An Analysis of Public Tree Benefits for Xenia, Ohio

By

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EXECUTIVE SUMMARY

A full inventory of public street trees was undertaken by citizen volunteers and overseen by the Green County Extension Office and its Master Gardeners. A total of 1,804 public trees were inventoried. A common bid price for this service is $3.00 per tree and thus the inventory represents a savings of $5,412 for Xenia taxpayers. Most importantly however, is that the City of Xenia now has a tree inventory that can be used to better manage the public tree resource of Xenia OH. Benefits mentioned above do not include the subsequent analysis.

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. This program allows individuals interested in making informed decisions about the community tree resource and to explore many aspects including 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 Xenia, Callery pears exceed the limit for specie at 12%, while maples exceed both the genera and family limits at 37% (Table 1). Care should be taken to limit these groups, especially maple, in future Xenia plantings. Broadleaf deciduous trees constitute nearly 24% of the population but consist of various taxa (groups).

Under ideal conditions tree numbers among size classes should decline as tree size increases as trees die. Uniform numbers of smaller trees indicate an active planting program as seen in the overall numbers for Xenia (Table 2 and 3). Maple numbers in Xenia are skewed toward larger sizes suggesting a senescent maple population and a potential management concern. Pears are somewhat evenly distributed in smaller sizes as pears rarely exceed 18-inch diameter. Ginkgos and oaks while large trees at maturity are more recently planted and thus the population of these species is skewed to the smaller sizes.

Maples, larger broadleaved deciduous trees, and pears have importance values greater than their respective percentages in the inventory because of their larger size. For example maple represents 37 percent of the trees but constitutes 59% of the leaf area, 56% of the canopy cover, and has an importance value of 51% (Table 4). Further this demonstrates Xenia's need for larger statured trees whenever possible as the importance value is a measure of the overall contribution of the species to the overall.

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 Xenia intercept more than 2 million gallons of storm water annually at a savings to the community of nearly 60,000 dollars per year.

Carbon sequestration, as reported here, represents the carbon removed from the air and stored in Xenia's trees (Table 6). More than 6 million pounds or 3,000 tons of carbon have been stored by Xenia's 1,804

trees over time. Xenia's trees currently sequester and avoid more than 800,000 lbs of CO_2 (Table 8) and could represent carbon credits worth $6,180 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 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 Xenia trees is $9,419 (Table 9). This includes both direct savings ($2,505) from the trees and avoided pollution which is even greater ($7,882). 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 $968 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 Xenia saves $20,000 in electricity and $35,000 in natural gas for a total savings in excess of $55,000 or an average of$30 per tree with larger trees resulting in greater savings per tree.

Aesthetic and miscellaneous benefits from trees contribute $53,323 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 Xenia contributes $102 per tree annually to the community (Table 11). Species vary in their annual benefits but mature size, longevity, and maintenance costs are but some of the factors determining annual benefits. Thus Xenia's 1,804 trees contribute more than $184,300. This would be well in excess of their maintenance and planting costs.

Stated differently the City of Xenia estimated that they spent $7,000 to plant trees in public areas last year yet receive $184,300 in benefits including storm water abatement, CO2 avoidance and storage, energy savings, air quality, and aesthetic benefits. Total benefits yield an astounding 2500% return on your annual investment in trees in public spaces. Xenia does not currently track some costs such as picking up brush following a storm as tree maintenance. Let's assume that Xenia had maintenance costs of $2 per capita as suggested for Tree City USA status. Then Xenia's tree budget would be about $48,000 and then the return on an investment of $48,000 would still be more than 280%. Trees are truly a contributing part of Xenia Ohio's infrastructure. Unlike most community infrastructure, tree benefits per tree continue to increase over a tree's lifetime.

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Table 1 Species Distribution of Xenia Public Trees (%)
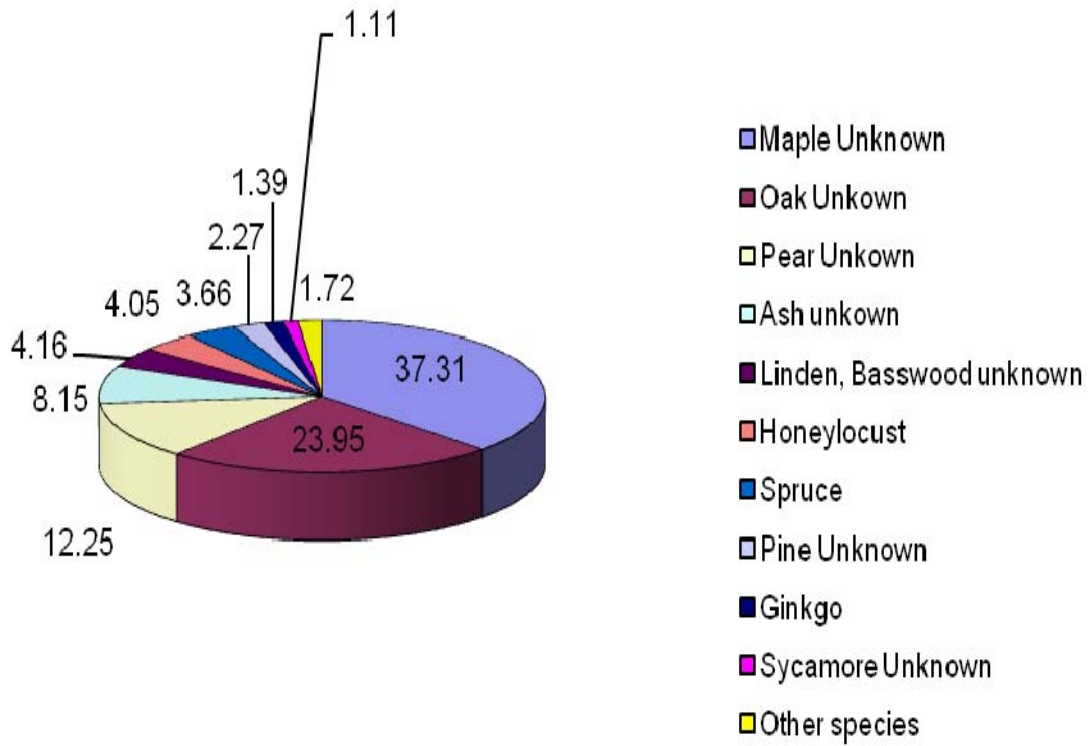
Species	Percent
Maple (unknown)	37.31
Broadleaf Deciduous (unknown)	23.95
Pear (unknown)	12.25
Ash (unknown)	8.15
Linden, Basswood (unknown)	4.16
Honeylocust	4.05
Spruce	3.66
Pine (unknown)	2.27
Ginkgo	1.39
Sycamore (unknown)	1.11
Other species	1.72
Total	**100.00**

Table 2. Relative Age Distribution of the Top 10 Most Commonly Planted Public Tree Taxa in Xenia (%)
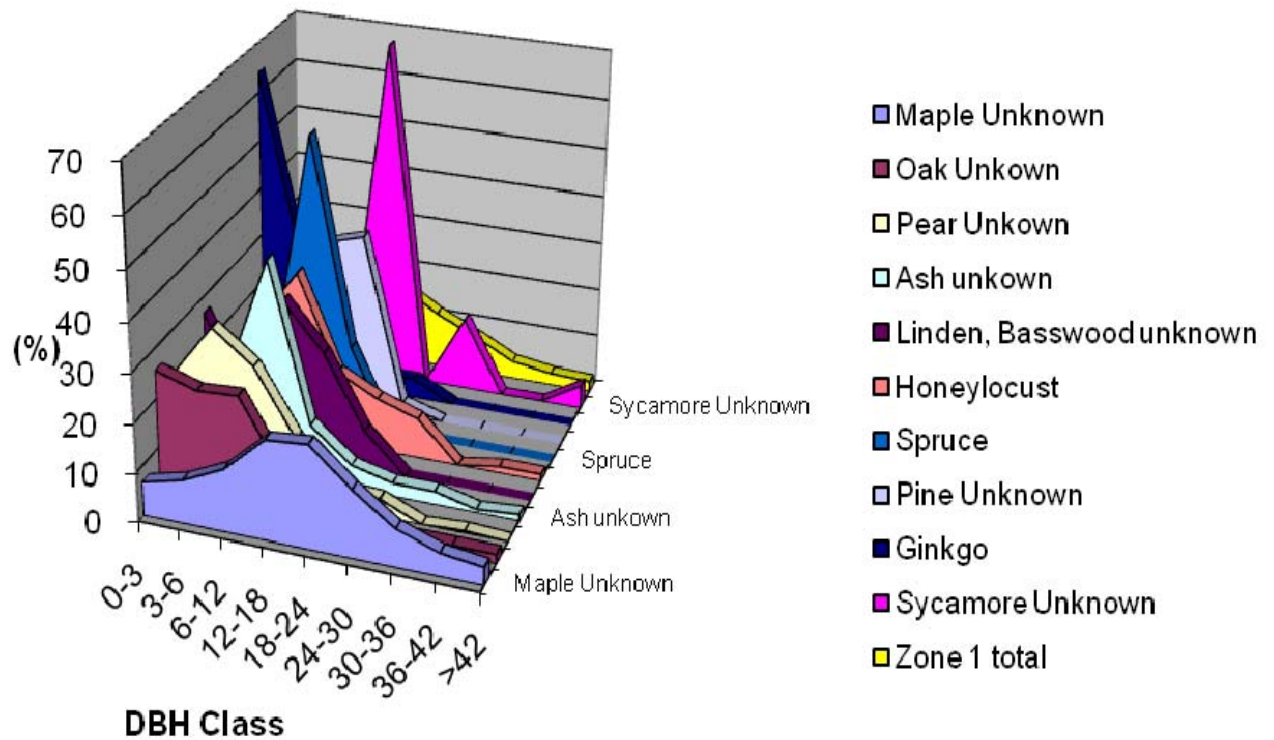
Species Name	DBH class (in)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Maple (unknown)	6.84	8.92	12.78	20.36	21.10	13.82	7.73	4.75	3.71
Broadleaf Deciduous (unknown)	25.69	23.15	23.61	9.95	6.48	5.56	1.85	1.85	1.85
Pear (unknown)	21.27	32.13	25.79	12.67	4.07	3.62	0.00	0.45	0.00
Ash (unknown)	12.93	19.73	43.54	11.56	4.76	2.72	2.72	0.68	1.36
Linden, Basswood (unknown)	26.67	10.67	32.00	22.67	8.00	0.00	0.00	0.00	0.00
Honeylocust	5.48	23.29	34.25	15.07	10.96	8.22	0.00	1.37	1.37
Spruce	12.12	12.12	59.09	16.67	0.00	0.00	0.00	0.00	0.00
Pine (unknown)	4.88	21.95	34.15	36.59	2.44	0.00	0.00	0.00	0.00
Ginkgo	64.00	28.00	0.00	4.00	4.00	0.00	0.00	0.00	0.00
Sycamore (unknown)	5.00	0.00	5.00	70.00	0.00	15.00	0.00	0.00	5.00
Xenia's citywide total	**15.24**	**17.41**	**23.17**	**16.46**	**11.53**	**7.87**	**3.66**	**2.49**	**2.16**

Table 3 Complete Population of Xenia Public Trees

| | DBH Class (in) | | | | | | | | | |
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total
Broadleaf Deciduous Large (BDL)										
Maple Unknown	46	60	86	137	142	93	52	32	25	673
Linden, Basswood	20	8	24	17	6	0	0	0	0	75
Pine Unknown	2	9	14	15	1	0	0	0	0	41
Sycamore Unknown	1	0	1	14	0	3	0	0	1	20
Oak unknown	1	2	4	1	3	4	1	1	2	19
Tulip tree	0	2	0	2	3	0	1	0	0	8
Black walnut	0	1	2	0	0	0	0	1	0	4
BDL OTHER	111	100	102	43	28	24	8	8	8	432
Total	**181**	**182**	**233**	**229**	**183**	**124**	**62**	**42**	**36**	**1,272**
Broadleaf Deciduous Medium (BDM)										
Ash unkown	19	29	64	17	7	4	4	1	2	147
Honeylocust	4	17	25	11	8	6	0	1	1	73
Ginkgo	16	7	0	1	1	0	0	0	0	25
Total	**39**	**53**	**89**	**29**	**16**	**10**	**4**	**2**	**3**	**245**
Broadleaf Deciduous Small (BDS)										
Pear Unkown	47	71	57	28	9	8	0	1	0	221
Total	**47**	**71**	**57**	**28**	**9**	**8**	**0**	**1**	**0**	**221**
Broadleaf Evergreen Large (BEL)										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Broadleaf Evergreen Medium (BEM)										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Broadleaf Evergreen Small (BES)										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Conifer Evergreen Large (CEL)										
Spruce	8	8	39	11	0	0	0	0	0	66
Total	**8**	**8**	**39**	**11**	**0**	**0**	**0**	**0**	**0**	**66**
Conifer Evergreen Medium (CEM)										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Conifer Evergreen Small (CES)										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Grand Total:	**275**	**314**	**418**	**297**	**208**	**142**	**66**	**45**	**39**	**1,804**

Table 4. Importance Values for Xenia's Most Abundant Public Tree Species

Species	Number of Trees	% of Total Trees	Leaf Area (ft2)	% Total Leaf Area	Canopy Cover (ft2)	% Total Canopy Cover	Importance Value
Maple (unknown)	673	37.31	1,997,833	59.22	677,561	56.32	50.95
Deciduous Broadleaf (unk.)	432	23.95	469,112	13.90	177,0789	14.72	17.52
Pear (unknown)	221	12.25	192,599	5.71	90,640	7.53	8.50
Ash (unknown)	147	8.15	251,816	7.46	91,736	7.62	7.75
Linden, Basswood (unknown)	75	4.16	61,316	1.82	27,327	2.27	2.75
Honeylocust	73	4.05	172,866	5.12	59,885	4.98	4.72
Spruce	66	3.66	54,258	1.61	14,895	1.24	2.17
Pine (unknown)	41	2.27	34,566	1.02	18,553	1.54	1.61
Ginkgo	25	1.39	2,774	0.08	2,128	0.18	0.55
Sycamore (unknown)	20	1.11	43,134	1.28	15,267	1.27	1.22
Oak (unknown)	19	1.05	55,101	1.63	15,616	1.30	1.33
Other trees	12	0.67	38,333	1.14	12,442	1.03	0.95
Total	**1,804**	**100.00**	**3,373,708**	**100.00**	**1,203,129**	**100.00**	**100.00**

Table 5. Annual Storm water Benefits of Xenia Public Trees by Species

Species	Total Rainfall Interception (Gal)	Total ($)	% of Total Trees	% of Total $	Avg. $/tree
Maple (unknown)	1,268,432.25	34,376.90	37.31	57.35	51.08
Deciduous Broadleaf (unk.)	326,615.44	8,851.89	23.95	14.77	20.49
Pear (unknown)	142,440.53	3,860.41	12.25	6.44	17.47
Ash (unknown)	171,774.20	4,655.41	8.15	7.77	31.67
Linden, Basswood (unknown)	45,470.18	1,232.33	4.16	2.06	16.43
Honeylocust	96,669.49	2,619.93	4.05	4.37	35.89
Spruce	42,239.33	1,144.77	3.66	1.91	17.34
Pine (unknown)	28,883.14	782.79	2.27	1.31	19.09
Ginkgo	2,643.10	71.63	1.39	0.12	2.87
Sycamore (unknown)	29,372.89	796.06	1.11	1.33	39.80
Oak (unknown)	34,018.68	921.97	1.05	1.54	48.52
Other street trees	23,119.65	626.59	0.67	1.05	52.22
Citywide total	**2,211,678.50**	**59,940.67**	**100.00**	**100.00**	**33.23**

Table 6. Stored CO2 Benefits of Xenia's Public Trees by Species

Species	Total stored CO2 (lbs)	Total ($)	% of Total Tree Numbers	% of Total	Avg. $/tree
Maple (unknown)	3338229	$25,037	37.3	54.3	$37.20
Broadleaf Deciduous (unk.)	1240723	$9,305	24.0	20.2	$21.54
Pear (unknown)	323532	$2,426	12.3	5.3	$10.98
Ash (unknown)	438137	$3,286	8.1	7.1	$22.35
Linden, Basswood (unknown)	136758	$1,026	4.2	2.2	$13.68
Honeylocust	211084	$1,583	4.1	3.4	$21.69
Spruce	23209	$174	3.7	0.4	$2.64
Pine (unknown)	78192	$586	2.3	1.3	$14.30
Ginkgo	6604	$50	1.4	0.1	$1.98
Sycamore (unknown)	112323	$842	1.1	1.8	$42.12
Oak (unknown)	154645	$1,160	1.0	2.5	$61.04
Other street trees	35653	$590	0.7	1.3	$49.13
Xenia's Citywide total	**6099089**	**$46,065**	**100.0**	**100.0**	**$25.54**

Table 7. Annual Energy Benefits of Xenia's Public Trees by Species ($/tree)

Species	Total Electricity (MWh)	Electricity ($)	Natural Gas Total (Therms)	Natural Gas ($)	Total ($)	% of Total Trees	% of Total Dollars	Avg. $/tree ($)
Maple (unknown)	145	$10,995	19,610	$19,218	$30,213	37.31	54.46	$44.89
Broadleaf Deciduous (unk.)	41	$3,119	5,727	$5,612	$8,732	23.95	15.74	$20.21
Pear (unknown)	21	$1,621	2,906	$2,848	$4,470	12.25	8.06	$20.22
Ash (unknown)	19	$1,455	2,447	$2,398	$3,853	8.15	6.95	$26.21
Linden, Basswood (unk.)	8	$570	1,040	$1,019	$1,589	4.16	2.86	$21.18
Honeylocust	13	$961	1,725	$1,691	$2,651	4.05	4.78	$36.32
Spruce	4	$290	568	$557	$847	3.66	1.53	$12.84
Pine (unknown)	5	$368	630	$617	$985	2.27	1.78	$24.03
Ginkgo	1	$41	73	$71	$112	1.39	0.20	$4.50
Sycamore (unknown)	4	$294	487	$478	$772	1.11	1.39	$38.59
Oak (unknown)	3	$255	475	$466	$721	1.05	1.30	$37.95
Other street trees	3	$192	345	$338	$530	0.67	0.96	$44.19
Xenia's Citywide total	**266**	**$20,162**	**36,034**	**$35,314**	**$55,476**	**100.0**	**100.0**	**$30.75**

Table 8. Annual Carbon Dioxide Benefits of Xenia's Public Trees by Species

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% of Total Trees	% of Total ($)	Avg. $/tree
Maple (unknown)	213980	$1,605	-16023	-131	-121	242995	$1,822	440821	$3,306	37.3	53.5	$4.91
Broadleaf Deciduous (unk.)	52755	$396	-5955	-84	-45	68940	$517	115656	$867	24.0	14.0	$2.01
Pear (unknown)	34142	$256	-1553	-43	-12	35833	$269	68379	$513	12.3	8.3	$2.32
Ash (unknown)	40917	$307	-2103	-29	-16	32153	$241	70939	$532	8.1	8.6	$3.62
Linden, Basswood (unk)	12175	$91	-656	-15	-5	12588	$94	24092	$181	4.2	2.9	$2.41
Honeylocust	27461	$206	-1013	-14	-8	21228	$159	47662	$357	4.1	5.8	$4.90
Spruce	3496	$26	-111	-13	-1	6414	$48	9786	$73	3.7	1.2	$1.11
Pine (unknown)	7171	$54	-375	-8	-3	8130	$61	14918	$112	2.3	1.8	$2.73
Ginkgo	509	$4	-32	-5	0	910	$7	1382	$10	1.4	0.2	$0.41
Sycamore (unknown)	5200	$39	-539	-4	-4	6498	$49	11156	$84	1.1	1.4	$4.18
Oak (unknown)	3611	$27	-742	-4	-6	5645	$42	8510	$64	1.0	1.0	$3.36
Other street trees	6778	$51	-377	-2	-3	4246	$32	10644	$80	0.7	1.3	$6.65
Xenia Citywide total	**408196**	**$3,061**	**-29482**	**-352**	**-224**	**445582**	**$3,342**	**823944**	**$6,180**	**100.0**	**100.0**	**$3.43**

Table 9. Annual Air Quality Benefits of Xenia's Public Trees by Species

Species	Deposition				Total Deposition ($)	Avoided				Total Avoided ($)	BVOC Emission (lb)	BVOC Emission ($)	Total (lb)	Total ($)	% of Total Trees	Avg. $/tree ($)
	O3 (lb)	NO2 (lb)	PM10 (lb)	SO2 (lb)		NO2 (lb)	PM10 (lb)	VOC (lb)	SO2 (lb)							
Maple (unknown)	309.0	52.7	143.7	13.7	1644	688.8	100.5	95.8	656.2	$4,297	-103	-$386	1957.4	$5,555	37.3	$8.25
Broadleaf Deciduous (unk.)	61.0	10.5	31.3	2.7	333	196.7	28.6	27.3	186.2	$1,224	-87	-$327	457.1	$1,231	23.9	$2.85
Pear (unknown)	27.5	4.7	13.8	1.2	149	101.6	14.8	14.1	96.8	$634	-10	-$37	264.6	$746	12.3	$3.38
Ash (unknown)	23.0	3.7	11.4	1.0	123	89.8	13.2	12.6	86.8	$563	0	$0	241.4	$687	8.1	$4.67
Linden, Basswood (unk)	3.6	0.6	2.3	0.2	21	36.0	5.2	5.0	34.1	$224	-4	-$15	83.1	$230	4.2	$3.07
Honeylocust	16.6	2.7	8.0	0.8	89	60.3	8.8	8.4	57.3	$376	-12	-$44	151.0	$420	4.0	$5.76
Spruce	3.9	0.8	3.8	0.5	28	18.6	2.7	2.6	17.3	$115	-13	-$49	37.1	$93	3.7	$1.42
Pine (unknown)	4.6	0.8	2.5	0.2	26	22.8	3.3	3.2	22.0	$143	-6	-$24	53.0	$145	2.3	$3.52
Ginkgo	0.5	0.1	0.2	0.0	3	2.6	0.4	0.4	2.5	$16	0	-$1	6.4	$18	1.4	$0.72
Sycamore (unknown)	5.7	1.0	2.9	0.3	31	18.1	2.7	2.5	17.6	$114	-8	-$30	42.7	$115	1.1	$5.74
Oak (unknown)	7.1	1.2	3.5	0.3	38	16.2	2.3	2.2	15.2	$100	-10	-$38	37.9	$101	1.1	$5.29
Other street trees	3.6	0.6	1.9	0.2	20	12.1	1.8	1.7	11.5	$75	-4	-$17	28.8	$78	0.7	$6.53
Xenia's Citywide total	**466.2**	**79.4**	**225.3**	**21.0**	**2505**	**12645**	**184.3**	**175.8**	**1203**	**$7,882**	**-258**	**-$968**	**3360.6**	**$9,419**	**100.0**	**$5.22**

Table 10. Annual Aesthetic or Other Benefits of Xenia's Public Trees by Species

Species	Total ($)	% of Total Number of Trees	% of Total	Avg. $/tree
Maple (unknown)	$27,521	37.3	51.6	$40.89
Broadleaf Deciduous (unk.)	$4,925	24.0	9.2	$11.40
Pear (unknown)	$5,046	12.3	9.5	$22.83
Ash (unknown)	$5,575	8.1	10.4	$37.92
Linden, Basswood (unknown)	$1,157	4.2	2.2	$15.43
Honeylocust	$5,938	4.1	11.1	$81.35
Spruce	$1,058	3.7	2.0	$16.03
Pine (unknown)	$684	2.3	1.3	$16.68
Ginkgo	$55	1.4	0.1	$2.19
Sycamore (unknown)	$426	1.1	0.8	$21.32
Oak (unknown)	$283	1.0	0.5	$14.88
Other street trees	$655	0.7	1.2	$54.60
Xenia's Citywide total	**$53,323**	**100.0**	**100.0**	**$29.56**

Table 11. Average Annual Benefits of Xenia's Public Trees by Species ($/tree)

Species	Energy	CO2	Air Quality	Storm water	Aesthetic/Other	Total/Tree
Maple (unknown)	$44.89	$4.91	$8.25	$51.08	$40.89	$150.03
Broadleaf Deciduous (unk.)	$20.21	$2.01	$2.85	$20.49	$11.40	$56.96
Pear (unknown)	$20.22	$2.32	$3.38	$17.47	$22.83	$66.22
Ash (unknown)	$26.21	$3.62	$4.67	$31.67	$37.92	$104.10
Linden/Basswood (unknown)	$21.18	$2.41	$3.07	$16.43	$15.43	$58.52
Honeylocust	$36.32	$4.90	$5.76	$35.89	$81.35	$164.21
Spruce	$12.84	$1.11	$1.42	$17.34	$16.03	$48.74
Pine (unknown)	$24.03	$2.73	$3.52	$19.09	$16.68	$66.06
Ginkgo	$4.50	$0.41	$0.72	$2.87	$2.19	$10.69
Sycamore (unknown)	$38.59	$4.18	$5.74	$39.80	$21.32	$109.63
Oak (unknown)	$37.95	$3.36	$5.29	$48.52	$14.88	$110.00
Other street trees	$44.19	$6.65	$6.53	$52.22	$54.60	$164.18