

# An Analysis of Street Tree Benefits for



By

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# **An Analysis of Street Tree Benefits for Westerville, Ohio**

## **EXECUTIVE SUMMARY**

An existing inventory of street trees less park trees was modified to allow an analysis of environmental benefits to be run. A total of 12,176 street trees were inventoried. A common bid price for this service is \$3.00 per tree and thus the inventory represents a savings of \$35,568 for Westerville taxpayers had the inventory not been maintained by the Department of Parks and Recreation Urban Forestry Section. More importantly however, is that the City of Westerville now has an expanded use for the tree inventory that can be used to better manage the street tree resource. Benefits mentioned above do not include the subsequent analysis which was performed by The School of Environment and Natural Resources at The Ohio State University.

Analysis of the inventory data was done using iTree, a software suite distributed by the USDA Forest Service. The specific program in the iTree suite used to identify benefits was Shade Tree Resource Analysis Tool for Urban forest Managers (STRATUM) and is soon to be known as iStreets. This program allows individuals with interests in making informed decisions about the community tree resource to evaluate costs and benefits of some of those decisions such as biodiversity.

A long standing rule of thumb for biodiversity is the 10–20–30 guideline which suggests that no more than 10 percent of trees should be from the same species, no more than twenty percent should be from the same genera, and no more than thirty percent should be from the same family. In Westerville, crabapples and Callery pears exceeds the limit for specie at 15 and 14% respectively. While maple (24%) somewhat above the 20%genera limit. This is low relative to other Ohio communities and will assist in dealing with Asian longhorned beetle should it reach central Ohio. The Rose family is over represented at 32%. It is tough to reduce this as crabapples and Callery pears are among the longest lived small flowering trees.

Limiting future plantings of maples and plants in the rose family is desirable to maintain a diverse urban canopy. The problem with emerald ash borer, now established in central Ohio, is well known. Ash has not been planted for four years and is presently preferentially removed when conflicts arise but still represents 9% of Westerville's street trees. Using statewide averages, this may cost Westerville more than \$700,000 to cut down, remove the stump, and replace the 1119 ash trees on the streets.

Under ideal conditions tree numbers among size classes of larger growing trees such as oaks and maples should remain somewhat constant to 24-inch caliper then decline as tree size increases and then die from old age. Westerville's tree population is skewed toward smaller trees even for larger growing species because few plantings exceed 40 years of age. High numbers of smaller trees indicate an active planting program as seen in the overall numbers for Westerville (Tables 2 to 3). Westerville's trees are now reaching sizes where environmental benefits per tree will increase dramatically (Table 4).

Larger growing broadleaved deciduous trees such as honeylocusts have importance values greater than their respective percentages in the inventory because of their larger size. For example silver maple represents 2 percent of the trees but constitutes 15% of the leaf area, 6% of the canopy cover, and has an

importance value of 5% (Table 4). Further this demonstrates Westerville's need for larger statured trees whenever possible as the importance value is a measure of the overall contribution of the species.

A major benefit of urban trees is their ability to intercept rainfall and reduce storm water runoff (Table 6). Storm water runoff is a major cost for many communities. Columbus is about to embark on a multi-billion dollar sewer and storm water upgrade for the community. Trees in Westerville intercept more than 10,674 CCF (5,576,340 gallons) of storm water annually at a savings of \$151,134 per year.

Carbon sequestration, as reported here, represents the carbon removed from the air and stored in Westerville's trees (Table 8). More than 15 million pounds or nearly 8,000 tons of carbon have been stored by Westerville's 12,176 trees over time. Westerville's trees currently sequester and avoid nearly 1.8 million lbs of CO<sub>2</sub> (Table 9) and could represent carbon credits worth \$25,434 per year if a carbon trading system were in place and if a system for accounting for them were available for community trees. These are net gain figures and include deductions for tree losses and maintenance. Larger, longer lived species and species requiring less maintenance would also produce greater benefits (Table 8).

Annual air quality savings (reduced ozone, nitrous and sulfur oxides as well as particulate matter) for Westerville's trees is \$33,097 (Table 9). This includes both direct savings (\$4,548) from the trees and avoided pollution which is even greater (\$29,892). Avoided pollution is pollution not generated at power source because energy was not required by the community. The total annual air quality benefits are discounted by \$1,343 for the volatile emissions from the trees themselves.

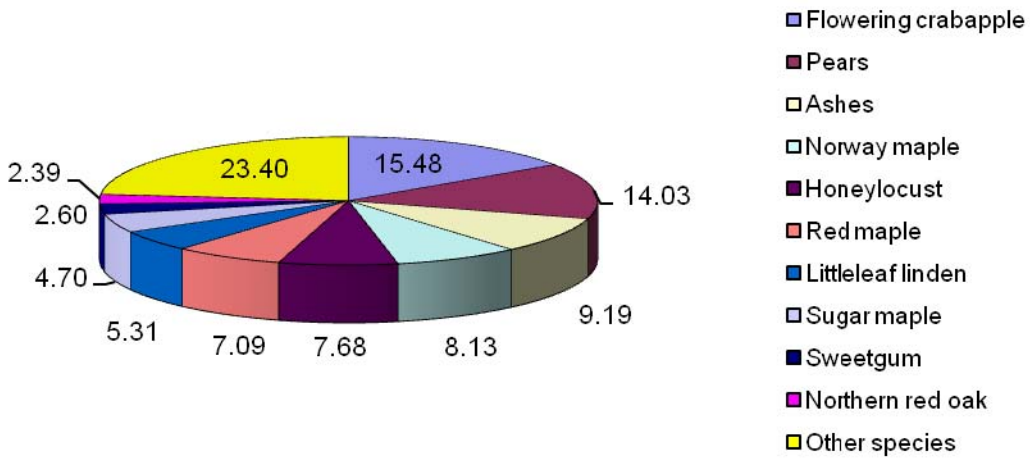
Planting trees in our communities may well be more cost effective than building power plants to as an alternative to meeting our energy needs. Energy is saved by shading structures, evaporating water (evapotranspiration) and reducing wind speed around structures (Table 10). Citywide, Westerville saves \$75,611 in electricity and \$193,885 in natural gas for a total savings of \$217,053 or \$17.83 per tree.

Aesthetic and miscellaneous benefits from trees contribute \$204,364 annually to the community in the form of increased property values and enhanced community identity among other things (Table 11). Research in public housing has shown that areas with trees facilitate civil interactions among residents and lead to reduced domestic violence and more sociable environments. Customer surveys suggest that customers prefer to spend their money and time in commercial streetscapes with trees and are willing to spend up to 11% more in such settings.

When all benefits are included the average tree in Westerville contributes \$51.83 per tree annually to the community (Table 12). Species vary in their annual benefits. Mature size, longevity, and maintenance costs are but some of the factors determining annual benefits. Thus Westerville's 12,161 trees contribute more than \$631,082. This would be well in excess of their maintenance and planting costs.

The budget for the City of Westerville's urban forestry budget is \$250,000 yet the community receives \$631,082 in benefits including storm water abatement, CO<sub>2</sub> avoidance and storage, energy savings, air quality, and aesthetic benefits. Dividing benefits by costs yields a 252% return on the community's investment in urban forestry. Trees are truly a contributing part of Westerville, Ohio's infrastructure. Unlike most community infrastructure, tree benefits per tree continue to increase over a tree's lifetime especially when a community has a young tree population as does Westerville.

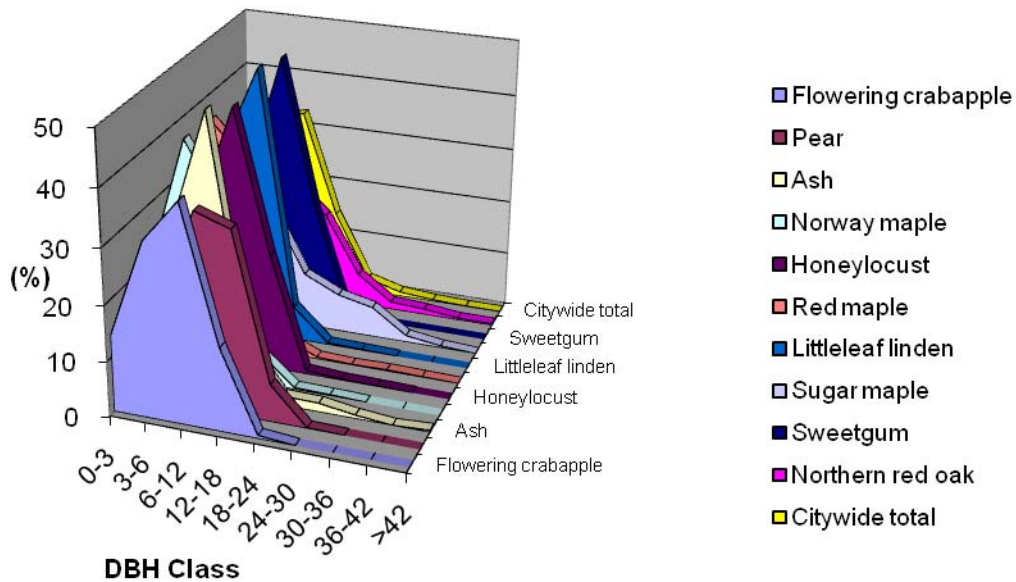
**Table 1 Species Distribution of Westerville's Ten Most Commonly Planted Street Trees (%)**



Species	Percent
Flowering crabapple	15.48
Pears	14.03
Ashes	9.19
Norway maple	8.13
Honeylocust	7.68
Red maple	7.09
Littleleaf linden	5.31
Sugar maple	4.70
Sweetgum	2.60
Northern red oak	2.39
Other species	23.40
<b>Total</b>	<b>100.00</b>



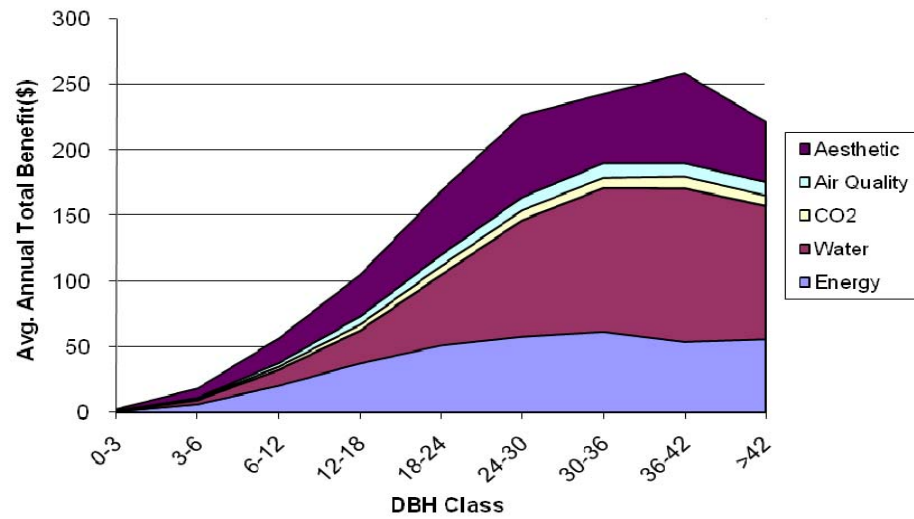
**Table 2. Relative Age Distribution of the Top 10 Most Commonly Planted Street Trees in Westerville (%)**



Species	DBH class (in)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Flowering crabapple	13.79	31.46	39.10	15.07	0.58	0.00	0.00	0.00	0.00
Pear	7.26	17.74	35.13	32.96	6.79	0.12	0.00	0.00	0.00
Ash	6.61	29.40	49.78	9.92	1.70	1.61	0.63	0.00	0.36
Norway maple	20.61	42.02	31.11	5.76	0.30	0.20	0.00	0.00	0.00
Honeylocust	3.53	28.24	46.31	20.96	0.64	0.21	0.11	0.00	0.00
Red maple	20.39	41.25	34.41	3.13	0.35	0.12	0.23	0.12	0.00
Littleleaf linden	9.74	34.47	49.15	6.18	0.31	0.15	0.00	0.00	0.00
Sugar maple	24.13	.90	21.85	9.97	6.99	5.59	1.22	0.35	0.00
Sweetgum	5.68	25.87	47.32	20.19	0.95	0.00	0.00	0.00	0.00
Northern red oak	23.02	29.55	21.99	16.49	5.84	1.37	1.03	0.34	0.34
<b>Citywide total</b>	<b>16.95</b>	<b>31.67</b>	<b>33.15</b>	<b>14.48</b>	<b>2.51</b>	<b>0.79</b>	<b>0.28</b>	<b>0.08</b>	<b>0.09</b>



**Table 4. Totals for Five Benefit Categories and Grand Total for Westerville's Street Tree Benefits by Diameter at Breast Height**



Species	DBH Class(in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Avg.
Energy	\$0.80	\$6.41	\$20.54	\$37.51	\$51.20	\$57.94	\$61.64	\$53.92	\$55.93	\$17.83
Aesthetic	\$1.09	\$7.03	\$18.82	\$31.53	\$48.69	\$62.53	\$52.77	\$68.54	\$45.71	\$16.78
Water	\$0.27	\$3.05	\$11.86	\$24.78	\$53.55	\$88.60	\$109.49	\$116.90	\$101.57	\$12.41
Air Quality	\$0.10	\$0.87	\$2.91	\$6.32	\$8.54	\$10.00	\$11.20	\$10.10	\$10.49	\$2.74
CO2	\$0.08	\$0.73	\$2.28	\$4.52	\$6.82	\$7.71	\$8.00	\$9.29	\$7.99	\$2.09
<b>Westerville Total</b>	<b>\$2.34</b>	<b>\$18.10</b>	<b>\$56.41</b>	<b>\$104.66</b>	<b>\$168.80</b>	<b>\$226.76</b>	<b>\$243.10</b>	<b>\$258.75</b>	<b>\$221.69</b>	<b>\$51.85</b>



**Table 3. Complete Inventory of Westerville's Trees by Scientific Name and Size Category**

Species	DBH Class (in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total
<b>Broadleaf Deciduous Large (BDL)</b>										
Acer rubrum	176	356	297	27	3	1	2	1	0	863
Acer saccharinum	13	57	50	67	44	18	9	3	2	263
Acer saccharum	138	171	125	57	40	32	7	2	0	572
Acer x freemanii	70	102	5	1	0	0	0	0	0	178
Betula papyrifera	0	2	1	1	0	0	0	0	0	4
Betula pendula	0	0	0	1	0	0	0	0	0	1
Carya species	0	0	1	2	2	0	0	0	0	5
Carya cordiformis	0	0	0	0	0	1	1	1	0	3
Carya ovata	0	0	0	0	0	0	1	0	0	1
Castanea dentata	0	0	0	1	0	0	0	0	0	1
Catalpa species	0	0	0	0	1	0	0	1	1	3
Celtis occidentalis	19	9	2	2	3	0	1	0	1	37
Cercidiphyllum japonicum	21	0	0	0	0	0	0	0	0	21
Fagus grandifolia	0	0	0	0	0	1	0	0	0	1
Fagus sylvatica	0	1	0	0	0	0	0	0	0	1
Gymnocladus dioicus	13	0	0	0	0	0	0	0	0	13
Juglans cineria	0	0	1	0	0	0	0	0	0	1
Juglans nigra	0	1	2	2	3	1	1	0	0	10
Liquidambar styraciflua	18	82	150	64	3	0	0	0	0	317
Liriodendron tulipifera	0	1	4	2	0	2	0	0	0	9
Platanus occidentalis	0	1	0	0	2	0	0	0	0	3
Platanus x acerifolia	26	63	71	52	4	1	0	0	1	218
Populus species	0	0	1	1	0	0	0	1	0	3
Populus tremuloides	0	0	1	0	0	0	0	0	0	1
Quercus species	2	5	1	0	0	0	0	0	0	8
Quercus acutissima	29	19	2	3	0	0	0	0	0	53
Quercus alba	6	2	3	0	0	0	0	0	0	11
Quercus imbricaria	12	41	26	6	0	0	0	0	0	85
Quercus lyrata	2	3	0	0	0	0	0	0	0	5
Quercus macrocarpa	7	1	1	1	0	1	0	0	0	11
Quercus muehlenbergii	3	2	0	0	0	0	0	0	0	5
Quercus palustris	0	9	15	30	3	0	0	0	0	57
Quercus phellos	6	1	1	0	0	0	0	0	0	8
Quercus robur	7	14	0	0	0	0	0	0	0	21
Quercus rubra	67	86	64	48	17	4	3	1	1	291
Quercus velutina	4	0	0	0	0	0	0	0	0	4
Tilia species	1	0	4	1	0	0	0	0	0	6
Tilia tomentosa	5	0	0	0	0	0	0	0	0	5
Ulmus species	29	41	27	13	4	0	1	0	1	116
Ulmus americana	0	0	0	0	1	0	0	0	0	1
Ulmus parvifolia	13	31	14	0	0	0	0	0	0	58
<b>Total</b>	<b>687</b>	<b>1,101</b>	<b>869</b>	<b>382</b>	<b>130</b>	<b>62</b>	<b>26</b>	<b>10</b>	<b>7</b>	<b>3,274</b>

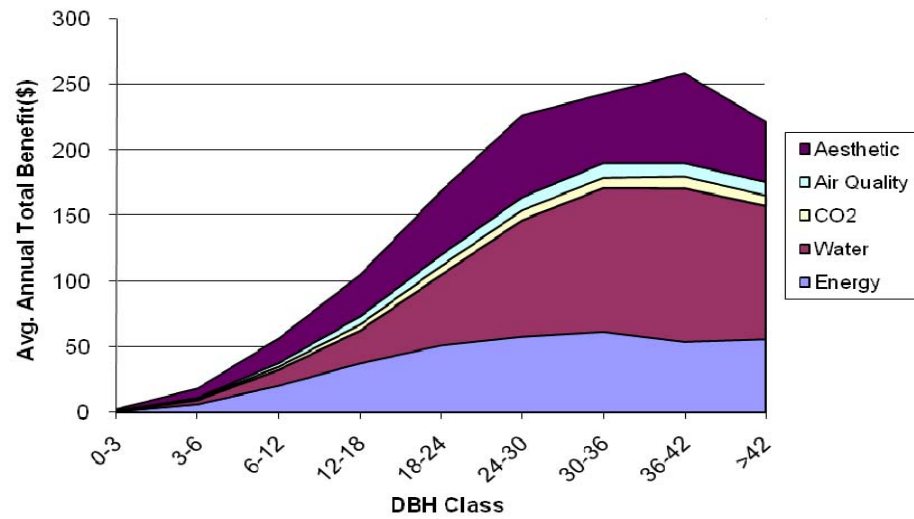
**Table 3. (contd.) Inventory by scientific name and size class**

Species	DBH Class (in)									Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	
Broadleaf Deciduous Medium (BDM)										
Acer buergeranum	3	0	0	0	0	0	0	0	0	3
Acer campestre	30	23	1	0	0	0	0	0	0	54
Acer miyabei	12	16	0	0	0	0	0	0	0	28
Acer negundo	0	1	1	3	0	0	0	0	0	5
Acer platanoides	204	416	308	57	3	2	0	0	0	990
Acer tartaricum	15	15	13	0	0	0	0	0	0	43
Acer truncatum	1	0	0	0	0	0	0	0	0	1
Aesculus glabra	9	0	4	0	0	2	0	0	0	15
Betula nigra	0	0	1	0	0	0	0	0	0	1
Carpinus species	13	1	0	0	0	0	0	0	0	14
Cladrastis kentukea	8	1	0	0	0	0	0	0	0	9
Corylus columna	0	1	0	0	0	0	0	0	0	1
Diospyros virginiana	0	1	0	0	0	0	0	0	0	1
Eucommia ulmoides	11	80	0	0	0	0	0	0	0	91
Fraxinus species	74	329	557	111	19	18	7	0	4	1,119
Ginkgo biloba	43	31	0	0	0	0	0	0	0	74
Gleditsia triacanthos	33	264	433	196	6	2	1	0	0	935
Koelreutaria paniculata	23	21	1	0	0	0	0	0	0	45
Nyssa sylvatica	20	10	2	0	0	0	0	0	0	32
Phellodendron amurense	8	0	0	0	0	0	0	0	0	8
Prunus serotina	3	7	9	4	0	1	0	0	0	24
Quercus bicolor	37	104	52	3	0	1	0	0	0	197
Robinia pseudoacacia	0	7	4	0	0	2	0	0	0	13
Sassafras albidum	0	0	1	0	0	0	0	0	0	1
Tilia cordata	63	223	318	40	2	1	0	0	0	647
Zelkova serrata	7	21	8	16	4	0	0	0	0	56
Total	617	1,572	1,713	430	34	29	8	0	4	4,407
Broadleaf Deciduous Small (BDS)										
Acer ginnala	0	0	1	0	0	0	0	0	0	1
Acer palmatum	2	3	0	0	0	0	0	0	0	5
Albizia julibrissin	0	0	2	0	0	0	0	0	0	2
Amalanchier species	120	139	1	0	0	0	0	0	0	260
Asimina triloba	1	0	0	0	0	0	0	0	0	1
Cercis canadensis	5	4	6	12	4	2	0	0	0	33
Cornus florida	0	2	2	0	0	0	0	0	0	4
Cornus kousa	3	0	0	0	0	0	0	0	0	3
Cornus mas	19	3	0	0	0	0	0	0	0	22
Crataegus species	13	32	5	1	0	0	0	0	0	51
Hibiscus syriacus	0	2	2	1	0	0	0	0	0	5
Maackia amurensis	26	0	0	0	0	0	0	0	0	26
Malus hybrid	260	593	737	284	11	0	0	0	0	1,885
Morus species	0	1	1	1	1	0	0	0	0	4
Ostrya virginiana	35	7	0	1	0	0	0	0	0	43

**Table 3. (contd.) Inventory by scientific name and size class**

Species	DBH Class (in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total
<b>Broadleaf Deciduous Small (BDS) (contd.)</b>										
Prunus species	2	0	1	0	0	0	0	0	0	3
Prunus serrulata	0	2	0	0	0	0	0	0	0	2
Prunus spp	0	0	2	1	0	0	0	0	0	3
Pyrus species	124	303	600	563	116	2	0	0	0	1,708
Syringa pekinensis	4	0	0	0	0	0	0	0	0	4
Syringa reticulata	114	77	11	0	0	0	0	0	0	202
<b>Total</b>	<b>728</b>	<b>1,168</b>	<b>1,371</b>	<b>864</b>	<b>132</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4,267</b>
<b>Broadleaf Evergreen Small (BES)</b>										
Magnolia species	5	1	3	1	1	0	0	0	0	11
Magnolia virginiana	0	1	0	0	0	0	0	0	0	1
<b>Total</b>	<b>5</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12</b>
<b>Conifer Evergreen Large (CEL)</b>										
Metasequoia glyptostroboides	1	0	0	0	0	1	0	0	0	2
Picea species	10	1	1	2	0	0	0	0	0	14
Picea abies	1	6	9	7	6	0	0	0	0	29
Pinus nigra	0	0	32	50	1	0	0	0	0	83
Pinus strobus	0	0	6	8	2	0	0	0	0	16
Pinus sylvestris	0	0	3	9	0	0	0	0	0	12
Taxodium distichum	12	1	0	0	0	0	0	0	0	13
Thuja occidentalis	0	1	0	0	0	0	0	0	0	1
Tsuga canadensis	0	0	1	0	0	0	0	0	0	1
<b>Total</b>	<b>24</b>	<b>9</b>	<b>52</b>	<b>76</b>	<b>9</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>171</b>
<b>Conifer Evergreen Medium (CEM)</b>										
Picea glauca	0	0	1	0	0	0	0	0	0	1
Picea pungens	3	4	25	5	0	0	0	0	0	37
<b>Total</b>	<b>3</b>	<b>4</b>	<b>26</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>38</b>
<b>Conifer Evergreen Small (CES)</b>										
Juniperus virginiana	0	0	2	5	0	0	0	0	0	7
<b>Total</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>7</b>
<b>Westerville Totals</b>										
	<b>2,064</b>	<b>3,856</b>	<b>4,036</b>	<b>1,763</b>	<b>306</b>	<b>96</b>	<b>34</b>	<b>10</b>	<b>11</b>	<b>12,176</b>

**Table 4. Totals for Five Benefit Categories and Grand Total for Westerville's Street Tree Benefits by Diameter at Breast Height**



Species	DBH Class(in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Avg.
Energy	\$0.80	\$6.41	\$20.54	\$37.51	\$51.20	\$57.94	\$61.64	\$53.92	\$55.93	\$17.83
Aesthetic	\$1.09	\$7.03	\$18.82	\$31.53	\$48.69	\$62.53	\$52.77	\$68.54	\$45.71	\$16.78
Water	\$0.27	\$3.05	\$11.86	\$24.78	\$53.55	\$88.60	\$109.49	\$116.90	\$101.57	\$12.41
Air Quality	\$0.10	\$0.87	\$2.91	\$6.32	\$8.54	\$10.00	\$11.20	\$10.10	\$10.49	\$2.74
CO2	\$0.08	\$0.73	\$2.28	\$4.52	\$6.82	\$7.71	\$8.00	\$9.29	\$7.99	\$2.09
<b>Westerville Total</b>	<b>\$2.34</b>	<b>\$18.10</b>	<b>\$56.41</b>	<b>\$104.66</b>	<b>\$168.80</b>	<b>\$226.76</b>	<b>\$243.10</b>	<b>\$258.75</b>	<b>\$221.69</b>	<b>\$51.85</b>



**Table 5. Importance Values for Westerville's Most Abundant Street Tree Species Ordered by Importance Value**

Species	Number of Trees	% of Total Trees	Leaf Area (ft2)	% Total Leaf Area	Canopy Cover (ft2)	% Total Canopy Cover	Importance Value
Pears	1708	14.0	776,519	11.3	714,541	17.8	14.39
Flowering crabapple	1885	15.5	417,827	6.1	494,192	12.3	11.30
Ashes	1119	9.2	829,598	12.1	435,009	10.8	10.71
Honeylocust	935	7.7	761,345	11.1	535,686	13.3	10.71
Sugar maple	572	4.7	708,578	10.4	249,749	6.2	7.09
Norway maple	990	8.1	366,419	5.4	240,364	6.0	6.49
Red maple	863	7.1	320,091	4.7	230,766	5.7	5.84
Silver maple	263	2.2	666,976	9.7	217,255	5.4	5.77
Littleleaf linden	647	5.3	258,994	3.8	144,581	3.6	4.23
Sweetgum	317	2.6	277,293	4.1	122,149	3.0	3.23
Northern red oak	291	2.4	216,962	3.2	102,496	2.6	2.70
London planetree	218	1.8	163,426	2.4	75,073	1.9	2.02
Swamp white oak	197	1.6	56,267	0.8	40,408	1.0	1.15
Freeman maple	178	1.5	45,398	0.7	20,493	0.5	0.88
Serviceberry	260	2.1	5,365	0.1	14,831	0.4	0.86
Japanese tree lilac	202	1.7	5,320	0.1	12,073	0.3	0.68
Other trees	1531	12.6	969,433	14.2	366,257	9.1	11.95
<b>Westerville Totals</b>	<b>12,176</b>	<b>100.0</b>	<b>6,845,808</b>	<b>100.0</b>	<b>4,015,923</b>	<b>100.0</b>	<b>100.00</b>



**Table 6. Annual Stormwater Benefits of Westerville's Street Trees by Common Name and Ordered by Average Benefit per Tree**

Species	Total Rainfall Interception (CCF)	Total (\$)	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Silver maple	630	\$12,777	2.2	8.4	\$48.58
Sugar maple	593	\$12,014	4.7	7.9	\$21.00
Honeylocust	878	\$17,793	7.7	11.8	\$19.03
Sweetgum	277	\$5,614	2.6	3.7	\$17.71
Ashes	927	\$18,794	9.2	12.4	\$16.80
Northern red oak	226	\$4,572	2.4	3.0	\$15.71
London planetree	164	\$3,324	1.8	2.2	\$15.25
Pears	928	\$18,813	14.0	12.4	\$11.01
Littleleaf linden	303	\$6,142	5.3	4.1	\$9.49
Norway maple	462	\$9,375	8.1	6.2	\$9.47
Red maple	401	\$8,130	7.1	5.4	\$9.42
Swamp white oak	75	\$1,513	1.6	1.0	\$7.68
Flowering crabapple	588	\$11,918	15.5	7.9	\$6.32
Freeman maple	50	\$1,011	1.5	0.7	\$5.68
Japanese tree lilac	12	\$245	1.7	0.2	\$1.21
Serviceberry	14	\$290	2.1	0.2	\$1.12
Other street trees	928	\$18,809	12.6	12.4	\$12.29
<b>Citywide total</b>	<b>7,455</b>	<b>\$151,134</b>	<b>100.0</b>	<b>100.0</b>	<b>\$12.41</b>



**Table 7. Stored CO2 Benefits of Westerville's Street Trees by Common Name and Ordered by Average Benefits per Tree**

Species	Total stored CO2 (lbs)	Total (\$)	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Silver maple	1,317,474	\$9,881	2.2	8.7	\$37.57
Sugar maple	1,385,608	\$10,392	4.7	9.1	\$18.17
Northern red oak	531,881	\$3,989	2.4	3.5	\$13.71
Pears	3,105,884	\$23,294	14.0	20.5	\$13.64
London planetree	373,348	\$2,800	1.8	2.5	\$12.84
Ashes	1,653,560	\$12,402	9.2	10.9	\$11.08
Sweetgum	430,976	\$3,232	2.6	2.8	\$10.20
Honeylocust	1,112,989	\$8,347	7.7	7.3	\$8.93
Flowering crabapple	1,714,864	\$12,861	15.5	11.3	\$6.82
Littleleaf linden	543,711	\$4,078	5.3	3.6	\$6.30
Norway maple	692,296	\$5,192	8.1	4.6	\$5.24
Red maple	561,105	\$4,208	7.1	3.7	\$4.88
Swamp white oak	105,731	\$793	1.6	0.7	\$4.03
Freeman maple	32,590	\$244	1.5	0.2	\$1.37
Japanese tree lilac	25,248	\$189	1.7	0.2	\$0.94
Serviceberry	27,275	\$205	2.1	0.2	\$0.79
Other street trees	701,768	\$11,604	12.6	10.2	\$7.58
<b>Westerville totals</b>	<b>15,161,678</b>	<b>\$113,713</b>	<b>100.0</b>	<b>100.0</b>	<b>\$9.34</b>



**Table 8. Annual Energy Benefits of Westerville's Street Trees by Common Name and Ordered by (\$/tree)**

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (MBtu)	Natural Gas (\$)	Total (\$)	% of Total Tree Numbers	% Total \$	Avg. \$/tree
Silver maple	47	\$3,571	607	\$5,944	\$9,516	2.2	4.4	\$36.18
Honeylocust	129	\$9,757	1775	\$17,399	\$27,156	7.7	12.5	\$29.04
Pear	179	\$13,559	2655	\$26,014	\$39,573	14.0	18.2	\$23.17
Ash	112	\$8,486	1688	\$16,545	\$25,030	9.2	11.5	\$22.37
Sweetgum	32	\$2,459	421	\$4,128	\$6,587	2.6	3.0	\$20.78
Sugar maple	56	\$4,284	761	\$7,461	\$11,745	4.7	5.4	\$20.53
London planetree	21	\$1,598	289	\$2,831	\$4,429	1.8	2.0	\$20.31
Northern red oak	25	\$1,915	342	\$3,352	\$5,266	2.4	2.4	\$18.10
Flowering crabapple	123	\$9,335	1922	\$18,839	\$28,174	15.5	13.0	\$14.95
Norway maple	64	\$4,859	982	\$9,625	\$14,484	8.1	6.7	\$14.63
Red maple	55	\$4,198	798	\$7,824	\$12,022	7.1	5.5	\$13.93
Littleleaf linden	40	\$3,037	593	\$5,811	\$8,849	5.3	4.1	\$13.68
Swamp white oak	11	\$807	169	\$1,652	\$2,459	1.6	1.1	\$12.48
Freeman maple	5	\$378	72	\$709	\$1,087	1.5	0.5	\$6.11
Japanese tree lilac	3	\$220	50	\$495	\$715	1.7	0.3	\$3.54
Serviceberry	4	\$270	62	\$603	\$873	2.1	0.4	\$3.36
Other street trees	91	\$6,877	1246	\$12,211	\$19,088	12.6	8.8	\$12.47
<b>Citywide total</b>	<b>996</b>	<b>\$75,611</b>	<b>14433</b>	<b>\$141,442</b>	<b>\$217,053</b>	<b>100.0</b>	<b>100.0</b>	<b>\$17.83</b>



**Table 9. Annual Carbon Dioxide Benefits of Westerville's Street Trees by Species and Ordered by Average Benefits per Tree**

Species	Sequestered (lb)	Sequestered (\$)	Decomp Release(lb)	Maintenance Release (lb)	Total Release (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total (\$)	% Total Tree Numbers	% of Total \$	Avg. \$/tree
Silver maple	140594	1054	-6324	-51	-\$48	78929	\$592	213148	\$1,599	2.2	6.3	\$6.08
Honeylocust	200914	1507	-5342	-182	-\$41	215620	\$1,617	411010	\$3,083	7.7	12.1	\$3.30
Sweetgum	67929	509	-2069	-62	-\$16	54348	\$408	120147	\$901	2.6	3.5	\$2.84
Ash	215026	1613	-7937	-218	-\$61	187537	\$1,407	394408	\$2,958	9.2	11.6	\$2.64
Pear	287078	2153	-14908	-333	-\$114	299640	\$2,247	571477	\$4,286	14.0	16.9	\$2.51
Sugar maple	103790	778	-6651	-112	-\$51	94672	\$710	191700	\$1,438	4.7	5.7	\$2.51
London planetree	33054	248	-1792	-43	-\$14	35311	\$265	66531	\$499	1.8	2.0	\$2.29
Littleleaf linden	108705	815	-2610	-126	-\$21	67125	\$503	173094	\$1,298	5.3	5.1	\$2.01
Northern red oak	35976	270	-2553	-57	-\$20	42312	\$317	75678	\$568	2.4	2.2	\$1.95
Norway maple	134006	1005	-3323	-193	-\$26	107384	\$805	237874	\$1,784	8.1	7.0	\$1.80
Swamp white oak	23318	175	-508	-38	-\$4	17844	\$134	40616	\$305	1.6	1.2	\$1.55
Flowering crabapple	189953	1425	-8231	-368	-\$64	206308	\$1,547	387662	\$2,907	15.5	11.4	\$1.54
Red maple	79184	594	-2693	-168	-\$21	92776	\$696	169098	\$1,268	7.1	5.0	\$1.47
Freeman maple	10417	78	-156	-35	-\$1	8360	\$63	18586	\$139	1.5	0.6	\$0.78
Japanese tree lilac	5164	39	-121	-39	-\$1	4869	\$37	9872	\$74	1.7	0.3	\$0.37
Serviceberry	6429	48	-131	-51	-\$1	5967	\$45	12215	\$92	2.1	0.4	\$0.35
Other street trees	153771	1153	-7426	-299	-\$58	151979	\$1,140	298025	\$2,235	12.6	8.8	\$1.46
<b>Westerville Totals</b>	<b>1,795,310</b>	<b>13465</b>	<b>-72776</b>	<b>-2374</b>	<b>-\$564</b>	<b>1,670,983</b>	<b>\$12,532</b>	<b>3391142</b>	<b>\$25,434</b>	<b>100.0</b>	<b>100.0</b>	<b>\$2.09</b>

**Table 10. Annual Air Quality Benefits of Westerville's Street Trees by Species and Ordered by Average Dollars per Tree**

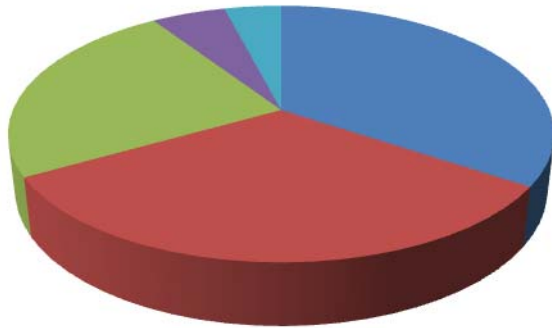
Species	Deposit O3 (lb)	Deposit NO2 (lb)	Deposit PM10 (lb)	Deposit SO2 (lb)	Total Deposit (\$)	Avoided NO2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	Avoided SO2 (lb)	Total Avoided (\$)	BVOC Emission (lb)	BVOC Emission (\$)	Net Total (lb)	Total (\$)	% Tree	Avg. \$/tree
Silver maple	58.0	9.8	31.6	2.6	\$321.48	220.8	32.4	31.0	213.1	\$1,384.7	-37.4	-\$140.10	561.9	\$1,566	2.2	\$5.95
Honeylocust	88.5	14.6	48.7	4.0	\$490.80	614.4	89.4	85.2	582.5	\$3,825.5	-52.2	-\$195.59	1475.1	\$4,121	7.7	\$4.41
Pear	196.5	32.4	95.0	8.9	\$1,053	871.5	125.5	119.4	809.7	\$5,382.8	-1.1	-\$3.96	2257.8	\$6,432	14.0	\$3.77
Ash	92.0	15.9	53.2	4.1	\$519.91	549.0	78.9	75.0	507.6	\$3,384.3	-26.2	-\$98.43	1349.3	\$3,806	9.2	\$3.40
Sweetgum	11.6	1.9	8.2	0.5	\$69.40	152.5	22.4	21.4	146.8	\$955.43	0.0	\$0.00	365.3	\$1,025	2.6	\$3.23
Sugar maple	47.1	8.0	26.5	2.1	\$263.95	267.9	39.1	37.3	255.6	\$1,672	-39.5	-\$147.99	644.4	\$1,789	4.7	\$3.13
London planetree	9.5	1.6	6.2	0.4	\$55.59	100.8	14.7	14.0	95.6	\$627.63	-10.5	-\$39.48	232.2	\$644	1.8	\$2.95
Northern red oak	28.6	4.9	15.2	1.3	\$157.77	119.9	17.5	16.7	114.3	\$748.12	-40.3	-\$151.18	278.0	\$755	2.4	\$2.59
Flowering crabapple	99.6	16.4	51.8	4.5	\$544.13	608.3	87.0	82.6	557.4	\$3,737	-0.6	-\$2.13	1507.1	\$4,279	15.5	\$2.27
Norway maple	35.6	6.1	23.2	1.6	\$208.75	315.8	45.3	43.0	290.7	\$1,943	-11.6	-\$43.48	749.8	\$2,109	8.1	\$2.13
Red maple	40.0	6.8	23.3	1.8	\$226.27	267.0	38.6	36.8	250.5	\$1,655	-16.5	-\$61.86	648.3	\$1,820	7.1	\$2.11
Littleleaf linden	19.9	3.4	13.4	0.9	\$117.91	195.4	28.2	26.8	181.7	\$1,207	-12.7	-\$47.63	457.0	\$1,278	5.3	\$1.97
Swamp white oak	5.1	0.9	3.6	0.2	\$30.59	52.9	7.6	7.2	48.3	\$324.76	-1.8	-\$6.68	124.0	\$349	1.6	\$1.77
Freeman maple	0.7	0.1	1.1	0.0	\$6.03	24.0	3.5	3.3	22.6	\$149.05	-2.5	-\$9.54	52.8	\$146	1.5	\$0.82
Japanese tree lilac	0.8	0.1	0.7	0.0	\$5.12	14.8	2.1	2.0	13.1	\$89.78	0.0	-\$0.03	33.6	\$95	1.7	\$0.47
Serviceberry	0.6	0.1	0.7	0.0	\$4.31	18.1	2.6	2.4	16.1	\$109.81	0.0	-\$0.03	40.5	\$114	2.1	\$0.44
Other street trees	79.5	14.1	52.8	5.4	\$473.38	432.6	63.0	60.1	410.6	\$2,694	-105.3	-\$394.95	1012.6	\$2,773	12.6	\$1.81
<b>Citywide total</b>	<b>813.8</b>	<b>137.2</b>	<b>455.1</b>	<b>38.4</b>	<b>\$4,548</b>	<b>4825.7</b>	<b>697.7</b>	<b>664.0</b>	<b>4516.2</b>	<b>\$29,892</b>	<b>-358.1</b>	<b>-\$1,343</b>	<b>11789.9</b>	<b>\$33,097</b>	<b>100.</b>	<b>\$2.72</b>

**Table 11. Annual Aesthetic or Other Benefits of Westerville's Street Trees by Common Name and Ordered by Benefit per Tree**

Species	% Total Tree Numbers	% Total \$	Total (\$)	Avg. \$/tree
Silver maple	2.2	6.9	\$14,205	\$54.01
Honeylocust	7.7	18.5	\$37,734	\$40.36
Sweetgum	2.6	4.3	\$8,694	\$27.43
Littleleaf linden	5.3	7.3	\$14,913	\$23.05
Ashes	9.2	12.1	\$24,778	\$22.14
Sugar maple	4.7	5.8	\$11,935	\$20.86
Freeman maple	1.5	1.6	\$3,267	\$18.35
Norway maple	8.1	8.0	\$16,419	\$16.59
Red maple	7.1	6.6	\$13,567	\$15.72
Swamp white oak	1.6	1.5	\$2,954	\$14.99
London planetree	1.8	1.5	\$3,152	\$14.46
Northern red oak	2.4	1.7	\$3,481	\$11.96
Pears	14.0	8.1	\$16,526	\$9.68
Flowering crabapple	15.5	5.2	\$10,661	\$5.66
Japanese tree lilac	1.7	0.1	\$233	\$1.15
Serviceberry	2.1	0.2	\$297	\$1.14
Other street trees	12.6	10.5	\$21,549	\$14.08
<b>Citywide total</b>	<b>100.0</b>	<b>100.0</b>	<b>\$204,364</b>	<b>\$16.78</b>



**Table 12. Totals for Five Benefit Categories and Grand Total for Westerville's Street Tree Benefits**



Benefits	Total (\$)	\$/tree
Energy	\$217,053	\$17.83
Aesthetic/Other	\$204,364	\$16.78
Stormwater	\$151,134	\$12.41
Air Quality	\$33,097	\$2.72
CO2 Stored	\$25,434	\$2.09
<b>Total Benefits</b>	<b>\$631,082</b>	<b>\$51.83</b>

■ Energy      ■ Aesthetic/Other      ■ Stormwater  
■ Air Quality      ■ CO2

