An Analysis of Environmental Benefits for Park Trees

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EXECUTIVE SUMMARY

An inventory of trees in the City of Bellbrook's Parks was undertaken by Greene County Master Gardener Volunteers and Ohio Certified Volunteer Naturalists from the OSU Greene County Extension Office as well as, Bellbrook Garden Club members and interested Bellbrook citizen volunteers to allow an analysis of environmental benefits to be run. This information was then analyzed by The Ohio State University's School of Environment and Natural Resources. A total of 1142 trees were inventoried. A common bid price for this service is $3.00 per tree and thus the inventory represents a savings of $3426 for Bellbrook's taxpayers over contracting for this service. Most importantly, however, is that the community now has a tree inventory that can be used to better manage the tree resource of the parks. Benefits mentioned above do not include the value of the subsequent analysis and report.

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 available at no charge should this be desired. This program allows individuals interested in making informed decisions about the community tree resource and to explore many aspects including biodiversity and the value of environmental services.

A long standing rule of thumb for taxonomic 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 20 percent should be from the same genera, and no more than 30 percent should be from the same family. In Bellbrook Parks, ashes exceed genera guidelines (Table 1). This will be a bit of a concern as they are very sensitive to the emerald as borer and likely will have to be removed within five years. Ashes are generally less than 18-inch diameter which will moderate removal costs since they increase dramatically as trees get larger (Tables 2 and 3). Ashes should not be replaced. Large deciduous trees that could be used to replace the ash include the Kentucky coffeetree, honeylocust, ginkgo, deciduous conifers, maples, and sycamore which are currently available in the nursery trade. Cottonwoods and elms are somewhat above species guidelines if they are of a single species but likely are the result of natural regeneration. One may wish to limit planting additional cottonwoods and elms in future plantings especially if they are common in adjacent areas. Large trees are preferred especially in parks where overhead utility lines may not be present as they produce markedly more environmental benefits.

Under ideal conditions tree numbers among smaller size classes should be stable and then decline as tree size increases and older trees die. This is generally true for the trees in the parks although more trees in the 24-inch and larger sizes are desirable for long lived species (Tables 2 and 3). Trees that live longer and mature at larger sizes are preferred by a residents based on a preference survey in Toledo, OH. Fortunately, larger growing trees dominate Bellbrook's Parks.

A major benefit of urban trees is their ability to intercept rainfall and reduce storm water runoff (Table 4). Storm water runoff is a major cost for many communities. Columbus, OH is about to embark on a multi-billion dollar sewer and storm water upgrade for the community. Trees in the public parks intercept more

than 2526 hundred cu. ft (nearly 2,000,000 gallons) of storm water annually at a savings to Bellbrook, OH of more than $51,000 per year from the storm water mitigation benefits of the park trees.

More than 5,773,700 pounds or 2,888 tons of carbon have been stored by Bellbrook's 1,142 park trees over time (Table 5). Additionally, Bellbrook's park trees currently sequester and avoid nearly 777,512 lbs of CO_2 yearly (Table 7) and would represent carbon credits worth more than $5,800 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_2 benefits vary by species and size but average $5.11 per tree per year while honeylocusts average $9.82 per tree per year.

Energy savings by trees are particularly 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 as a conservation alternative to meeting our energy needs. Energy is saved by shading structures, evaporating water (evapotranspiration) and reducing wind speed around structures (Table 6). Bellbrook saves nearly$18,000 in electricity and $31,000 in natural gas for a total savings of nearly $49,000 or an average of $42.89 per tree per year.

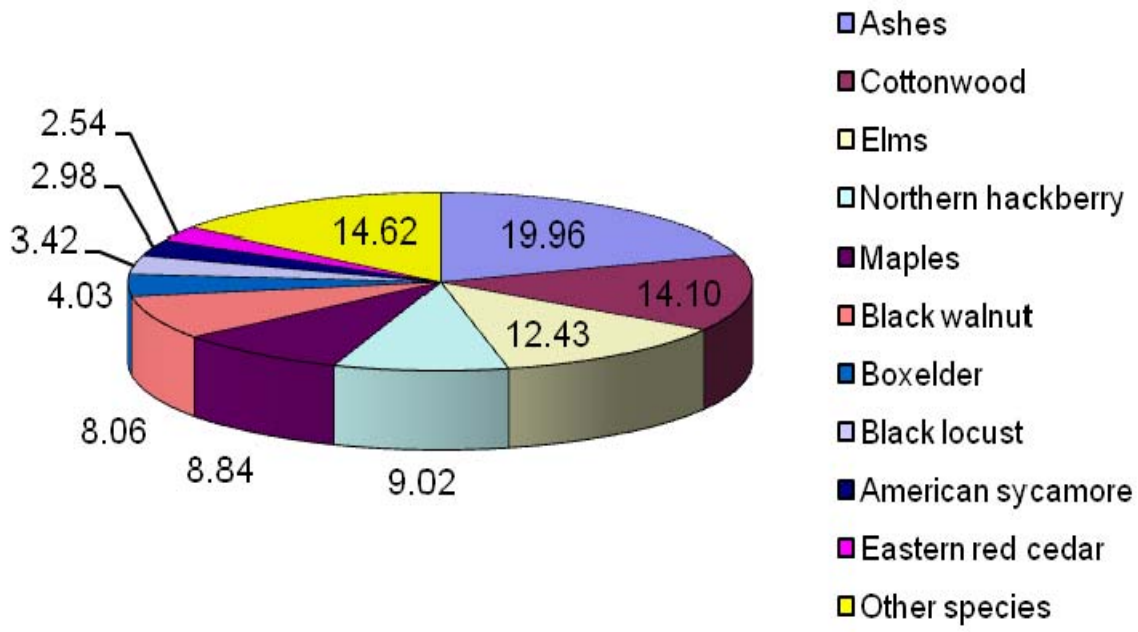
Annual air quality savings (reduced ozone, nitrous and sulfur oxides as well as particulate matter) for the Bellbrook's park trees is $8,241 (Table 8). This includes both direct savings ($1,500) from the trees and avoided pollution which is much greater at ($7,005). Avoided pollution is pollution not generated at power source because energy was not required (avoided) by the community. The total annual air quality benefits are discounted by $265 for the volatile emissions from the trees themselves.

Aesthetic and miscellaneous benefits from trees contribute $45,000 annually to the community in the form of increased property values and enhanced community identity among other things (Table 9). Research in public housing has shown that areas with trees facilitate interaction among residents and lead to reduced domestic violence and more sociable environments. Hospitals try to have park like scenes visible from patient's rooms because a number of studies have shown shorter recovery times and reduced use of pain medication when natural settings are visible to patients.

Species vary in their annual benefits but mature size, longevity, and maintenance costs are but some of the factors determining annual benefits (Table 10). When all benefits are included the 1142 park trees contribute and average of $139 per tree annually to the community (Table 11). Thus the parks' 1142 trees contribute $159,451 per year. This would be well in excess of their maintenance and planting costs.

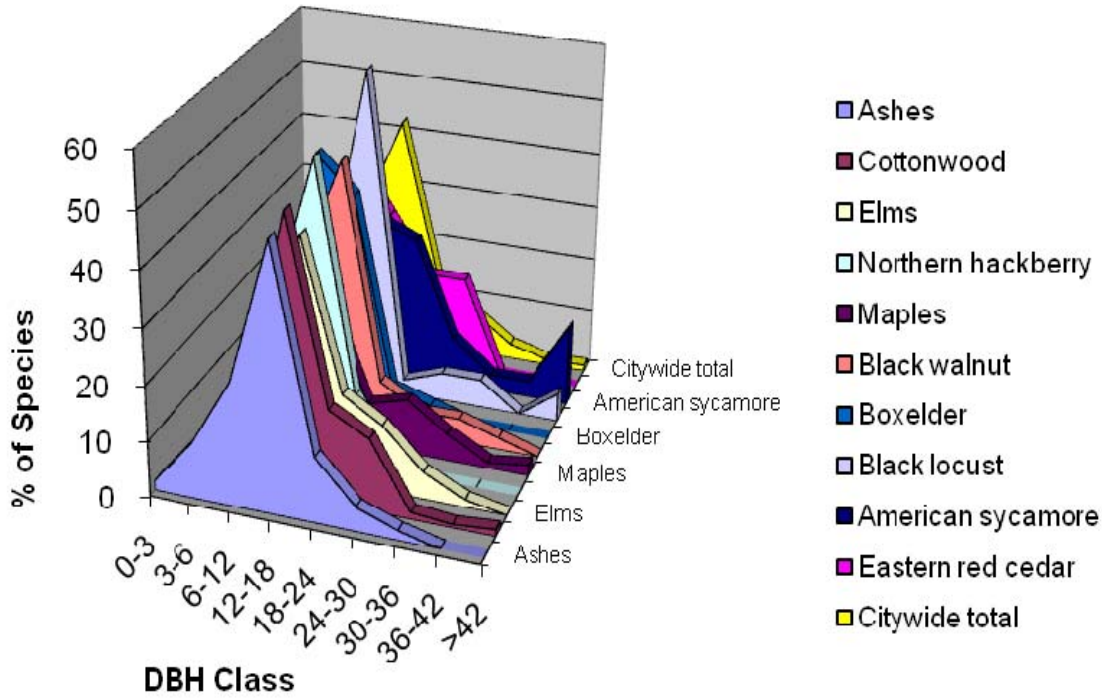
The City Bellbrook does not have a budget for trees or tree maintenance, thus it was estimated at $14,018 by using National Arbor Day's minimum guideline of $2.00 per capita and the 2000 census estimate of 7,009 residents. Thus the 1142 park trees receive an estimated 14,000 dollars of care per year yet deliver $159,451 in annual benefits from storm water abatement, CO2 avoidance and storage, energy savings, air quality, aesthetic benefits, and the like. This is an astounding 1100% return on investment. This may be high but other Ohio communities studied routinely discover returns on their tree maintenance dollars of 2-300%. Further, unlike most community infrastructure, tree benefits per tree continue to increase over a tree's lifetime.

Table 1. Species Distribution of the Bellbrook Park Trees



Species	Percent
Ashes	19.96
Cottonwood	14.10
Elms	12.43
Northern hackberry	9.02
Maples	8.84
Black walnut	8.06
Boxelder	4.03
Black locust	3.42
American sycamore	2.98
Eastern red cedar	2.54
Other species	14.62
Total	**100.00**

Table 2. Relative Age Distribution of the Top 10 Most Commonly Planted Trees in Bellbrook Parks in % of Type



Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Ashes	1.8	10.1	22.4	47.8	11.8	4.4	1.8	0.0	0.0
Cottonwood	0.0	0.0	17.4	49.7	16.8	13.0	1.2	0.6	1.2
Elms	0.0	1.4	21.1	43.0	16.2	12.0	4.9	1.4	0.0
Northern hackberry	0.0	4.9	28.2	53.4	12.6	1.0	0.0	0.0	0.0
Maples	0.0	12.9	35.6	25.7	7.9	9.9	5.0	1.0	2.0
Black walnut	0.0	3.3	29.3	47.8	8.7	4.3	4.3	2.2	0.0
Boxelder	0.0	8.7	45.7	39.1	4.3	2.2	0.0	0.0	0.0
Black locust	0.0	0.0	23.1	59.0	2.6	5.1	5.1	0.0	5.1
American sycamore	0.0	0.0	14.7	29.4	26.5	8.8	2.9	2.9	14.7
Eastern red cedar	0.0	0.0	37.9	27.6	17.2	17.2	0.0	0.0	0.0
Citywide total	**0.4**	**5.0**	**25.6**	**42.5**	**13.9**	**7.8**	**2.8**	**1.0**	**1.1**

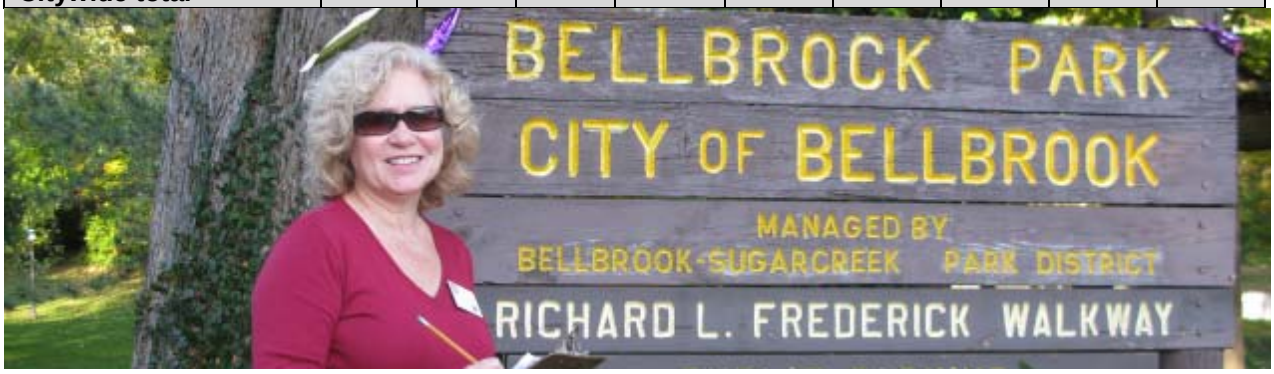


Table 3. Population of Bellbrook's Trees by Common Name and Size Class.

Species	DBH Class (in)									
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total
Broadleaf Deciduous Large (BDL)										
Cottonwood	0	0	28	80	27	21	2	1	2	161
Northern hackberry	0	5	29	55	13	1	0	0	0	103
Maples	0	13	36	26	8	10	5	1	2	101
Black walnut	0	3	27	44	8	4	4	2	0	92
American sycamore	0	0	5	10	9	3	1	1	5	34
Catalpa	0	1	6	7	2	3	2	2	1	24
Oaks	0	0	3	8	3	2	4	0	0	20
Pin oak	0	0	0	6	8	0	0	0	0	14
BDL OTHER	0	0	10	6	4	0	0	1	1	22
Total	**0**	**22**	**144**	**242**	**82**	**44**	**18**	**8**	**11**	**571**
Broadleaf Deciduous Medium (BDM)										
Ashes	4	23	51	109	27	10	4	0	0	228
Elms	0	2	30	61	23	17	7	2	0	142
Boxelder	0	4	21	18	2	1	0	0	0	46
Black locust	0	0	9	23	1	2	2	0	2	39
Osage-Orange	0	0	4	8	8	3	1	1	0	25
Honeylocust	0	0	4	2	6	5	0	0	0	17
BDM OTHER	0	3	6	8	1	0	0	0	0	18
Total	**4**	**32**	**125**	**229**	**68**	**38**	**14**	**3**	**2**	**515**
Conifer Evergreen Large (CEL)										
CEL OTHER	0	2	2	0	1	0	0	0	0	5
Total	**0**	**2**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**5**
Conifer Evergreen Medium (CEM)										
CEM OTHER	0	0	0	1	0	0	0	0	0	1
Total	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
Conifer Evergreen Small (CES)										
Eastern red cedar	0	0	11	8	5	5	0	0	0	29
Total	**0**	**0**	**11**	**8**	**5**	**5**	**0**	**0**	**0**	**29**
Zone 1 Total	**4**	**57**	**292**	**485**	**159**	**89**	**32**	**11**	**13**	**1142**

Table 4. Annual Storm Water Benefits of Bellbrook's Park Trees by Species

Species	Total Rainfall Interception (CCF)	Total ($)	% of Total Tree Numbers	% of Total Savings	Avg. $/tree
American sycamore	136.0	$2,758	3.0	5.4	$81.11
Honeylocust	62.1	$1,260	1.5	2.5	$74.09
Catalpa	85.3	$1,729	2.1	3.4	$72.02
Oaks	68.4	$1,387	1.8	2.7	$69.33
Osage-Orange	79.5	$1,611	2.2	3.1	$64.43
Cottonwood	427.4	$8,664	14.1	16.9	$53.81
Elms	345.9	$7,012	12.4	13.7	$49.38
Black walnut	206.3	$4,183	8.1	8.2	$45.47
Black locust	83.9	$1,700	3.4	3.3	$43.60
Maples	187.9	$3,809	8.8	7.4	$37.71
Ashes	410.3	$8,317	20.0	16.2	$36.48
Northern hackberry	177.1	$3,591	9.0	7.0	$34.86
Eastern red cedar	49.0	$994	2.5	1.9	$34.27
Boxelder	66.8	$1,355	4.0	2.6	$29.45
Broadleaf Deciduous Large	39.5	$800	1.2	1.6	$57.14
Other street trees	101.5	$2,057	5.9	4.0	$30.71
Citywide total	**2526.9**	**$51,225**	**100.0**	**100.0**	**$44.86**

Table 5. Stored CO2 Benefits of Bellbrook Park Trees by Species

Species	Total stored CO2 (lbs)	Total ($)	% Total Tree Numbers	% of Total $	Avg. $/tree
American sycamore	510440	$3,828.30	3.0	8.8	$112.60
Catalpa	282714	$2,120.36	2.1	4.9	$88.35
Oaks	193169	$1,448.77	1.8	3.3	$72.44
Osage-Orange	213694	$1,602.71	2.2	3.7	$64.11
Cottonwood	1085408	$8,140.56	14.1	18.8	$50.56
Honeylocust	111386	$835.40	1.5	1.9	$49.14
Elms	808556	$6,064.17	12.4	14.0	$42.71
Black walnut	503092	$3,773.19	8.1	8.7	$41.01
Black locust	186888	$1,401.66	3.4	3.2	$35.94
Ashes	870705	$6,530.28	20.0	15.1	$28.64
Maples	343270	$2,574.52	8.8	5.9	$25.49
Boxelder	119394	$895.45	4.0	2.1	$19.47
Northern hackberry	166954	$1,252.15	9.0	2.9	$12.16
Eastern red cedar	22886	$171.64	2.5	0.4	$5.92
Broadleaf Deciduous Large	89692	$672.69	1.2	1.5	$48.05
Other street trees	120389	$1,990.60	5.9	4.6	$29.71
Bellbrook Park Total	**5773658**	**$43,302.44**	**100.0**	**100.0**	**$37.92**

Table 6. Annual Energy Benefits of Bellbrook's Park Trees by Species ($/tree)

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (MBtu)	Natural Gas ($)	Total ($)	% of Total Tree Number	% of Total $	Avg. $/tree
Honeylocust	4.8	$362	63.9	$626	$987	1.5	2.0	$58.09
American sycamore	9.4	$715	125.0	$1,225	$1,940	3.0	4.0	$57.07
Oaks	5.2	$391	68.0	$666	$1,058	1.8	2.2	$52.88
Osage-Orange	6.2	$468	82.9	$812	$1,281	2.2	2.6	$51.23
Catalpa	5.9	$447	78.0	$765	$1,211	2.1	2.5	$50.47
Elms	32.0	$2,426	446.0	$4,371	$6,797	12.4	13.9	$47.87
Cottonwood	37.6	$2,853	484.9	$4,752	$7,605	14.1	15.5	$47.24
Northern hackberry	22.7	$1,723	306.3	$3,002	$4,725	9.0	9.6	$45.87
Black locust	8.5	$649	115.4	$1,131	$1,780	3.4	3.6	$45.64
Black walnut	18.8	$1,427	239.4	$2,346	$3,773	8.1	7.7	$41.01
Ashes	43.5	$3,301	595.2	$5,833	$9,134	20.0	18.6	$40.06
Maples	18.5	$1,406	248.1	$2,431	$3,837	8.8	7.8	$37.99
Boxelder	6.7	$505	86.5	$848	$1,353	4.0	2.8	$29.40
Eastern red cedar	2.5	$193	38.3	$375	$568	2.5	1.2	$19.60
Broadleaf Deciduous Lg	3.5	$266	46.7	$457	$724	1.2	1.5	$51.71
Other street trees	10.4	$786	144.8	$1,419	$2,205	5.9	4.5	$32.90
Citywide total	**236.1**	**$17,918**	**3169.4**	**$31,060**	**$48,978**	**100.0**	**100.0**	**$42.89**

Table 7. Annual Carbon Dioxide Benefits of Bellwood Park Trees by Species

Species	Sequester (lb)	Sequester ($)	Decomp Release (lb)	Maint. Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% Total Tree Number	% Total $	Avg. $/tree
Honeylocust	14801	$111.01	-534.7	-3.3	-4.0	7990	59.9	22254	$166.90	1.5	2.9	$9.82
Oaks	11720	$87.90	-927.2	-3.9	-7.0	8648	64.9	19437	$145.78	1.8	2.5	$7.29
Osage-Orange	14118	$105.88	-1025.7	-4.9	-7.7	10350	77.6	23437	$175.78	2.2	3.0	$7.03
American sycamore	18271	$137.03	-2450.1	-6.6	-18.4	15801	118.5	31615	$237.11	3.0	4.1	$6.97
Catalpa	12557	$94.17	-1357.0	-4.7	-10.2	9872	74.0	21067	$158.00	2.1	2.7	$6.58
Cottonwood	81068	$608.01	-5210.0	-31.4	-39.3	63050	472.9	138877	$1,041.57	14.1	17.9	$6.47
Black walnut	39822	$298.67	-2414.8	-17.9	-18.2	31527	236.5	68917	$516.88	8.1	8.9	$5.62
Elms	47551	$356.64	-3881.1	-27.7	-29.3	53624	402.2	97267	$729.50	12.4	12.5	$5.14
Black locust	12102	$90.77	-897.1	-7.6	-6.8	14339	107.5	25537	$191.53	3.4	3.3	$4.91
Ashes	72099	$540.74	-4179.4	-44.5	-31.7	72958	547.2	140833	$1,056.25	20.0	18.1	$4.63
Maples	26403	$198.02	-1647.7	-19.7	-12.5	31068	233.0	55804	$418.53	8.8	7.2	$4.14
Northern hackberry	18483	$138.62	-801.4	-20.1	-6.2	38084	285.6	55746	$418.09	9.0	7.2	$4.06
Boxelder	13978	$104.83	-573.1	-9.0	-4.4	11157	83.7	24552	$184.14	4.0	3.2	$4.00
Eastern red cedar	781	$5.86	-109.9	-5.7	-0.9	4265	32.0	4930	$36.98	2.5	0.6	$1.28
Broadleaf Deciduous Lg	7950	$59.62	-430.5	-2.7	-3.2	5888	44.2	13405	$100.53	1.2	1.7	$7.18
Other street trees	17757	$133.17	-1274.0	-13.1	-9.7	17365	130.2	33835	$253.76	5.9	4.3	$3.79
Citywide total	**409461**	**$3,070.96**	**-27713.6**	**-222.7**	**-209.5**	**395987**	**2969.9**	**777512**	**$5,831.34**	**100.0**	**100.0**	**$5.11**

Table 8. Annual Air Quality Benefits of Bellbrook Trees by Species Ordered by Savings per Tree

Species	Deposit O3 (lb)	Deposit NO2 (lb)	Deposit PM10 (lb)	Deposit SO2 (lb)	Total Deposit ($)	Avoid NO2 (lb)	Avoid PM10 (lb)	Avoid VOC (lb)	Avoid SO2 (lb)	Total Avoided ($)	BVOC Emission (lb)	BVOC Emission ($)	Net Total (lb)	Total ($)	% of Total Tree Number	Avg. $/tree
American sycamore	14.97	2.39	7.01	0.67	$79.28	44.6	6.5	6.2	42.7	$278.88	0.0	0.0	125.1	$358.16	3.0	$10.53
Honeylocust	8.78	1.45	4.06	0.40	$46.51	22.6	3.3	3.1	21.6	$141.00	-6.5	-24.6	58.7	$162.96	1.5	$9.59
Oaks	5.91	0.94	2.90	0.26	$31.68	24.4	3.6	3.4	23.4	$152.49	0.0	0.0	64.7	$184.17	1.8	$9.21
Catalpa	8.42	1.35	3.99	0.38	$44.73	27.9	4.1	3.9	26.7	$174.20	0.0	0.0	76.6	$218.93	2.1	$9.12
Osage-Orange	6.53	1.04	3.28	0.29	$35.23	29.3	4.3	4.1	28.0	$183.01	0.0	0.0	76.8	$218.24	2.2	$8.73
Elms	48.79	8.42	24.55	2.16	$265.26	153.7	22.3	21.3	145.1	$955.23	-11.8	-44.3	414.4	$1,176.20	12.4	$8.28
Cottonwood	32.89	5.26	17.09	1.48	$179.01	176.8	25.9	24.8	170.4	$1,108.21	0.0	0.0	454.7	$1,287.22	14.1	$8.00
Black locust	11.21	1.93	5.74	0.50	$61.22	40.8	5.9	5.7	38.8	$254.18	-2.8	-10.4	107.8	$304.98	3.4	$7.82
Northern hackberry	12.93	2.24	8.10	0.58	$74.88	108.2	15.8	15.0	103.0	$674.73	0.0	0.0	265.9	$749.61	9.0	$7.28
Black walnut	15.06	2.41	7.98	0.68	$82.42	88.1	13.0	12.4	85.2	$553.08	0.0	0.0	224.8	$635.50	8.1	$6.91
Ashes	52.20	9.01	27.13	2.31	$286.23	208.1	30.3	28.9	197.4	$1,295.95	-13.2	-49.4	542.1	$1,532.74	20.0	$6.72
Maples	30.77	5.24	14.72	1.36	$164.87	87.8	12.8	12.2	83.9	$548.53	-10.7	-40.1	238.2	$673.24	8.8	$6.67
Boxelder	4.71	0.75	2.57	0.21	$25.96	31.3	4.6	4.4	30.1	$196.01	-2.4	-8.9	76.2	$213.09	4.0	$4.63
Eastern red cedar	6.87	1.36	5.52	0.85	$44.91	12.4	1.8	1.7	11.5	$76.59	-20.1	-75.4	21.9	$46.12	2.5	$1.59
Broadleaf Deciduous Lg	2.78	0.44	1.50	0.12	$15.28	16.6	2.4	2.3	15.9	$103.97	0.0	0.0	42.2	$119.25	1.2	$8.52
Other street trees	11.56	1.93	6.09	0.57	$63.54	49.7	7.2	6.9	46.9	$309.03	-3.2	-11.8	127.7	$360.72	5.9	$5.38
Bellbrook Park Total	**274.38**	**46.17**	**142.23**	**12.83**	**$1,500.99**	**1122.3**	**163.8**	**156.3**	**1070.5**	**$7,005.10**	**-70.7**	**-265.0**	**2917.9**	**$8,241.13**	**100.0**	**$7.22**

Table 9. Annual Aesthetic or Other Benefits of Bellbrook Park Trees by Species

Species	Total ($)	% Total Tree Numbers	% of Total $	Avg. $/tree
Honeylocust	$3,443.47	1.49	7.62	$202.56
Oaks	$1,023.16	1.75	2.26	$51.16
Osage-Orange	$1,264.28	2.19	2.80	$50.57
Cottonwood	$7,651.69	14.10	16.94	$47.53
American sycamore	$1,585.09	2.98	3.51	$46.62
Catalpa	$1,097.66	2.10	2.43	$45.74
Black walnut	$3,939.81	8.06	8.72	$42.82
Maples	$3,754.55	8.84	8.31	$37.17
Northern hackberry	$3,677.63	9.02	8.14	$35.71
Elms	$4,726.17	12.43	10.46	$33.28
Boxelder	$1,522.65	4.03	3.37	$33.10
Ashes	$7,389.99	19.96	16.36	$32.41
Black locust	$1,242.63	3.42	2.75	$31.86
Eastern red cedar	$344.24	2.54	0.76	$11.87
Broadleaf Deciduous Large	$736.63	1.23	1.63	$52.62
Other street trees	$1,776.03	5.87	3.93	$26.51
Citywide total	**$45,175.66**	**100.00**	**100.00**	**$39.56**

Table 10. Average Annual Benefits of Bellbrook Park Trees by Species and Ordered by Total Savings.

Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total
Honeylocust	$58.09	$9.82	$9.59	$74.09	$202.56	$354.14
American sycamore	$57.07	$6.97	$10.53	$81.11	$46.62	$202.31
Oaks	$52.88	$7.29	$9.21	$69.33	$51.16	$189.87
Catalpa	$50.47	$6.58	$9.12	$72.02	$45.74	$183.94
Osage-Orange	$51.23	$7.03	$8.73	$64.43	$50.57	$181.99
Cottonwood	$47.24	$6.47	$8.00	$53.81	$47.53	$163.04
Elms	$47.87	$5.14	$8.28	$49.38	$33.28	$143.95
Black walnut	$41.01	$5.62	$6.91	$45.47	$42.82	$141.83
Black locust	$45.64	$4.91	$7.82	$43.60	$31.86	$133.83
Northern hackberry	$45.87	$4.06	$7.28	$34.86	$35.71	$127.78
Maples	$37.99	$4.14	$6.67	$37.71	$37.17	$123.68
Ashes	$40.06	$4.63	$6.72	$36.48	$32.41	$120.31
Boxelder	$29.40	$4.00	$4.63	$29.45	$33.10	$100.59
Eastern red cedar	$19.60	$1.28	$1.59	$34.27	$11.87	$68.61
Broadleaf Deciduous Lg	$51.71	$7.18	$8.52	$57.14	$52.62	$177.17
Other street trees	$32.90	$3.79	$5.38	$30.71	$26.51	$99.29

Table 11 Percentage Environmental Benefits for Trees in Bellbrook's Park Trees from Five Benefit Categories

Benefits	Total ($)	$/tree	$/capita
Energy	$48,978	$42.89	$6.99
CO2	$5,831	$5.11	$0.83
Air Quality	$8,241	$7.22	$1.18
Stormwater	$51,225	$44.86	$7.31
Aesthetic/Other	$45,176	$39.56	$6.45
Total Benefits	**$159,451**	**$139.62**	**$22.75**