

# An Analysis of Public Tree Benefits for Dublin, Ohio

By

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## EXECUTIVE SUMMARY

An existing inventory of public street trees less parkway trees was modified to allow an analysis of environmental benefits to be run. A total of 18,662 public trees were inventoried. A common bid price for this service is \$3.00 per tree and thus the inventory represents a savings of \$55,986 for Dublin taxpayers had the inventory not been maintained by Dublin Urban Forestry. More importantly however, is that the City of Dublin now has an expanded use for the tree inventory that can be used to better manage the public 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). This program allows individuals with interested in making informed decisions about the community tree resource and 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 Dublin, only green ash exceeds the limit for specie at 11%. While maple is at the genera limit of 20%, it is the lowest amount of maple that we have seen on community streets in Ohio and will assist in dealing with Asian longhorned beetle should it reach central Ohio. Limiting future plantings of maples 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. Ash is also being treated since ashes are among the largest trees in Dublin and deliver greater environmental benefits because of their size. Dublin is to be congratulated for having worked to develop a diverse urban tree canopy with oaks, maples, honeylocust, sweetgum and a number of lesser known taxa.

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 trees die from old age. Dublin's tree population is skewed toward smaller trees even for larger growing species because few plantings exceed 40 years of age. Dublin's trees are now reaching sizes where environmental benefits per tree will increase dramatically. High numbers of smaller trees indicate an active planting program as seen in the overall numbers for Dublin (Table 2 and 3).

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 honeylocust represents 7 percent of the trees but constitutes 15% of the leaf area, 15% of the canopy cover, and has an importance value of 12% (Table 4). Further this demonstrates Dublin'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 5). 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 Dublin intercept more than 10,674 CCF (8 million gallons) of storm water annually at a savings of \$216,000 per year.

Carbon sequestration, as reported here, represents the carbon removed from the air and stored in Dublin's trees (Table 6). More than 15 million pounds or nearly 8,000 tons of carbon have been stored by Dublin's 18,662 trees over time. Dublin's trees currently sequester and avoid more than 4.8 million lbs of CO<sub>2</sub> (Table 8) and could represent carbon credits worth \$36,559 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. Annual CO<sub>2</sub> benefits vary by species but are confounded by size as larger trees would produce more benefits. 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 Dublin trees is \$43,592 (Table 9). This includes both direct savings (\$3,694) from the trees and avoided pollution which is even greater (\$43,952). 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 \$1,397 for the volatile emissions from the trees themselves.

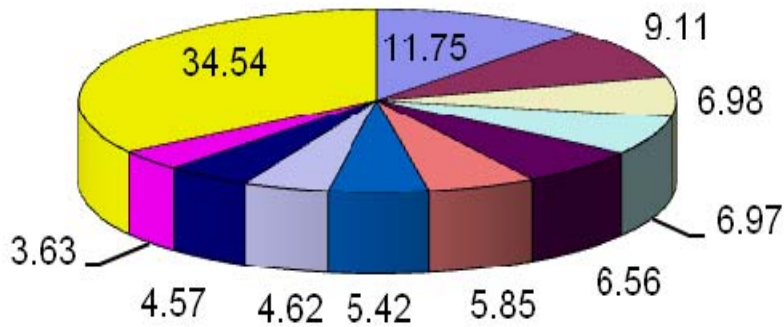
Energy savings by trees are exceptionally important in view of the citizenry's increasing concern over the nation's energy dependency. Planting trees in our communities may well be more cost effective than building power plants to as an alternative to meeting our energy needs. Energy is saved by shading structures, evaporating water (evapotranspiration) and reducing wind speed around structures (Table 7). Citywide, Dublin saves \$105,785 in electricity and \$193,885 in natural gas for a total savings of nearly \$330,000 or more than \$16 per tree with larger trees resulting in greater savings per tree.

Aesthetic and miscellaneous benefits from trees contribute \$368,576 annually to the community in the form of increased property values and enhanced community identity among other things (Table 10). Research in public housing has shown that areas with trees facilitate interaction 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 Dublin contributes \$51.72 per tree annually to the community (Table 11). Species vary in their annual benefits. Mature size, longevity, and maintenance costs are but some of the factors determining annual benefits. Thus Dublin's 18,662 trees contribute more than \$965,139. This would be well in excess of their maintenance and planting costs.

The budget for the City of Dublin's urban forestry budget is \$480,000 yet the community receives \$965,139 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 201% return on the community's investment. Trees are truly a contributing part of Dublin, 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 Dublin.

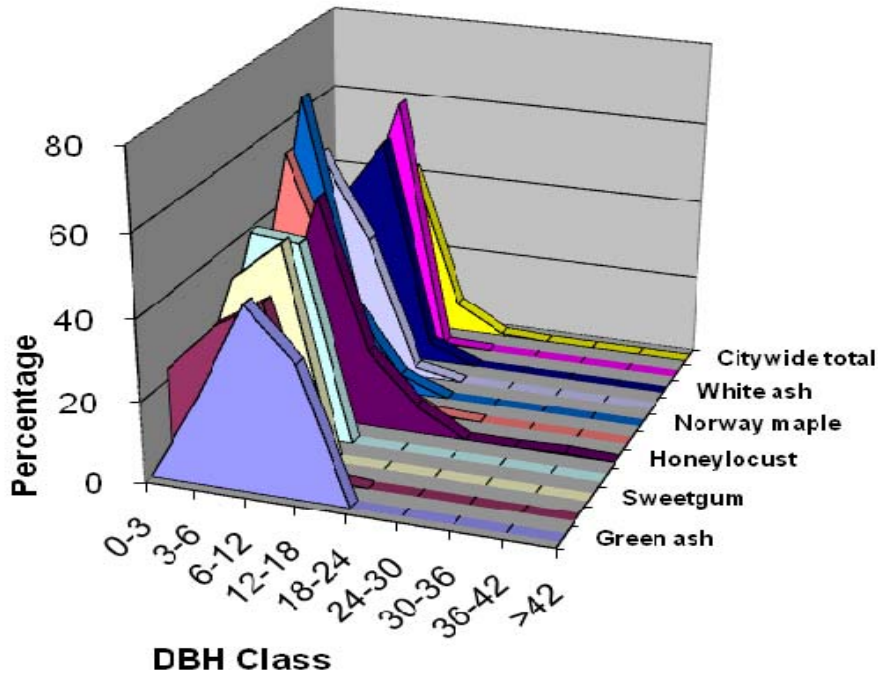
**Table 1 Species Distribution of Dublin’s Ten Most Commonly Planted Public Trees (%)**



- Green ash
- Northern red oak
- Sweetgum
- Freeman maple
- Honeylocust
- Silver linden
- Norway maple
- Sugar maple
- White ash
- Flowering crabapple
- Other species

Species	Percent
Green ash	11.75
Northern red oak	9.11
Sweetgum	6.98
Freeman maple	6.97
Honeylocust	6.56
Silver linden	5.85
Norway maple	5.42
Sugar maple	4.62
White ash	4.57
Flowering crabapple	3.63
Other species	34.54
<b>Total</b>	<b>100.00</b>

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



- Green ash
- Northern red oak
- Sweetgum
- Freeman maple
- Honeylocust
- Silver linden
- Norway maple
- Sugar maple
- White ash
- Flowering crabapple
- Citywide total

Species	DBH class (in)					
	0-3	3-6	6-12	12-18	18-24	24-42
Green ash	0.00	21.16	45.69	33.15	0.00	0.00
Northern red oak	22.46	34.57	42.09	0.88	0.00	0.00
Sweetgum	5.45	42.29	52.26	0.00	0.00	0.00
Freeman maple	1.92	49.62	48.46	0.00	0.00	0.00
Honeylocust	3.43	13.88	55.92	19.43	6.94	0.41
Silver linden	0.00	61.96	30.98	6.60	0.46	0.00
Norway maple	2.08	72.23	21.05	4.64	0.00	0.00
Sugar maple	7.66	55.34	34.57	2.44	0.00	0.00
White ash	0.00	39.20	56.10	4.69	0.00	0.00
Flowering crabapple	10.47	26.40	62.68	0.44	0.00	0.00
<b>Dublin total</b>	<b>7.51</b>	<b>41.95</b>	<b>42.64</b>	<b>7.35</b>	<b>0.52</b>	<b>0.03</b>

**Table 3. Complete Inventory of Dublin Trees by Scientific Name and Size Category**

Species	DBH Class (in)						Total
	0-3	3-6	6-12	12-18	18-24	36-42	
<b>Broadleaf Deciduous Large (BDL)</b>							
Fraxinus pennsylvanica	0	464	1,002	727	0	0	2,193
Quercus rubra	382	588	716	15	0	0	1,701
Liquidambar styraciflua	71	551	681	0	0	0	1,303
Acer x freemanii	25	645	630	0	0	0	1,300
Tilia tomentosa	0	676	338	72	5	0	1,091
Acer saccharum	66	477	298	21	0	0	862
Fraxinus americana	0	334	478	40	0	0	852
Ulmus parvifolia	0	220	170	0	5	0	395
Acer species	0	379	3	4	0	0	386
Acer rubrum	0	129	212	4	0	0	345
Ulmus species	0	85	205	54	0	0	344
Quercus acutissima	22	163	120	0	0	0	305
Platanus x acerifolia	6	160	91	0	0	0	257
Quercus imbricaria	8	151	59	0	0	0	218
Quercus sumardii	73	29	74	0	0	0	176
Tilia americana	30	42	87	0	0	0	159
Quercus macrocarpa	0	0	97	0	0	0	97
Liriodendron tulipifera	54	0	0	0	0	0	54
Quercus alba	0	27	0	0	0	0	27
Celtis occidentalis	23	0	0	0	0	0	23
Quercus robur	17	0	0	0	0	0	17
Gymnocladus dioicus	16	0	0	0	0	0	16
Quercus coccinea	0	0	11	0	0	0	11
Quercus palustris	0	10	0	0	1	0	11
Quercus muehlenbergii	7	0	0	0	0	0	7
Betula papyrifera	5	0	0	0	0	0	5
Cercidiphyllum japonicum	0	0	5	0	0	0	5
Tilia species	5	0	0	0	0	0	5
<b>Total</b>	<b>810</b>	<b>5,130</b>	<b>5,277</b>	<b>937</b>	<b>11</b>	<b>0</b>	<b>12,165</b>
<b>Broadleaf Deciduous Medium (BDM)</b>							
Gleditsia triacanthos	42	170	685	238	85	5	1,225
Acer platanoides	21	731	213	47	0	0	1,012
Acer truncatum	114	295	70	0	0	0	479
Tilia cordata	49	10	367	0	0	0	426
Pyrus calleryana	0	69	203	134	1	0	407
Ginkgo biloba	81	73	142	0	0	0	296
Quercus bicolor	0	28	144	0	0	0	172
Acer campestre	0	0	131	0	0	0	131
Zelkova serrata	0	93	28	0	0	0	121
Corylus colurna	14	54	22	0	0	0	90
Cladrastis kentukea	12	23	9	0	0	0	44

**Table 3 (continued). Complete Inventory of Dublin Trees by Scientific Name and Size Category**

Species	DBH Class (in)						Total
	0-3	3-6	6-12	12-18	18-24	36-42	
Eucommia ulmoides	21	0	13	0	0	0	34
Sophora japonica	0	0	0	12	0	0	12
Phellodendron amurense	0	0	9	0	0	0	9
Carpinus betulus	8	0	0	0	0	0	8
Robinia pseudoacacia	0	8	0	0	0	0	8
Nyssa sylvatica	0	0	7	0	0	0	7
Koelreutaria paniculata	0	0	4	0	0	0	4
<b>Total</b>	<b>362</b>	<b>1,554</b>	<b>2,047</b>	<b>431</b>	<b>86</b>	<b>5</b>	<b>4,485</b>
<b>Broadleaf Deciduous Small (BDS)</b>							
Malus hybrid	71	179	425	3	0	0	678
Syringa reticulata	53	176	53	0	0	0	282
Crataegus species	0	201	0	0	0	0	201
Amelanchier x grandiflora	63	133	0	0	0	0	196
Crataegus viridis	0	0	37	0	0	0	37
Prunus virginiana	12	21	0	0	0	0	33
Prunus sargentii	0	15	14	0	0	0	29
Crataegus punctata	0	18	0	0	0	0	18
Prunus subhirtella	0	0	13	0	0	0	13
Ostrya virginiana	0	11	0	0	0	0	11
<b>Total</b>	<b>199</b>	<b>754</b>	<b>542</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1,498</b>
<b>Conifer Evergreen Large (CEL)</b>							
Taxodium distichum	31	155	92	0	0	0	278
Metasequoia glyptostroboides	0	236	0	0	0	0	236
<b>Total</b>	<b>31</b>	<b>391</b>	<b>92</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>514</b>
<b>Dublin Total</b>	<b>1,402</b>	<b>7,829</b>	<b>7,958</b>	<b>1,371</b>	<b>97</b>	<b>5</b>	<b>18,662</b>

**Table 4. Importance Values for Dublin’s Most Abundant Public Tree Species Ordered by Importance Value**

Species	Number of Trees	% of Total Trees	Leaf Area (ft <sup>2</sup> )	% Total Leaf Area	Canopy Cover (ft <sup>2</sup> )	% Total Canopy Cover	Importance Value
Green ash	2,193	11.8	2,377,499	25.2	1,021,005	18.5	18.5
Honeylocust	1,225	6.6	1,449,888	15.3	839,503	15.3	12.4
Freeman maple	1,300	7.0	808,819	8.6	347,149	6.3	7.3
Northern red oak	1,701	9.1	458,450	4.9	397,297	7.2	7.1
Sweetgum	1,303	7.0	630,741	6.7	324,082	5.9	6.5
Other trees	1,394	7.5	474,503	5.0	332,049	6.0	6.2
White ash	852	4.6	523,039	5.5	259,792	4.7	4.9
Silver linden	1,091	5.8	370,464	3.9	239,093	4.3	4.7
Norway maple	1,012	5.4	306,080	3.2	227,509	4.1	4.3
Sugar maple	862	4.6	276,927	2.9	210,146	3.8	3.8
Callery pear	407	2.2	379,100	4.0	202,600	3.7	3.3
Flowering crabapple	678	3.6	101,418	1.1	154,058	2.8	2.5
Hybrid elm	344	1.8	289,274	3.1	132,765	2.4	2.4
Littleleaf linden	426	2.3	187,177	2.0	111,111	2.0	2.1
Lacebark elm	395	2.1	193,679	2.0	96,569	1.8	2.0
Red maple	345	1.8	162,052	1.7	122,222	2.2	1.9
Shantung maple	479	2.6	79,535	0.8	71,512	1.3	1.6
Sawtooth oak	305	1.6	79,751	0.8	74,056	1.3	1.3
Unspecified maple	386	2.1	34,094	0.4	62,454	1.1	1.2
Baldcypress	278	1.5	61,648	0.7	47,254	0.9	1.0
London planetree	257	1.4	61,528	0.7	47,201	0.9	1.0
Ginkgo	296	1.6	39,120	0.4	45,079	0.8	0.9
Shingle oak	218	1.2	54,558	0.6	49,229	0.9	0.9
Japanese tree lilac	282	1.5	17,919	0.2	33,972	0.6	0.8
Dawn-redwood	236	1.3	20,728	0.2	24,655	0.4	0.6
Unspecified hawthorn	201	1.1	7,181	0.1	18,959	0.3	0.5
Apple serviceberry	196	1.1	4,847	0.1	13,282	0.2	0.4
<b>Dublin Totals</b>	<b>18,662</b>	<b>100.0</b>	<b>9,450,020</b>	<b>100.0</b>	<b>5,504,604</b>	<b>100.0</b>	<b>100.0</b>



**Table 5. Annual Storm water Benefits of Dublin's Public 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
Honeylocust	1,473.3	\$29,866	6.6	13.8	\$24.38
Green ash	2,345.0	\$47,538	11.8	22.0	\$21.68
Callery pear	429.7	\$8,712	2.2	4.0	\$21.41
Hybrid elm	292.0	\$5,919	1.8	2.7	\$17.21
Freeman maple	868.7	\$17,610	7.0	8.1	\$13.55
White ash	554.0	\$11,230	4.6	5.2	\$13.18
Red maple	209.5	\$4,246	1.9	2.0	\$12.31
Littleleaf linden	227.7	\$4,616	2.3	2.1	\$10.83
Sweetgum	681.5	\$13,815	7.0	6.4	\$10.60
Lacebark elm	205.9	\$4,175	2.1	1.9	\$10.57
Other street trees	597.4	\$12,111	7.5	5.6	\$8.69
Silver linden	449.2	\$9,105	5.8	4.2	\$8.35
Norway maple	414.7	\$8,407	5.4	3.9	\$8.31
Sugar maple	346.5	\$7,024	4.6	3.3	\$8.15
Sawtooth oak	121.9	\$2,470	1.6	1.1	\$8.10
Northern red oak	671.3	\$13,609	9.1	6.3	\$8.00
Shingle oak	78.4	\$1,589	1.2	0.7	\$7.29
London planetree	82.9	\$1,680	1.4	0.8	\$6.54
Baldcypress	83.0	\$1,683	1.5	0.8	\$6.05
Shantung maple	120.9	\$2,450	2.6	1.1	\$5.11
Flowering crabapple	170.1	\$3,448	3.6	1.6	\$5.09
Ginkgo	66.0	\$1,337	1.6	0.6	\$4.52
Unspecified maple	80.6	\$1,635	2.1	0.8	\$4.23
Dawn-redwood	37.2	\$754	1.3	0.3	\$3.20
Japanese tree lilac	35.4	\$718	1.5	0.3	\$2.55
Unspecified hawthorn	18.4	\$374	1.1	0.2	\$1.86
Apple serviceberry	12.8	\$260	1.0	0.1	\$1.33
<b>Dublin total</b>	<b>10,673.8</b>	<b>\$216,382</b>	<b>100.0</b>	<b>100.0</b>	<b>\$11.59</b>

**Table 6. Stored CO2 Benefits of Dublin's Public Trees by Common Name and Ordered by Average Benefits per Tree**

<b>Species</b>	<b>Total stored CO2 (lbs)</b>	<b>Total (\$)</b>	<b>% Total Tree Numbers</b>	<b>% of Total \$</b>	<b>Average \$/tree</b>
Callery pear	732,093	\$5,491	2.2	4.8	\$13.49
Green ash	3,792,074	\$28,441	11.8	25.0	\$12.97
Honeylocust	2,009,918	\$15,074	6.6	13.2	\$12.31
Hybrid elm	365,240	\$2,739	1.8	2.4	\$7.96
Littleleaf linden	378,525	\$2,839	2.3	2.5	\$6.66
White ash	703,321	\$5,275	4.6	4.6	\$6.19
Red maple	276,020	\$2,070	1.9	1.8	\$6.00
Silver linden	772,392	\$5,793	5.8	5.1	\$5.31
Lacebark elm	258,959	\$1,942	2.1	1.7	\$4.92
Freeman maple	834,753	\$6,261	7.0	5.5	\$4.82
Flowering crabapple	427,775	\$3,208	3.6	2.8	\$4.73
Sweetgum	807,566	\$6,057	7.0	5.3	\$4.65
Other street trees	389,444	\$6,439	7.5	5.7	\$4.62
Sugar maple	509,426	\$3,821	4.6	3.3	\$4.43
Norway maple	564,830	\$4,236	5.4	3.7	\$4.19
Northern red oak	902,075	\$6,766	9.1	5.9	\$3.98
Sawtooth oak	153,647	\$1,152	1.6	1.0	\$3.78
London planetree	123,172	\$924	1.4	0.8	\$3.59
Baldcypress	123,577	\$927	1.5	0.8	\$3.33
Shingle oak	88,729	\$665	1.2	0.6	\$3.05
Shantung maple	143,414	\$1,076	2.6	0.9	\$2.25
Japanese tree lilac	80,141	\$601	1.5	0.5	\$2.13
Unspecified maple	100,597	\$754	2.1	0.7	\$1.95
Ginkgo	73,341	\$550	1.6	0.5	\$1.86
Dawn-redwood	44,035	\$330	1.3	0.3	\$1.40
Unspecified hawthorn	35,736	\$268	1.1	0.2	\$1.33
Apple serviceberry	24,515	\$184	1.0	0.2	\$0.94
<b>Dublin total</b>	<b>15,184,447</b>	<b>\$113,883</b>	<b>100.0</b>	<b>100.0</b>	<b>\$6.10</b>

**Table 7. Annual Energy Benefits of Dublin’s Public Trees by Common Name and Ordered by (\$/tree)**

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (MBtu)	Natural Gas (\$)	Total (\$)	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Honeylocust	194.1	\$14,732	2699	\$26,448	\$41,180	6.6	13.7	\$33.62
Callery pear	55.76	\$4,232	784	\$7,683	\$11,915	2.2	4.0	\$29.27
Green ash	278.56	\$21,143	3509	\$34,389	\$55,532	11.8	18.5	\$25.32
Hybrid elm	34.43	\$2,613	454	\$4,453	\$7,066	1.8	2.4	\$20.54
Red maple	29.12	\$2,211	429	\$4,208	\$6,419	1.9	2.1	\$18.61
White ash	66.02	\$5,011	892	\$8,744	\$13,755	4.6	4.6	\$16.14
Littleleaf linden	29.6	\$2,247	463	\$4,538	\$6,785	2.3	2.3	\$15.93
Freeman maple	83.22	\$6,317	1209	\$11,846	\$18,162	7.0	6.1	\$13.97
Norway maple	61.61	\$4,676	952	\$9,326	\$14,002	5.4	4.7	\$13.84
Other street trees	83.39	\$6,329	1279	\$12,535	\$18,864	7.5	6.3	\$13.53
Silver linden	66.21	\$5,025	981	\$9,610	\$14,635	5.9	4.9	\$13.41
Sweetgum	80.62	\$6,119	1142	\$11,187	\$17,306	7.0	5.8	\$13.28
Flowering crabapple	36.22	\$2,749	625	\$6,126	\$8,875	3.6	3.0	\$13.09
Lacebark elm	23.78	\$1,805	334	\$3,270	\$5,075	2.1	1.7	\$12.85
Sawtooth oak	17.88	\$1,357	261	\$2,557	\$3,914	1.6	1.3	\$12.83
Sugar maple	51.81	\$3,932	723	\$7,081	\$11,013	4.6	3.7	\$12.78
Northern red oak	96.35	\$7,313	1414	\$13,855	\$21,168	9.1	7.1	\$12.44
Shingle oak	11.83	\$898	172	\$1,682	\$2,580	1.2	0.9	\$11.83
London planetree	12.71	\$965	199	\$1,949	\$2,914	1.4	1.0	\$11.34
Baldcypress	12.72	\$965	199	\$1,953	\$2,918	1.5	1.0	\$10.50
Shantung maple	19.17	\$1,455	310	\$3,034	\$4,489	2.6	1.5	\$9.37
Unknown Maple	15	\$1,139	215	\$2,107	\$3,246	2.1	1.1	\$8.41
Ginkgo	11.14	\$846	165	\$1,620	\$2,465	1.6	0.8	\$8.33
Japanese tree lilac	8	\$607	138	\$1,354	\$1,961	1.5	0.7	\$6.95
Dawn-redwood	6.88	\$522	107	\$1,049	\$1,571	1.3	0.5	\$6.66
Hawthorn	4.46	\$338	76	\$748	\$1,086	1.1	0.4	\$5.40
Apple serviceberry	3.16	\$240	54	\$533	\$773	1.1	0.3	\$3.94
<b>Dublin totals</b>	<b>1,393.74</b>	<b>\$105,785</b>	<b>19784</b>	<b>\$193,885</b>	<b>\$299,670</b>	<b>100.0</b>	<b>100.0</b>	<b>\$16.06</b>

**Table 8. Annual Carbon Dioxide Benefits of Dublin’s Public Trees by Species and Ordered by Average Benefits per Tree**

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total (\$)	% of Total Tree Numbers	% of Total \$	Average \$/tree
Honeylocust	338470	\$2,539	-9648	-239	-\$74	325570	\$2,442	654153	\$4,906	6.6	13.4	\$4.01
Callery pear	104246	\$782	-3514	-79	-\$27	93522	\$701	194174	\$1,456	2.2	4.0	\$3.58
Green ash	567392	\$4,255	-18202	-428	-\$140	467254	\$3,504	1016016	\$7,620	11.8	20.8	\$3.47
Hybrid elm	54913	\$412	-1753	-67	-\$14	57750	\$433	110843	\$831	1.8	2.3	\$2.42
Littleleaf linden	83426	\$626	-1817	-83	-\$14	49653	\$372	131179	\$984	2.3	2.7	\$2.31
White ash	128621	\$965	-3376	-166	-\$27	110746	\$831	235824	\$1,769	4.6	4.8	\$2.08
Freeman maple	210701	\$1,580	-4007	-254	-\$32	139593	\$1,047	346034	\$2,595	7.0	7.1	\$2.00
Red maple	41965	\$315	-1325	-67	-\$10	48852	\$366	89425	\$671	1.9	1.8	\$1.94
Sweetgum	183248	\$1,374	-3876	-254	-\$31	135222	\$1,014	314340	\$2,358	7.0	6.4	\$1.81
Lacebark elm	55113	\$413	-1243	-77	-\$10	39896	\$299	93689	\$703	2.1	1.9	\$1.78
Norway maple	135848	\$1,019	-2711	-197	-\$22	103339	\$775	236278	\$1,772	5.4	4.8	\$1.75
Other street trees	157568	\$1,182	-4121	-272	-\$33	139876	\$1,049	293051	\$2,198	7.5	6.0	\$1.58
Sugar maple	79479	\$596	-2445	-168	-\$20	86903	\$652	163768	\$1,228	4.6	3.4	\$1.42
Sawtooth oak	26777	\$201	-738	-59	-\$6	29986	\$225	55967	\$420	1.6	1.1	\$1.38
Silver linden	89076	\$668	-3707	-213	-\$29	111052	\$833	196208	\$1,472	5.8	4.0	\$1.35
Northern red oak	144018	\$1,080	-4330	-332	-\$35	161621	\$1,212	300978	\$2,257	9.1	6.2	\$1.33
Flowering crabapple	56607	\$425	-2053	-132	-\$16	60746	\$456	115168	\$864	3.6	2.4	\$1.27
Shingle oak	17605	\$132	-426	-43	-\$4	19835	\$149	36971	\$277	1.2	0.8	\$1.27
Shantung maple	44500	\$334	-688	-93	-\$6	32163	\$241	75882	\$569	2.6	1.6	\$1.19
London planetree	16332	\$122	-591	-50	-\$5	21317	\$160	37008	\$278	1.4	0.8	\$1.08
Baldcypress	16370	\$123	-593	-54	-\$5	21329	\$160	37052	\$278	1.5	0.8	\$1.00
Maple	17109	\$128	-483	-75	-\$4	25164	\$189	41715	\$313	2.1	0.9	\$0.81
Ginkgo	9539	\$72	-352	-58	-\$3	18686	\$140	27815	\$209	1.6	0.6	\$0.70
Japanese tree lilac	13173	\$99	-385	-55	-\$3	13423	\$101	26156	\$196	1.5	0.5	\$0.70
Dawn-redwood	7947	\$60	-211	-46	-\$2	11539	\$87	19228	\$144	1.3	0.4	\$0.61
Hawthorn	7626	\$57	-172	-39	-\$2	7475	\$56	14890	\$112	1.1	0.3	\$0.56
Apple serviceberry	5593	\$42	-118	-38	-\$1	5300	\$40	10737	\$81	1.0	0.2	\$0.41
<b>Dublin totals</b>	<b>2613262</b>	<b>\$19,599</b>	<b>-72885</b>	<b>-3639</b>	<b>-\$574</b>	<b>2337812</b>	<b>\$17,534</b>	<b>4874550</b>	<b>\$36,559</b>	<b>100.0</b>	<b>100.0</b>	<b>\$1.96</b>

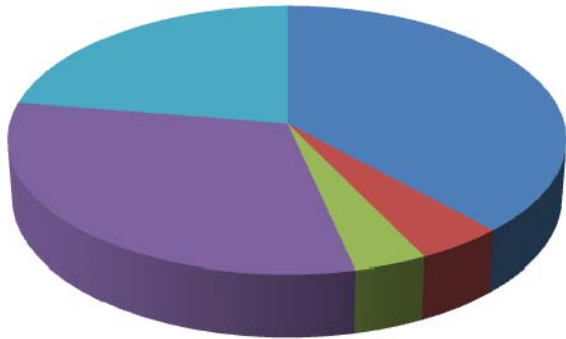
**Table 9. Annual Air Quality Benefits of Dublin’s Public Trees by Species and Ordered by Average Dollars per Tree**

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 Emissions (lb)	BVOC Emissions (\$)	Net Total (lb)	Total (\$)	% Total Tree Numbers	Avg. \$/tree
Honeylocust	161.1	26.5	84.9	7.3	\$883	929	135	129	879	\$5,782	-99.3	-372.5	2253.2	\$6,293	6.56	\$5.14
Callery pear	41.6	7.2	24.1	1.8	\$235	269	39	37	253	\$1,668	-12.0	-45.0	660.6	\$1,859	2.18	\$4.57
Green ash	104.9	16.8	71.4	4.7	\$619	1302	192	183	1263	\$8,180	0.0	0.0	3136.7	\$8,798	11.75	\$4.01
Hybrid elm	10.9	1.9	8.7	0.5	\$68	163	24	23	156	\$1,017	0.0	0.0	386.9	\$1,085	1.84	\$3.15
Red maple	18.9	3.2	11.5	0.8	\$108	141	20	19	132	\$875	-8.4	-31.3	339.1	\$951	1.85	\$2.76
White ash	14.6	2.3	13.7	0.6	\$96	313	46	44	299	\$1,956	0.0	0.0	732.8	\$2,052	4.57	\$2.41
Littleleaf linden	13.1	2.3	9.4	0.6	\$79	147	21	20	134	\$901	-9.2	-34.4	338.2	\$946	2.28	\$2.22
Norway maple	27.0	4.6	19.2	1.2	\$163	304	44	41	280	\$1,873	-9.7	-36.3	711.7	\$1,999	5.42	\$1.98
Sweetgum	17.9	2.8	16.9	0.8	\$119	387	56	54	365	\$2,405	0.0	0.0	900.3	\$2,524	6.98	\$1.94
Other street trees	39.5	6.7	26.9	1.8	\$235	410	59	56	378	\$2,526	-23.8	-89.2	954.4	\$2,672	7.47	\$1.92
Freeman maple	22.2	3.8	22.5	1.0	\$153	402	58	55	377	\$2,491	-45.3	-169.9	896.1	\$2,473	6.97	\$1.90
Lacebark elm	6.0	0.9	5.3	0.3	\$39	114	17	16	108	\$708	0.0	0.0	266.4	\$747	2.12	\$1.89
Silver linden	17.2	2.9	14.8	0.8	\$111	323	47	44	301	\$1,998	-23.9	-89.5	726.7	\$2,019	5.85	\$1.85
Sugar maple	13.8	2.3	12.4	0.6	\$90	248	36	34	235	\$1,541	-15.4	-57.8	566.2	\$1,574	4.62	\$1.83
Flowering crabapple	20.7	3.4	12.3	1.0	\$117	184	26	25	164	\$1,120	-0.1	-0.5	436.2	\$1,236	3.63	\$1.82
Sawtooth oak	9.8	1.7	6.7	0.4	\$59	86	13	12	81	\$536	-14.8	-55.6	195.7	\$539	1.63	\$1.77
Northern red oak	57.8	10.0	38.0	2.6	\$340	467	67	64	436	\$2,891	-85.2	-319.4	1058.1	\$2,911	9.11	\$1.71
Shingle oak	2.9	0.5	2.9	0.1	\$20	57	8	8	54	\$354	-9.8	-36.9	123.4	\$337	1.17	\$1.55
London planetree	2.4	0.4	2.5	0.1	\$17	63	9	9	58	\$387	-4.0	-14.9	139.8	\$389	1.38	\$1.51
Baldcypress	2.4	0.4	2.5	0.1	\$17	63	9	9	58	\$387	-4.0	-14.9	139.9	\$389	1.49	\$1.40
Shantung maple	5.8	1.0	5.0	0.3	\$38	96	14	13	87	\$587	-2.5	-9.4	219.3	\$616	2.57	\$1.29
Unknown Maple	4.6	0.8	3.9	0.2	\$30	72	10	10	68	\$448	-1.8	-6.6	168.1	\$471	2.07	\$1.22
Ginkgo	4.6	0.8	3.3	0.2	\$28	54	8	7	50	\$335	-2.3	-8.5	126.4	\$354	1.59	\$1.20
Japanese tree lilac	3.1	0.5	2.2	0.1	\$19	41	6	5	36	\$247	0.0	-0.1	94.0	\$266	1.51	\$0.94
Dawn-redwood	0.5	0.1	1.0	0.0	\$5	34	5	5	31	\$209	-1.3	-5.0	75.1	\$209	1.26	\$0.89
Hawthorn	0.8	0.1	0.8	0.0	\$6	23	3	3	20	\$137	0.0	0.0	50.7	\$143	1.08	\$0.71
Apple serviceberry	0.5	0.1	0.6	0.0	\$4	16	2	2	14	\$97	0.0	0.0	36.0	\$101	1.05	\$0.52
<b>Dublin totals</b>	<b>624.7</b>	<b>104.1</b>	<b>423.5</b>	<b>28.0</b>	<b>\$3,694</b>	<b>6708</b>	<b>973</b>	<b>927</b>	<b>6317</b>	<b>\$41,655</b>	<b>-372.7</b>	<b>-1397.8</b>	<b>15731.9</b>	<b>\$43,952</b>	<b>100.00</b>	<b>\$2.36</b>

**Table 10. Annual Aesthetic or Other Benefits of Dublin’s Public Trees by Common Name and Ordered by Average benefit per Tree**

Species	Total (\$)	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Honeylocust	\$63,865	6.56	17.33	\$52.13
Green ash	\$68,787	11.75	18.66	\$31.37
Freeman maple	\$37,282	6.97	10.12	\$28.68
Callery pear	\$11,503	2.18	3.12	\$28.26
Littleleaf linden	\$11,689	2.28	3.17	\$27.44
White ash	\$22,788	4.57	6.18	\$26.75
Red maple	\$7,528	1.85	2.04	\$21.82
Hybrid elm	\$7,459	1.84	2.02	\$21.68
Sweetgum	\$27,939	6.98	7.58	\$21.44
Lacebark elm	\$8,384	2.12	2.27	\$21.23
Norway maple	\$16,903	5.42	4.59	\$16.70
Other street trees	\$21,948	7.47	5.95	\$15.74
Shantung maple	\$5,949	2.57	1.61	\$12.42
Sugar maple	\$10,696	4.62	2.90	\$12.41
Shingle oak	\$2,568	1.17	0.70	\$11.78
Sawtooth oak	\$3,158	1.63	0.86	\$10.35
Northern red oak	\$16,817	9.11	4.56	\$9.89
Silver linden	\$9,640	5.85	2.62	\$8.84
Unknown maple	\$3,113	2.07	0.84	\$8.06
London planetree	\$1,891	1.38	0.51	\$7.36
Baldcypress	\$1,927	1.49	0.52	\$6.93
Flowering crabapple	\$3,138	3.63	0.85	\$4.63
Dawn-redwood	\$1,018	1.26	0.28	\$4.31
Ginkgo	\$1,193	1.59	0.32	\$4.03
Japanese tree lilac	\$703	1.51	0.19	\$2.49
Hawthorn	\$414	1.08	0.11	\$2.06
Apple serviceberry	\$276	1.05	0.07	\$1.41
<b>Citywide total</b>	<b>\$368,576</b>	<b>100.00</b>	<b>100.00</b>	<b>\$19.75</b>

**Table 11. Totals for Five Benefit Categories and Grand Total for Dublin's Street Tree Benefits**



Benefits	Totals (\$)	\$/tree
Aesthetic/Other	\$368,576	\$19.75
Air Quality	\$43,952	\$2.36
CO2	\$36,559	\$1.96
Energy	\$299,670	\$16.06
Storm water	\$216,382	\$11.59
<b>Total Benefits</b>	<b>\$965,139</b>	<b>\$51.72</b>

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

