33
maple, sugar	0.56	5.93	21.19	72.32	0.96	4,422 (±709)	7.17
maple, red	1.16	6.69	13.66	78.49	0.98	4,297 (±880)	6.97
planetree, London	0.00	1.20	4.80	94.00	1.05	3,123 (±837)	5.06
maple, silver	2.48	10.89	33.66	52.97	0.88	2,523 (±431)	4.09
pear, Callery	0.00	1.65	3.30	95.05	1.05	2,273 (±563)	3.69
linden, littleleaf	0.64	1.92	9.62	87.82	1.03	1,949 (±631)	3.16
maple, hedge	0.00	0.00	7.55	92.45	1.05	1,324 (±237)	2.15
oak, northern red	0.00	29.31	20.69	50.00	0.82	724 (±439)	1.18
zelkova, Japanese	8.00	4.00	16.00	72.00	0.92	625 (±221)	1.01
elm, Siberian	0.00	2.08	33.33	64.58	0.96	600 (±278)	0.97
sycamore, American	0.00	0.00	4.76	95.24	1.06	525 (±352)	0.85
ginkgo	0.00	0.00	5.56	94.44	1.06	450 (±179)	0.73
spruce, Colorado	0.00	0.00	0.00	100.00	1.07	400 (±141)	0.65
lilac, Japanese tree	6.25	3.13	28.13	62.50	0.91	400 (±150)	0.65
linden, American	0.00	0.00	3.13	96.88	1.06	400 (±141)	0.65
crabapple, flowering	0.00	0.00	16.67	83.33	1.02	375 (±126)	0.61
maple, Tatarian	3.85	7.69	19.23	69.23	0.93	325 (±100)	0.53
elm, American	0.00	4.17	33.33	62.50	0.94	300 (±84)	0.49
cherry/plum, spp.	0.00	8.33	29.17	62.50	0.93	300 (±109)	0.49
oak, pin	0.00	0.00	27.27	72.73	0.99	275 (±181)	0.45
hackberry, common	0.00	0.00	10.00	90.00	1.04	250 (±76)	0.41
filbert, Turkish	0.00	0.00	44.44	55.56	0.93	225 (±140)	0.36
ash, white	0.00	0.00	12.50	87.50	1.04	200 (±129)	0.32
oak, white	0.00	6.25	18.75	75.00	0.98	200 (±77)	0.32
Japanese pagodatree	0.00	6.25	6.25	87.50	1.02	200 (±109)	0.32
arborvitae spp.	0.00	0.00	0.00	100.00	1.07	175 (±112)	0.28
yellowwood	0.00	0.00	0.00	100.00	1.07	175 (±73)	0.28
hawthorn, spp.	0.00	0.00	33.33	66.67	0.97	150 (±91)	0.24
walnut, black	0.00	0.00	0.00	100.00	1.07	125 (±65)	0.20
elm, hybrid	0.00	0.00	10.00	90.00	1.04	125 (±65)	0.20
catalpa, northern	0.00	10.00	0.00	90.00	1.01	125 (±65)	0.20
ash, European	0.00	0.00	30.00	70.00	0.98	125 (±54)	0.20
oak, swamp white	0.00	10.00	30.00	60.00	0.92	125 (±54)	0.20
mulberry, white	0.00	0.00	25.00	75.00	1.00	100 (±60)	0.16
arborvitae, eastern	0.00	0.00	0.00	100.00	1.07	100 (±77)	0.16
locust, black	0.00	0.00	37.50	62.50	0.96	100 (±60)	0.16
hornbeam, American	0.00	0.00	25.00	75.00	1.00	100 (±49)	0.16
mountainash, American	0.00	0.00	0.00	100.00	1.07	75 (±42)	0.12
buckeye, Ohio	0.00	0.00	16.67	83.33	1.02	75 (±42)	0.12
tree of heaven	0.00	0.00	16.67	83.33	1.02	75 (±42)	0.12
oak, English	0.00	0.00	16.67	83.33	1.02	75 (±42)	0.12
beech, American	0.00	0.00	0.00	100.00	1.07	75 (±73)	0.12
elm, spp.	0.00	0.00	33.33	66.67	0.97	75 (±55)	0.12
spruce, Norway	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
hickory, shagbark	0.00	0.00	50.00	50.00	0.92	50 (±35)	0.08
Amur maackia	0.00	0.00	0.00	100.00	1.07	50 (±49)	0.08
plum, American	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
hophornbeam, American	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
birch, river	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
redbud, eastern	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
hemlock, eastern	0.00	0.00	0.00	100.00	1.07	50 (±49)	0.08
Amur corktree	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
maple, sycamore	0.00	0.00	25.00	75.00	1.00	50 (±35)	0.08
honeylocust	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08

Relative Performance Index for Public Trees

9/2/2010

Species	Dead or Dying	Poor	Fair	Good	RPI	# of Standard Trees Error	% of Public
walnut, English	0.00	0.00	0.00	100.00	1.07	50 (±49)	0.08
redcedar, eastern	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
boxelder	0.00	0.00	0.00	100.00	1.07	50 (±35)	0.08
oak, bur	0.00	0.00	75.00	25.00	0.84	50 (±35)	0.08
juniper, spp.	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
catalpa, southern	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
goldenraintree	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
birch, paper	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
persimmon, common	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
plum, cherry	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
cottonwood, eastern	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
Kentucky coffeetree	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
oak, cherrybark	0.00	50.00	50.00	0.00	0.60	25 (±24)	0.04
serviceberry, Allegheny	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
horsechestnut, red	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
Russian-olive	0.00	100.00	0.00	0.00	0.44	25 (±24)	0.04
birch, European white	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
serviceberry, spp.	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
katsuratre	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
hickory, spp.	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
linden, silver	0.00	0.00	0.00	100.00	1.07	25 (±24)	0.04
Citywide	0.51	4.21	13.64	81.64	1.00	61,654 (±3420)	100.00

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
Amur corktree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
Amur maackia	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
arborvitae spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	175	(±112)	100.00	0.28
	Total	175	(±112)	100.00	0.28
arborvitae, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	100	(±77)	100.00	0.16
	Total	100	(±77)	100.00	0.16
ash, European	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	40.00	0.08
	Good	75	(±42)	60.00	0.12
	Total	125	(±54)	100.00	0.20
ash, green	Dead or Dying	0	(±0)	0.00	0.00
	Poor	525	(±155)	11.60	0.85
	Fair	924	(±247)	20.44	1.50
	Good	3,073	(±858)	67.96	4.98
	Total	4,522	(±964)	100.00	7.33
ash, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	12.50	0.04
	Good	175	(±127)	87.50	0.28
	Total	200	(±129)	100.00	0.32
beech, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±73)	100.00	0.12
	Total	75	(±73)	100.00	0.12
birch, European white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
birch, paper	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
birch, river	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
boxelder	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
buckeye, Ohio	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	33.33	0.04
	Good	50	(±35)	66.67	0.08
	Total	75	(±42)	100.00	0.12
catalpa, northern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	20.00	0.04
	Fair	0	(±0)	0.00	0.00
	Good	100	(±60)	80.00	0.16
	Total	125	(±65)	100.00	0.20
catalpa, southern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
cherry/plum, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	50	(±49)	16.67	0.08
	Fair	75	(±42)	25.00	0.12
	Good	175	(±64)	58.33	0.28
	Total	300	(±109)	100.00	0.49
cottonwood, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
crabapple, flowering	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	75	(±55)	20.00	0.12
	Good	300	(±103)	80.00	0.49
	Total	375	(±126)	100.00	0.61
elm, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	100	(±49)	33.33	0.16
	Good	200	(±69)	66.67	0.32
	Total	300	(±84)	100.00	0.49
elm, hybrid	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	20.00	0.04
	Good	100	(±60)	80.00	0.16
	Total	125	(±65)	100.00	0.20
elm, Siberian	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	4.17	0.04
	Fair	200	(±109)	33.33	0.32
	Good	375	(±233)	62.50	0.61
	Total	600	(±278)	100.00	0.97
elm, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	33.33	0.04
	Good	50	(±35)	66.67	0.08
	Total	75	(±55)	100.00	0.12

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
filbert, Turkish	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	75	(±73)	33.33	0.12
	Good	150	(±85)	66.67	0.24
	Total	225	(±140)	100.00	0.36
ginkgo	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	5.56	0.04
	Good	425	(±177)	94.44	0.69
	Total	450	(±179)	100.00	0.73
goldenraintree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
hackberry, common	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	10.00	0.04
	Good	225	(±73)	90.00	0.36
	Total	250	(±76)	100.00	0.41
hawthorn, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	75	(±55)	50.00	0.12
	Good	75	(±73)	50.00	0.12
	Total	150	(±91)	100.00	0.24
hemlock, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
hickory, shagbark	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	100.00	0.08
	Good	0	(±0)	0.00	0.00
	Total	50	(±35)	100.00	0.08
hickory, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
honeylocust	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
honeylocust, thornless	Dead or Dying	0	(±0)	0.00	0.00
	Poor	75	(±55)	1.20	0.12
	Fair	1,449	(±573)	23.11	2.35
	Good	4,746	(±993)	75.70	7.70
	Total	6,270	(±1329)	100.00	10.17
hophornbeam, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
hornbeam, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	25.00	0.04
	Good	75	(±42)	75.00	0.12
	Total	100	(±49)	100.00	0.16
horsechestnut, red	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
Japanese pagodatree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	12.50	0.04
	Fair	25	(±24)	12.50	0.04
	Good	150	(±85)	75.00	0.24
	Total	200	(±109)	100.00	0.32
juniper, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
katsuratree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
Kentucky coffeetree	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
lilac, Japanese tree	Dead or Dying	25	(±24)	6.25	0.04
	Poor	25	(±24)	6.25	0.04
	Fair	150	(±69)	37.50	0.24
	Good	200	(±77)	50.00	0.32
	Total	400	(±150)	100.00	0.65
linden, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	6.25	0.04
	Good	375	(±139)	93.75	0.61
	Total	400	(±141)	100.00	0.65
linden, littleleaf	Dead or Dying	0	(±0)	0.00	0.00
	Poor	50	(±35)	2.56	0.08
	Fair	200	(±151)	10.26	0.32
	Good	1,699	(±572)	87.18	2.76
	Total	1,949	(±631)	100.00	3.16
linden, silver	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
locust, black	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	75	(±55)	75.00	0.12
	Good	25	(±24)	25.00	0.04
	Total	100	(±60)	100.00	0.16

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
maple, hedge	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	175	(±64)	13.21	0.28
	Good	1,149	(±220)	86.79	1.86
	Total	1,324	(±237)	100.00	2.15
maple, Norway	Dead or Dying	50	(±35)	0.24	0.08
	Poor	1,724	(±329)	8.19	2.80
	Fair	4,097	(±471)	19.48	6.65
	Good	15,164	(±1558)	72.09	24.59
	Total	21,034	(±1866)	100.00	34.12
maple, red	Dead or Dying	50	(±35)	1.16	0.08
	Poor	525	(±173)	12.21	0.85
	Fair	650	(±139)	15.12	1.05
	Good	3,073	(±800)	71.51	4.98
	Total	4,297	(±880)	100.00	6.97
maple, silver	Dead or Dying	50	(±35)	1.98	0.08
	Poor	500	(±153)	19.80	0.81
	Fair	1,374	(±265)	54.46	2.23
	Good	600	(±131)	23.76	0.97
	Total	2,523	(±431)	100.00	4.09
maple, sugar	Dead or Dying	25	(±24)	0.56	0.04
	Poor	525	(±125)	11.86	0.85
	Fair	1,599	(±315)	36.16	2.59
	Good	2,273	(±421)	51.41	3.69
	Total	4,422	(±709)	100.00	7.17
maple, sycamore	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	50.00	0.04
	Good	25	(±24)	50.00	0.04
	Total	50	(±35)	100.00	0.08
maple, Tatarian	Dead or Dying	0	(±0)	0.00	0.00
	Poor	50	(±35)	15.38	0.08
	Fair	75	(±42)	23.08	0.12
	Good	200	(±77)	61.54	0.32
	Total	325	(±100)	100.00	0.53
mountainash, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	75	(±42)	100.00	0.12
	Total	75	(±42)	100.00	0.12
mulberry, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	50.00	0.08
	Good	50	(±35)	50.00	0.08
	Total	100	(±60)	100.00	0.16
oak, bur	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	50	(±35)	100.00	0.08
	Good	0	(±0)	0.00	0.00
	Total	50	(±35)	100.00	0.08
oak, cherrybark	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	100.00	0.04
	Fair	0	(±0)	0.00	0.00
	Good	0	(±0)	0.00	0.00
	Total	25	(±24)	100.00	0.04

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
oak, English	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	33.33	0.04
	Good	50	(±35)	66.67	0.08
	Total	75	(±42)	100.00	0.12
oak, northern red	Dead or Dying	0	(±0)	0.00	0.00
	Poor	425	(±416)	58.62	0.69
	Fair	125	(±81)	17.24	0.20
	Good	175	(±95)	24.14	0.28
	Total	724	(±439)	100.00	1.18
oak, pin	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	150	(±125)	54.55	0.24
	Good	125	(±73)	45.45	0.20
	Total	275	(±181)	100.00	0.45
oak, swamp white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	20.00	0.04
	Fair	25	(±24)	20.00	0.04
	Good	75	(±42)	60.00	0.12
	Total	125	(±54)	100.00	0.20
oak, white	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	12.50	0.04
	Fair	50	(±35)	25.00	0.08
	Good	125	(±65)	62.50	0.20
	Total	200	(±77)	100.00	0.32
pear, Callery	Dead or Dying	0	(±0)	0.00	0.00
	Poor	50	(±49)	2.20	0.08
	Fair	125	(±81)	5.49	0.20
	Good	2,098	(±542)	92.31	3.40
	Total	2,273	(±563)	100.00	3.69
persimmon, common	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
planetree, London	Dead or Dying	0	(±0)	0.00	0.00
	Poor	75	(±55)	2.40	0.12
	Fair	250	(±103)	8.00	0.41
	Good	2,798	(±784)	89.60	4.54
	Total	3,123	(±837)	100.00	5.06
plum, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
plum, cherry	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
redbud, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08

Structural (Woody) Condition of Public Trees by Species

9/2/2010

Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
redcedar, eastern	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
Russian-olive	Dead or Dying	0	(±0)	0.00	0.00
	Poor	25	(±24)	100.00	0.04
	Fair	0	(±0)	0.00	0.00
	Good	0	(±0)	0.00	0.00
	Total	25	(±24)	100.00	0.04
serviceberry, Allegheny	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
serviceberry, spp.	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	25	(±24)	100.00	0.04
	Total	25	(±24)	100.00	0.04
spruce, Colorado	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	400	(±141)	100.00	0.65
	Total	400	(±141)	100.00	0.65
spruce, Norway	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±35)	100.00	0.08
	Total	50	(±35)	100.00	0.08
sycamore, American	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	4.76	0.04
	Good	500	(±351)	95.24	0.81
	Total	525	(±352)	100.00	0.85
tree of heaven	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	25	(±24)	33.33	0.04
	Good	50	(±35)	66.67	0.08
	Total	75	(±42)	100.00	0.12
walnut, black	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	125	(±65)	100.00	0.20
	Total	125	(±65)	100.00	0.20
walnut, English	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	50	(±49)	100.00	0.08
	Total	50	(±49)	100.00	0.08
yellowwood	Dead or Dying	0	(±0)	0.00	0.00
	Poor	0	(±0)	0.00	0.00
	Fair	0	(±0)	0.00	0.00
	Good	175	(±73)	100.00	0.28
	Total	175	(±73)	100.00	0.28

Structural (Woody) Condition of Public Trees by Species

9/2/2010

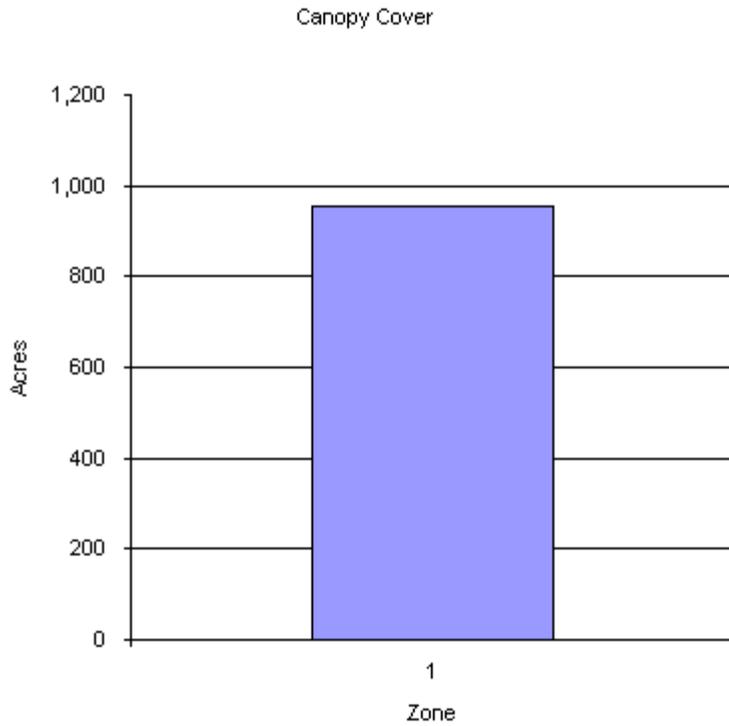
Species	Condition	Tree Count	Standard Error	% of Species	% of Public Trees
zelkova, Japanese	Dead or Dying	50	(±35)	8.00	0.08
	Poor	50	(±35)	8.00	0.08
	Fair	175	(±73)	28.00	0.28
	Good	350	(±128)	56.00	0.57
	Total		625	(±221)	100.00

Appendix H
Canopy Cover

Grand Rapids

Canopy Cover of Public Trees (Acres)

9/2/2010



Zone	Acres	% of Total Canopy Cover
1	953	100.0
Citywide total	953	100.0

	Total Land Area	Total Street and Sidewalk Area	Total Canopy Cover	Canopy Cover as % of Total Land Area	Canopy Cover as % of Total Streets and Sidewalks
Citywide total	28,800	2,593	953	3.31	36.74

Appendix I
Replacement Value (by Species and Zone)

Grand Rapids

Replacement Value for Public Trees by Species

9/2/2010

Species	DBH Class (in)									Total	Standard Error	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42			
maple, Norway	489,586	1,124,748	3,876,890	7,753,715	4,306,578	1,603,929	340,276	0	0	19,495,721	(±1,729,166)	27.50
honeylocust, thornless	184,803	340,986	489,634	2,191,428	2,009,904	591,522	293,936	0	0	6,102,214	(±1,293,666)	8.61
ash, green	7,315	270,455	621,129	1,143,321	1,668,892	329,734	0	114,310	132,200	4,287,356	(±914,029)	6.05
maple, sugar	63,100	98,020	321,383	1,561,784	2,890,571	2,290,755	1,414,118	194,755	225,557	9,060,043	(±1,452,702)	12.78
maple, red	374,035	582,757	432,170	418,411	355,395	398,905	225,501	128,180	0	2,915,354	(±596,917)	4.11
planetree, London	17,372	7,688	18,334	878,239	3,753,702	2,581,052	1,092,917	0	0	8,349,303	(±2,238,662)	11.78
maple, silver	26,947	27,711	10,127	336,237	1,132,932	1,378,748	1,447,136	122,587	758,178	5,240,603	(±895,691)	7.39
pear, Callery	216,002	333,583	157,813	300,126	0	0	0	0	0	1,007,524	(±249,302)	1.42
linden, littleleaf	102,306	105,395	220,068	868,253	639,027	91,025	0	0	0	2,026,074	(±656,511)	2.86
maple, hedge	202,970	135,731	186,710	0	0	0	97,703	0	0	623,113	(±111,504)	0.88
oak, northern red	8,686	21,782	0	20,104	106,514	442,630	1,122,117	578,538	351,603	2,651,975	(±1,606,796)	3.74
zelkova, Japanese	83,043	55,232	27,769	47,987	0	0	0	0	0	214,032	(±75,744)	0.30
elm, Siberian	69,705	31,376	83,307	0	43,918	47,961	54,753	0	0	331,020	(±153,365)	0.47
sycamore, American	6,131	0	0	71,952	811,711	293,171	141,829	194,755	0	1,519,549	(±1,018,466)	2.14
ginkgo	118,688	11,088	36,307	39,757	0	0	0	0	0	205,839	(±81,778)	0.29
spruce, Colorado	11,603	6,978	76,632	101,783	0	53,289	0	0	0	250,284	(±88,578)	0.35
lilac, Japanese tree	116,462	0	0	0	0	0	0	0	0	116,462	(±43,621)	0.16
linden, American	23,770	28,477	84,642	100,183	0	91,025	132,190	0	0	460,288	(±162,900)	0.65
crabapple, flowering	84,304	31,072	31,275	0	0	0	0	0	0	146,651	(±49,280)	0.21
maple, Tatarian	82,771	18,579	0	0	0	0	0	0	0	101,350	(±31,113)	0.14
cherry/plum, spp.	46,367	27,036	12,960	0	0	0	0	0	0	86,364	(±31,270)	0.12
elm, American	7,271	0	24,474	50,556	46,691	123,789	163,536	143,722	117,395	677,433	(±188,742)	0.96
oak, pin	17,490	0	0	34,086	50,033	155,957	490,576	154,829	0	902,970	(±595,508)	1.27
hackberry, common	68,981	9,982	0	0	0	0	0	0	0	78,963	(±24,167)	0.11
filbert, Turkish	62,852	0	0	0	0	0	0	0	0	62,852	(±39,229)	0.09
ash, white	0	9,798	94,513	21,082	0	0	0	0	0	125,393	(±81,122)	0.18
oak, white	17,372	0	36,668	35,976	53,257	54,610	0	166,115	0	363,998	(±139,944)	0.51
Japanese pagodatree	0	0	11,843	121,873	87,836	0	0	0	0	221,552	(±120,987)	0.31
yellowwood	40,169	0	0	59,732	0	0	0	0	0	99,901	(±41,697)	0.14
arborvitae spp.	23,207	6,978	21,895	0	0	0	0	0	0	52,080	(±33,345)	0.07
hawthorn, spp.	20,948	32,673	0	0	0	0	0	0	0	53,622	(±32,693)	0.08
catalpa, northern	0	0	0	0	99,100	182,051	132,190	0	0	413,341	(±213,553)	0.58
ash, European	0	7,520	13,885	70,077	0	0	0	0	0	91,481	(±39,868)	0.13
walnut, black	0	9,982	0	100,183	0	0	0	0	210,336	320,501	(±165,587)	0.45
oak, swamp white	37,043	0	0	0	0	0	0	0	0	37,043	(±16,143)	0.05

Species	DBH Class (in)									Total	Standard Error	% of Total	
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42				
elm, hybrid	35,288	0	0	0	0	0	0	0	0	0	35,288	(±18,231)	0.05
hornbeam, American	32,189	0	0	0	0	0	0	0	0	0	32,189	(±15,705)	0.05
mulberry, white	0	9,798	0	25,474	0	0	212,251	0	0	0	247,523	(±148,177)	0.35
locust, black	0	0	0	0	43,918	57,953	167,140	0	0	0	269,012	(±161,042)	0.38
arborvitae, eastern	17,405	6,978	0	0	0	0	0	0	0	0	24,383	(±18,872)	0.03
buckeye, Ohio	8,627	0	0	70,164	0	0	0	0	0	0	78,791	(±44,450)	0.11
tree of heaven	0	8,889	0	0	86,515	0	0	0	0	0	95,403	(±53,822)	0.13
oak, English	0	0	17,704	63,159	0	0	0	0	0	0	80,863	(±45,619)	0.11
mountainash, American	0	10,891	36,668	0	0	0	0	0	0	0	47,559	(±26,830)	0.07
elm, spp.	12,404	0	0	27,284	0	0	0	0	0	0	39,688	(±28,952)	0.06
beech, American	0	29,945	0	0	0	0	0	0	0	0	29,945	(±29,340)	0.04
boxelder	0	8,889	14,347	0	0	0	0	0	0	0	23,235	(±16,076)	0.03
maple, sycamore	0	10,891	0	0	53,257	0	0	0	0	0	64,148	(±44,383)	0.09
birch, river	7,271	8,889	0	0	0	0	0	0	0	0	16,160	(±11,181)	0.02
hickory, shagbark	0	0	0	0	37,460	57,953	0	0	0	0	95,413	(±66,014)	0.13
redbud, eastern	8,686	0	18,334	0	0	0	0	0	0	0	27,020	(±18,694)	0.04
honeylocust	0	8,816	0	0	43,918	0	0	0	0	0	52,735	(±36,486)	0.07
walnut, English	0	8,816	13,885	0	0	0	0	0	0	0	22,701	(±22,242)	0.03
redcedar, eastern	0	0	11,619	22,373	0	0	0	0	0	0	33,992	(±23,518)	0.05
Amur maackia	16,067	0	0	0	0	0	0	0	0	0	16,067	(±15,743)	0.02
hophornbeam, American	8,686	0	18,334	0	0	0	0	0	0	0	27,020	(±18,694)	0.04
Amur corktree	0	0	18,964	37,866	0	0	0	0	0	0	56,830	(±39,319)	0.08
spruce, Norway	0	0	0	22,373	38,503	0	0	0	0	0	60,875	(±42,118)	0.09
plum, American	8,686	0	18,334	0	0	0	0	0	0	0	27,020	(±18,694)	0.04
oak, bur	0	0	0	0	0	68,981	120,972	0	0	0	189,953	(±131,424)	0.27
hemlock, eastern	0	0	39,188	0	0	0	0	0	0	0	39,188	(±38,396)	0.06
horsechestnut, red	8,034	0	0	0	0	0	0	0	0	0	8,034	(±7,871)	0.01
serviceberry, Allegheny	8,686	0	0	0	0	0	0	0	0	0	8,686	(±8,510)	0.01
serviceberry, spp.	8,686	0	0	0	0	0	0	0	0	0	8,686	(±8,510)	0.01
birch, paper	7,531	0	0	0	0	0	0	0	0	0	7,531	(±7,379)	0.01
birch, European white	0	0	14,347	0	0	0	0	0	0	0	14,347	(±14,057)	0.02
hickory, spp.	0	0	0	0	0	67,945	0	0	0	0	67,945	(±66,571)	0.10
catalpa, southern	0	9,798	0	0	0	0	0	0	0	0	9,798	(±9,600)	0.01
katsuratree	8,034	0	0	0	0	0	0	0	0	0	8,034	(±7,871)	0.01
persimmon, common	0	0	0	29,866	0	0	0	0	0	0	29,866	(±29,262)	0.04
Russian-olive	0	0	0	11,235	0	0	0	0	0	0	11,235	(±11,008)	0.02
Kentucky coffeetree	8,509	0	0	0	0	0	0	0	0	0	8,509	(±8,337)	0.01
juniper, spp.	0	6,727	0	0	0	0	0	0	0	0	6,727	(±6,591)	0.01
goldenraintree	7,315	0	0	0	0	0	0	0	0	0	7,315	(±7,167)	0.01
cottonwood, eastern	0	0	0	0	0	0	0	0	210,336	210,336	(±206,084)	0.30	

Species	DBH Class (in)									Total	Standard Error	% of Total	
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42				
plum, cherry	0	0	18,334	0	0	0	0	0	0	0	18,334	(±17,963)	0.03
oak, cherrybark	0	0	0	0	34,893	0	0	0	0	0	34,893	(±34,187)	0.05
linden, silver	7,923	0	0	0	0	0	0	0	0	0	7,923	(±7,763)	0.01
Citywide total	2,851,326	3,464,953	7,130,484	16,636,638	18,394,522	10,962,985	7,649,141	1,797,792	2,005,607	70,893,448	(±3,932,424)	100.00	

Appendix J
Annual Management Costs

Grand Rapids

Annual Management Costs of Public Trees

9/2/2010

Expenditures	Total (\$)	\$/Tree	\$/Capita
Purchasing Trees and Planting	218,369	3.54	1.13
Contract Pruning	622,408	10.10	3.21
Pest Management	16,519	0.27	0.09
Irrigation	19,681	0.32	0.10
Removal	504,014	8.17	2.60
Administration	64,994	1.05	0.34
Inspection/Service	99,740	1.62	0.51
Infrastructure Repairs	39,091	0.63	0.20
Litter Clean-up	199,797	3.24	1.03
Liability/Claim	0	0.00	0.00
Other Cost	19,979	0.32	0.10
Total Expenditures	1,804,592	29.27	9.32

Appendix K
Annual Energy Benefits (by Species and Zone)

Grand Rapids

Annual Energy Benefits of Public Trees By Species

9/3/2010

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total Standard (\$ Error)	% of Total Trees	% of Total \$	Avg. \$/tree
maple, Norway	3,294.8	330,138	461,721.3	558,960	889,098 (±78,858)	34.1	34.9	42.27
honeylocust, thornless	1,270.7	127,323	165,968.8	200,922	328,244 (±69,588)	10.2	12.9	52.35
ash, green	772.1	77,361	102,596.2	124,203	201,564 (±42,972)	7.3	7.9	44.58
maple, sugar	1,019.5	102,153	135,342.1	163,845	265,998 (±42,651)	7.2	10.5	60.16
maple, red	337.6	33,830	46,437.6	56,217	90,048 (±18,437)	7.0	3.5	20.96
planetree, London	678.3	67,970	93,568.1	113,274	181,243 (±48,596)	5.1	7.1	58.04
maple, silver	730.0	73,144	96,017.0	116,238	189,382 (±32,368)	4.1	7.4	75.06
pear, Callery	133.5	13,374	17,433.8	21,105	34,479 (±8,532)	3.7	1.4	15.17
linden, littleleaf	233.7	23,412	31,179.6	37,746	61,158 (±19,817)	3.2	2.4	31.39
maple, hedge	55.7	5,580	8,915.5	10,793	16,373 (±2,930)	2.2	0.6	12.37
oak, northern red	165.7	16,606	23,325.6	28,238	44,844 (±27,170)	1.2	1.8	61.90
zelkova, Japanese	31.6	3,168	4,433.6	5,367	8,535 (±3,020)	1.0	0.3	13.67
OTHER STREET TREES	875.7	87,740	120,292.8	145,626	233,367 (±19,595)	13.9	9.2	27.24
Citywide total	9,598.8	961,798	1,307,232.0	1,582,535	2,544,333 (±141,133)	100.0	100.0	41.27

Appendix L
Annual Carbon Dioxide Benefits (by Species and Zone)

Grand Rapids

Annual CO₂ Benefits of Public Trees by Species

9/3/2010

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total Standard (\$ Error)	% of Total Trees	% of Total \$	Avg. \$/tree
maple, Norway	5,784,620	43,385	-298,205	-32,219	-2,478	5,526,581	41,449	10,980,778	82,356 (±7,305)	34.1	32.1	3.92
honeylocust, thornless	2,755,654	20,667	-94,697	-10,210	-787	2,131,408	15,986	4,782,154	35,866 (±7,604)	10.2	14.0	5.72
ash, green	1,715,716	12,868	-91,883	-7,926	-749	1,295,034	9,713	2,910,940	21,832 (±4,654)	7.3	8.5	4.83
maple, sugar	2,014,269	15,107	-159,739	-10,488	-1,277	1,710,066	12,825	3,554,107	26,656 (±4,274)	7.2	10.4	6.03
maple, red	503,850	3,779	-26,648	-3,707	-228	566,325	4,247	1,039,821	7,799 (±1,597)	7.0	3.0	1.82
planetree, London	1,012,465	7,593	-134,993	-8,501	-1,076	1,137,828	8,534	2,006,800	15,051 (±4,036)	5.1	5.9	4.82
maple, silver	2,645,186	19,839	-149,066	-7,562	-1,175	1,224,445	9,183	3,713,003	27,848 (±4,760)	4.1	10.9	11.04
pear, Callery	231,740	1,738	-8,036	-1,573	-72	223,881	1,679	446,012	3,345 (±828)	3.7	1.3	1.47
linden, littleleaf	674,975	5,062	-25,922	-2,723	-215	391,929	2,939	1,038,259	7,787 (±2,523)	3.2	3.0	4.00
maple, hedge	104,093	781	-3,995	-789	-36	93,407	701	192,717	1,445 (±259)	2.2	0.6	1.09
oak, northern red	84,426	633	-44,477	-2,236	-350	277,983	2,085	315,697	2,368 (±1,435)	1.2	0.9	3.27
zelkova, Japanese	45,326	340	-1,233	-326	-12	53,028	398	96,795	726 (±257)	1.0	0.3	1.16
OTHER STREET TREES	1,803,414	13,526	-142,364	-10,601	-1,147	1,468,794	11,016	3,119,243	23,394 (±1,964)	13.9	9.1	2.73
Citywide total	19,375,734	145,318	-1,181,258	-98,863	-9,601	16,100,711	120,755	34,196,324	256,472 (±14,226)	100.0	100.0	4.16

Appendix M
Annual Air Quality Benefits (by Species and Zone)

Grand Rapids

Annual Air Quality Benefits of Public Trees by Species

9/3/2010

Species	Deposition (lb)				Total Depos. (\$)	Avoided (lb)				Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total Standard (\$) Error	% of Total Trees	Avg. \$/tree
	O ₃	NO ₂	PM ₁₀	SO ₂		NO ₂	PM ₁₀	VOC	SO ₂							
maple, Norway	3,664.1	632.1	1,939.2	162.4	20,191	15,859.1	2,301.4	2,192.4	14,954.0	98,532	-945.4	-3,545	40,759.3	115,178 (±10,216)	34.1	5.48
honeylocust, thornless	1,584.3	261.1	764.3	71.9	8,482	5,987.9	877.3	837.7	5,755.6	37,489	-1,069.4	-4,010	15,070.7	41,961 (±8,896)	10.2	6.69
ash, green	575.9	92.0	315.0	25.8	3,179	3,657.1	534.6	510.2	3,499.4	22,855	0.0	0	9,210.1	26,034 (±5,550)	7.3	5.76
maple, sugar	1,165.6	198.4	607.9	51.6	6,389	4,824.4	705.4	673.2	4,618.3	30,155	-936.2	-3,511	11,908.7	33,033 (±5,297)	7.2	7.47
maple, red	477.0	81.3	235.5	21.1	2,577	1,610.6	234.5	223.6	1,529.3	10,034	-167.1	-626	4,245.9	11,985 (±2,454)	7.0	2.79
planetree, London	1,358.9	234.4	662.5	60.2	7,327	3,240.6	471.6	449.6	3,072.9	20,179	-1,916.8	-7,188	7,633.9	20,318 (±5,448)	5.1	6.51
maple, silver	1,427.5	242.0	720.6	63.3	7,753	3,441.7	503.9	481.1	3,303.4	21,536	-769.6	-2,886	9,413.9	26,403 (±4,513)	4.1	10.46
pear, Callery	63.1	10.1	40.0	2.8	364	629.0	92.2	88.1	605.6	3,941	-38.0	-143	1,492.8	4,162 (±1,030)	3.7	1.83
linden, littleleaf	240.9	41.6	127.5	10.7	1,328	1,110.7	162.2	154.8	1,060.7	6,936	-126.5	-474	2,782.6	7,789 (±2,524)	3.2	4.00
maple, hedge	40.7	7.0	24.7	1.8	233	278.0	39.6	37.6	252.9	1,703	-12.0	-45	670.3	1,891 (±338)	2.1	1.43
oak, northern red	413.2	71.3	198.0	18.3	2,218	795.8	115.5	110.0	750.6	4,945	-596.3	-2,236	1,876.3	4,927 (±2,985)	1.2	6.80
zelkova, Japanese	17.8	2.9	10.3	0.8	100	151.7	22.0	21.0	143.3	943	-10.4	-39	359.5	1,004 (±355)	1.0	1.61
OTHER STREET TREES	1,268.1	217.9	668.7	62.7	6,991	4,182.6	608.8	580.4	3,968.2	26,050	-1,238.1	-4,643	10,319.3	28,399 (±2,385)	13.9	3.31
Citywide total	12,297.0	2,092.1	6,314.2	553.5	67,132	45,769.3	6,669.2	6,359.7	43,514.3	285,298	-7,825.9	-29,347	115,743.5	323,084 (±17,921)	100.0	5.24

Appendix N
Annual Stormwater Benefits (by Species and Zone)

Grand Rapids

Annual Stormwater Benefits of Public Trees by Species

9/3/2010

Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
maple, Norway	22,607,783	612,714	(±54,344)	34.1	28.7	29.13
honeylocust, thornless	9,139,836	247,707	(±52,514)	10.2	11.6	39.50
ash, green	6,312,288	171,075	(±36,472)	7.3	8.0	37.84
maple, sugar	9,581,771	259,684	(±41,638)	7.2	12.2	58.73
maple, red	2,350,239	63,696	(±13,042)	7.0	3.0	14.82
planetree, London	6,519,641	176,695	(±47,376)	5.1	8.3	56.58
maple, silver	9,167,972	248,469	(±42,467)	4.1	11.7	98.48
pear, Callery	886,145	24,016	(±5,943)	3.7	1.1	10.56
linden, littleleaf	1,739,847	47,153	(±15,279)	3.2	2.2	24.20
maple, hedge	334,501	9,066	(±1,622)	2.2	0.4	6.85
oak, northern red	1,881,499	50,992	(±30,895)	1.2	2.4	70.39
zelkova, Japanese	147,519	3,998	(±1,415)	1.0	0.2	6.40
OTHER STREET TREES	8,040,387	217,910	(±18,297)	13.9	10.2	25.43
Citywide total	78,709,427	2,133,174	(±118,326)	100.0	100.0	34.60

Appendix O
Annual, Aesthetic, and Other Value Benefits
(by Species and Zone)

Grand Rapids

Annual Aesthetic/Other Benefits of Public Trees by Species

9/3/2010

Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
maple, Norway	327,298	(±29,030)	34.1	26.4	15.56
honeylocust, thornless	316,477	(±67,093)	10.2	25.5	50.47
ash, green	94,622	(±20,173)	7.3	7.6	20.93
maple, sugar	119,075	(±19,093)	7.2	9.6	26.93
maple, red	39,429	(±8,073)	7.0	3.2	9.18
planetree, London	39,662	(±10,634)	5.1	3.2	12.70
maple, silver	118,951	(±20,330)	4.1	9.6	47.14
pear, Callery	26,084	(±6,454)	3.7	2.1	11.47
linden, littleleaf	40,362	(±13,078)	3.2	3.3	20.71
maple, hedge	7,618	(±1,363)	2.2	0.6	5.75
oak, northern red	3,203	(±1,941)	1.2	0.3	4.42
zelkova, Japanese	4,401	(±1,557)	1.0	0.4	7.05
OTHER STREET TREES	104,486	(±8,773)	13.9	8.4	12.19
Citywide total	1,241,668	(±68,875)	100.0	100.0	20.14

Appendix P
Annual Benefits, Net Benefits, and Cost Summary

Grand Rapids

Total Annual Benefits, Net Benefits, and Costs for Public Trees

9/3/2010

Benefits	Total (\$) Standard Error	\$/tree Standard Error	\$/capita Standard Error
Energy	2,544,333 (±141,133)	41.27 (±2.29)	13.13 (±0.73)
CO2	256,472 (±14,226)	4.16 (±0.23)	1.32 (±0.07)
Air Quality	323,084 (±17,921)	5.24 (±0.29)	1.67 (±0.09)
Stormwater	2,133,174 (±118,326)	34.60 (±1.92)	11.01 (±0.61)
Aesthetic/Other	1,241,668 (±68,875)	20.14 (±1.12)	6.41 (±0.36)
Total Benefits	6,498,731 (±360,481)	105.41 (±5.85)	33.55 (±1.86)
Costs			
Planting	218,369	3.54	1.13
Contract Pruning	622,408	10.10	3.21
Pest Management	16,519	0.27	0.09
Irrigation	19,681	0.32	0.10
Removal	504,014	8.17	2.60
Administration	64,994	1.05	0.34
Inspection/Service	99,740	1.62	0.51
Infrastructure Repairs	39,091	0.63	0.20
Litter Clean-up	199,797	3.24	1.03
Liability/Claims	0	0.00	0.00
Other Costs	19,979	0.32	0.10
Total Costs	1,804,592	29.27	9.32
Net Benefits	4,694,139 (±360,481)	76.14 (±5.85)	24.23 (±1.86)
Benefit-cost ratio	3.60 (±0.20)		