



Chapter 3: Goshen's Benefit-Cost Analysis

Public trees provide the City of Goshen a multitude of environmental and economic benefit savings equivalent to what the community may pay to manage their environment. Trees mitigate stormwater runoff, conserve energy, improve air quality, and reduce carbon dioxide levels. They also provide other aesthetic benefits such as economic, social, psychological, and wildlife enhancements. This chapter uses Goshen's public inventory and the i-Tree Streets model to assess and quantify the beneficial functions of the City's public tree resource and to place a dollar value on the annual benefits they provide. These annual benefits are a "snapshot" of environmental and economic benefits produced by trees during one year. i-Tree Streets generally accounts for the benefits produced by Goshen's public trees—an accounting that is based on the best available science, with an accepted degree of uncertainty that can nonetheless provide a platform from which real management decisions can be made. A discussion concerning the methods used to quantify and price these benefits can be found in Chapter 2.

Benefits of Goshen's Public Trees

The i-Tree Streets model is considered a high level of data analysis upon which to base a management plan, and the information generated will become an integral part of the comprehensive urban forest management program. Beyond statistical calculations of public tree inventory data, i-Tree Streets provides conclusive data and rationales for the urban forester to promote its "green infrastructure" management program to other city agencies, elected officials, allied organizations, and the citizens the program serves. The i-Tree Streets analysis was performed to quantify stormwater mitigation, energy consumption savings, air quality improvement, carbon sequestration, and aesthetics and other public values. All benefit analysis reports are included in Appendix D.

Stormwater Mitigation

Trees reduce the volume of stormwater runoff in neighborhoods and ultimately community-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, particularly leaf and trunk surfaces, intercept and store rainfall. The tree's root system increases soil infiltration, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, thus reducing soil compaction rates and improving soil absorptive properties. Additionally, trees intercept suburban contaminants such as oils, solvents, pesticides, and fertilizers which are often part of stormwater runoff, reducing pollutant discharges into vital waterways.

Public trees in Goshen intercept 19,816,067 gallons of stormwater annually, for a savings of \$537,053 or \$41.97 per tree. The population of silver maple currently provides the greatest total benefit accounting for 38.1% (\$204,524) of the annual stormwater management savings. Silver maple also provides the greatest single tree benefit (\$88.62).



Energy Consumption Savings

The energy savings that trees provide can be attributed to climate changes, shading, and wind reduction. Ambient air is cooled when leaves use solar energy during transpiration and air movement in an urban setting is influenced by tree spacing, crown spread, and vertical distribution leaf area. These key factors also reduce the amount of radiant energy absorbed in buildings and other hardscapes, cool the air in buildings during hot summer months, and help retain heat during cold winter months. The energy savings is realized by lower cooling and heating costs.

Goshen's public trees provide annual electric and natural gas savings equal to 2,048.7 Megawatt-hours (\$221,467) and 277,663.0 therms (\$27,794), respectively. Goshen saves a total of \$249,261 per year and has an average annual savings of \$19.48 per tree. The population of silver maple currently provides the greatest total benefit accounting for 31.1% (\$77,449) of all annual energy savings. Silver maple also provides the greatest single tree benefit (\$33.56).

Air Quality Improvement

Urban environments greatly benefit from the presence of street and other public trees. Trees release oxygen through photosynthesis and absorb gaseous pollutants in the form of ozone (O₃) and nitrogen dioxide (NO₂). Ozone reduction can also be attributed to the trees' shading effect on hardscape surfaces, their cooling effect on ambient air from the transpiration process, and their contribution to reduced emissions from power generation. Trees intercept volatile organic compounds (VOCs), sulfuric dioxide (SO₂), and small particulate matter (PM₁₀), such as dust, ash, dirt, pollen, and smoke, from the air. Trees also emit an air pollutant called biogenic volatile organic compounds (BVOCs) that contribute to the formation of ozone. The i-Tree Streets model takes this whole process into account.

Goshen's public tree population removes 12.4 tons of air pollutants annually. The City experiences net air quality improvement benefits equal to \$69,190 per year, averaging \$5.41 per tree. The population of silver maple currently provides the greatest total air quality benefits accounting for 18.0% (\$69,190 annually) of all enhancements. Silver maple also provides the greatest single tree benefit (\$9.78).

Avoided and Sequestered Carbon Dioxide

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.

Goshen's public tree resource reduces a net 4,000.9 tons of CO₂ per year valued at \$50,014, with the average savings per tree at \$4.69. The population of silver maple currently provides the most avoided and sequestered CO₂ benefit accounting for 39.1% (\$23,449) of the total annual savings. Silver maple also provides the greatest single tree benefit (\$10.16).



Residents in Goshen with average-sized trees, such as this Ohio buckeye (*Aesculus glabra*), save approximately \$19.48 each year in cooling and heating costs.



Aesthetics and Other Public Values

It may seem difficult to place a dollar value on the benefit of trees provide to the overall ambiance of a community 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. Studies show that differences in property values reflect the willingness of buyers to pay for the benefits and costs associated with trees.

Aesthetic benefits, property value, social benefits, economic benefits, among other non-tangible related benefits, provide an estimate of \$206,958 annually to Goshen, for an average of \$16.17 per tree. The population of silver maple currently provides the greatest total benefit accounting for 37.5% (\$77,627) of the annual aesthetic benefits. Silver maple also provides the greatest single tree benefit (\$33.63).



Mature sugar maples (*Acer saccharum*) and pin oaks (*Quercus palustris*) along South 6th Street add beauty and value to residential properties.

Summary of Total Annual Benefits

Goshen's public trees provide \$1,122,476 of annual benefits to the community and its' environment. Figure 6 shows environmental services from public trees provide the largest benefit accounting for 81.6% of the total annual benefits. Environmental benefits include stormwater mitigation which accounts for 47.8% of the total annual benefits, energy savings which account for 22.2%, air quality improvements which account for 6.2%, and carbon dioxide reduction which contributes 5.4% of total annual benefits. Aesthetics, or annual increases in property value, contribute the remaining 18.4% of quantifiable benefits to the City per year. Leaf surface area, population, and canopy cover determine an urban forest's ability to produce benefits. The more canopy cover one community has the more benefits it will yield.

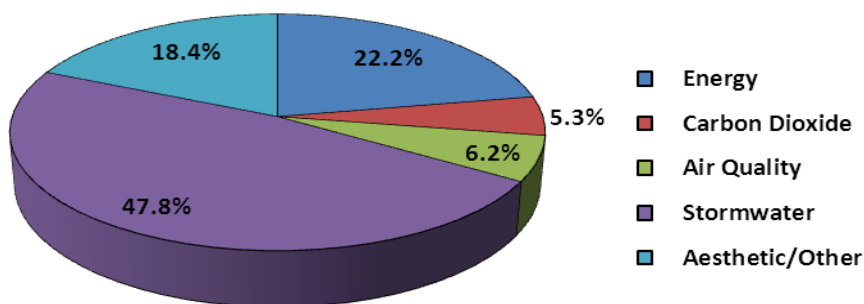


Figure 6. Distribution of Goshen's Annual Benefits



Large-growing trees consistently supply the most benefits per tree. They intercept large volumes of water, provide great amounts of shade, and absorb massive amounts of air pollution. Table 6 shows individual species' total annual benefit and their average annual per tree. Silver maple provides the greatest benefit overall and benefit on a per tree basis.

Table 6. Goshen's Top 20 Species Providing Annual Benefits

Benefits Per Species*	Stormwater Mitigation	Energy Savings	Air Quality Improvement	Carbon Dioxide Reduction	Aesthetic and Other Public Value	Gross Annual Benefits	Average Benefits per Tree
silver maple	\$204,524	\$77,449	\$22,575	\$23,449	\$77,627	\$405,623	\$175.75
sugar maple	\$91,313	\$43,276	\$11,558	\$9,351	\$32,032	\$187,531	\$117.21
black walnut	\$9,877	\$4,467	\$1,316	\$1,030	\$3,091	\$19,780	\$117.04
white oak	\$6,445	\$2,727	\$601	\$979	\$3,198	\$13,950	\$107.30
Siberian elm	\$8,091	\$4,120	\$1,227	\$832	\$2,118	\$16,388	\$105.73
pin oak	\$8,778	\$5,347	\$1,215	\$1,415	\$4,576	\$21,331	\$102.55
ash spp.	\$8,609	\$3,853	\$1,194	\$912	\$3,728	\$18,297	\$99.44
Norway maple	\$42,963	\$25,730	\$7,561	\$5,161	\$15,142	\$96,557	\$81.69
honeylocust	\$9,931	\$6,295	\$1,712	\$1,476	\$9,617	\$29,031	\$77.83
tulip tree	\$6,289	\$3,264	\$919	\$766	\$2,538	\$13,776	\$75.28
red maple	\$16,521	\$10,709	\$3,105	\$2,253	\$9,455	\$41,043	\$62.94
black spruce	\$6,536	\$1,996	\$286	\$324	\$1,797	\$10,939	\$62.15
northern hackberry	\$6,244	\$4,050	\$1,147	\$633	\$2,447	\$14,520	\$59.03
green ash	\$4,970	\$2,836	\$774	\$672	\$2,573	\$11,825	\$55.00
northern red oak	\$8,986	\$4,285	\$1,048	\$664	\$1,303	\$16,286	\$50.42
blue spruce	\$11,119	\$4,168	\$769	\$655	\$3,782	\$20,493	\$44.26
eastern white pine	\$8,910	\$3,205	\$556	\$503	\$2,905	\$16,079	\$40.20
red pine	\$2,518	\$1,006	\$196	\$155	\$891	\$4,766	\$36.67
unknown trees	\$3,217	\$1,992	\$580	\$395	\$1,342	\$7,526	\$33.75
callery pear	\$3,627	\$3,040	\$812	\$681	\$2,557	\$10,718	\$30.11
Citywide	\$537,053	\$249,261	\$69,190	\$60,014	\$206,958	\$1,122,476	\$87.71

*Species listed have populations greater than 1% of the inventoried population.



Benefits Susceptible to Insects and Diseases

Green ash and ash spp. provide \$30,122 per year in environmental and economic benefits. White ash and black ash are not included in this benefit total because i-Tree Streets only lists the benefits of individual species with population percentages that are greater than 1% of the entire street tree population. However, using the average annual per tree benefit of the entire tree population (\$87.71), we find the other 2 species populations (93 trees) may contribute an additional \$8,157 per year. This shows that the entire population of ash provides an annual gross benefit of approximately \$38,279, representing 3.4% of Goshen's total annual benefit.

Northern red oak, pin oak, and white oak provide \$51,270 per year in benefits. There were 6 oak species not included in benefit totals produced by i-Tree Streets. Using the average annual per tree benefit of the entire tree population, we find the other 6 oak species (190 trees) may contribute an additional \$16,665 per year. This shows that the entire population of oak provides an annual return of approximately \$67,935, representing 6.1% of Goshen's total annual benefit.

Silver maple, sugar maple, Norway maple, and red maple provide \$730,754 per year in benefits. There were 4 maple species not included in benefit totals produced by i-Tree Streets. Using the average annual per tree benefit of the entire tree population, we find the other 4 maple species (172 trees) may contribute an additional \$15,086 per year. This shows that the entire population of maple provides an annual return of approximately \$745,840, representing 66.4% of Goshen's total annual benefit.

Goshen's maple, oak, and ash trees are a valuable, yet vulnerable, resource worth additional attention in the presence of their respective insect or disease. If these species populations are not actively managed, Goshen could see a large drop in its annual benefit value. The City of Goshen currently has no pest or disease management programs.

Table 7. Goshen's Benefit Value Susceptible to Insects and Diseases

Species	Total	% of Total Annual Benefits
maple	\$745,840	66.4
oak	\$67,935	6.1
ash	\$38,279	3.4

Costs of Managing Goshen's Public Trees

The costs of managing Goshen's public trees are an investment back into the City of Goshen. In 2010, Goshen's total related expenditures for public trees were approximately \$289,245, approximately 1% of the City's total municipal budget. About \$22.60 is spent on average per tree during one year. Approximately 32,425 people live in Goshen and \$34.62 is spent per capita on tree maintenance.

Tree maintenance makes up 52.9% (\$152,964) of tree related expenditures, administration makes up about 14.6% (\$42,087), and other tree related costs make up 32.6% (\$94,194). These tree related expenditures include planting (\$56,842), pruning and removals (\$90,262), irrigation (\$5,860), storm and leaf litter cleanup (\$94,194), administration (\$40,587), education and training (\$700), and ESRI GIS agreement (\$800) Appendix D summarizes Goshen's annual program management costs for tree-related expenditures.



Net Benefits and Benefit-Cost Ratio Discussion

According to the benefits presented in this chapter, trees make good sense, but are the collective benefits worth the costs of management? In other words, are trees a good investment for Goshen? To answer that question, we must compare the benefit public trees provide to the cost of their management.

The sum of environmental and economic benefits provided to the City of Goshen is \$1,122,476 annually at an average of \$87.71 per public tree and \$34.62 per capita (Table 8). When Goshen's annual expenditures of \$289,245 are considered, the net annual benefit (benefits minus costs) returned by public trees to the City is \$833,231. Compared to the median values of eight benchmark communities used in the Sample Urban Statewide Inventory (Table 8), Goshen's gross benefit per tree is greater than the benchmark of \$84.24; Goshen's gross benefit per capita is greater than the benchmark of \$15.16; and, Goshen's net benefit is greater than the benchmark of \$107,412.

Applying a benefit-cost ratio (BCR) is another useful way to evaluate the investment in public 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 public trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. Goshen receives \$3.88 in benefits for every \$1 that is spent on its municipal forestry program (Table 8). Goshen receives as good positive return on its public tree population. Goshen's BCR is greater than the Sample Urban Statewide Inventory median benchmark of \$1.17. Appendix D provides a summary of Goshen's total annual benefits, annual costs for managing their public tree population, and net annual benefits.

While Goshen's tree benefit reports are good, the tree population is currently not sustainable. Chapter 2 analyzed the structure of Goshen's public trees. The analysis found that silver maple (18.0%) and sugar maple (12.5%) make up 30.5% of the population, the genus maple makes up 50.3% of the population, the relative age distribution is 29:22:34:15, and the majority of population is in fair condition (44.8%). Goshen should improve the resource sustainability by implementing informed, well-planned management decisions that are derived from established goals for improved species diversity and composition, relative age, general health and condition, tree maintenance, and stocking. Chapter 4 describes a recommended work plan to achieve a safe, healthy, diverse, and sustainable tree population.

Table 8. Goshen's Annual Benefits Compared to Other Indiana Communities' Annual Benefits

	SUSI Benchmark (Median Value)	Goshen
Annual Gross Benefit	\$179,916	\$1,122,476
Gross Benefit per Tree	\$84.24	\$87.71
Gross Benefit per Capita	\$15.16	\$34.62
Annual Costs	\$44,100	\$289,245
Cost per Tree	\$36.43	\$22.60
Cost per Capita	\$6.56	\$25.70
Annual Net Benefit	\$107,412	\$833,231
Net Benefit per Tree	\$47.81	\$65.11
Net Benefit per Capita	\$8.26	\$25.70
Benefit-Cost Ratio	\$1.17	\$3.88