An Analysis of Environmental Benefits for Medina's Public Square Trees

By

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EXECUTIVE SUMMARY

An inventory of trees on Medina's Public Square was undertaken by Medina County Extension and its Master Gardeners. This information was then analyzed by The Ohio State University's School of Environment and Natural Resources. A total of 56 trees were inventoried. A common bid price for this service is $3.00 per tree and thus the inventory represents a savings of $168 for Medina's taxpayers over contracting for this service. Most importantly, however, is that Medina County Extension now has a tree inventory that can be used to better manage the tree resource of the public square. 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. On the square, a number of taxa exceed species, genera, and family guidelines (Table 1) but because of the relatively small number of trees on the square and the fact that surrounding trees were not inventoried, it is difficult to generate specific suggestions. One may wish to limit planting additional plants in the red oak group and maples in future plantings especially if they are common in adjacent areas. Ash plantings represent only 4 individuals or 7% of the ground's trees. Limited numbers and moderate size limit the impact of EAB for the Medina Public Square Large deciduous trees that could be used to replace the ash include the Kentucky coffeetree, honeylocust, ginkgo, deciduous conifers, sycamore, and elms which are currently available in the nursery trade. Large trees 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 on the square (Tables 2 and 3). Fortunately, public square trees that live longer and mature at larger sizes such as preferred by a resident preference survey in Toledo, OH dominate the Medina Public Square.

Trees are variable in size at present with more than 62% of the trees less than 18-inch diameter. Importance values as detailed in (Table 4) show that the 10 larger pin oaks have nearly twice the importance value (a measure of canopy cover) as 11 smaller red oaks. This demonstrates the square's need for planting larger statured trees whenever possible as the importance value is a measure of the overall contribution of the species to the sum of environmental benefits delivered.

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, OH is about to embark on a multi-billion dollar sewer and storm water upgrade for the community. Trees on the public square intercept

more than 133 hundred cu. ft (nearly 100,000 gallons) of storm water annually at a savings to Medina, OH of 2,700 dollars per year despite the relatively small size of the property.

Carbon sequestration, as reported here, represents the carbon removed from the air and stored in the square's trees (Table 6). More than 335,667 pounds or 168 tons of carbon have been stored by the 56 trees over time. The ground's trees currently sequester and avoid nearly 45,624 lbs of CO_2 yearly (Table 8) and would represent carbon credits worth $342 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 $6.11 per tree per year while larger pin oaks average $12.53 per tree per year.

Annual air quality savings (reduced ozone, nitrous and sulfur oxides as well as particulate matter) for the public square trees is $380 (Table 9). This includes both direct savings ($87) from the trees and avoided pollution which is much greater at ($361). 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 $68 for the volatile emissions from the trees themselves.

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 to 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 7). Medina's Public Square saves $926 in electricity and $1,597 in natural gas for a total savings in excess of $2,523 or an average of $45.04 per tree per year.

Aesthetic and miscellaneous benefits from trees contribute $2,790 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 commercial settings with trees.

When all benefits are included the 56 public square trees contribute and average of $156 per tree annually to the community (Table 12). Species vary in their annual benefits but mature size, longevity, and maintenance costs are but some of the factors determining annual benefits. Thus the square's 56 trees contribute $8,735 per year. This would be well in excess of their maintenance and planting costs.

The City of Medina budget for maintenance of city trees was estimated by city officials at $60,000 for 12,000 trees or $5 per tree per year. Thus the 56 trees on the square require some 300 dollars of care per year yet deliver $8,735 in annual benefits from storm water abatement, CO2 avoidance and storage, energy savings, air quality, aesthetic benefits, and the like. This is an astounding 2900% 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.

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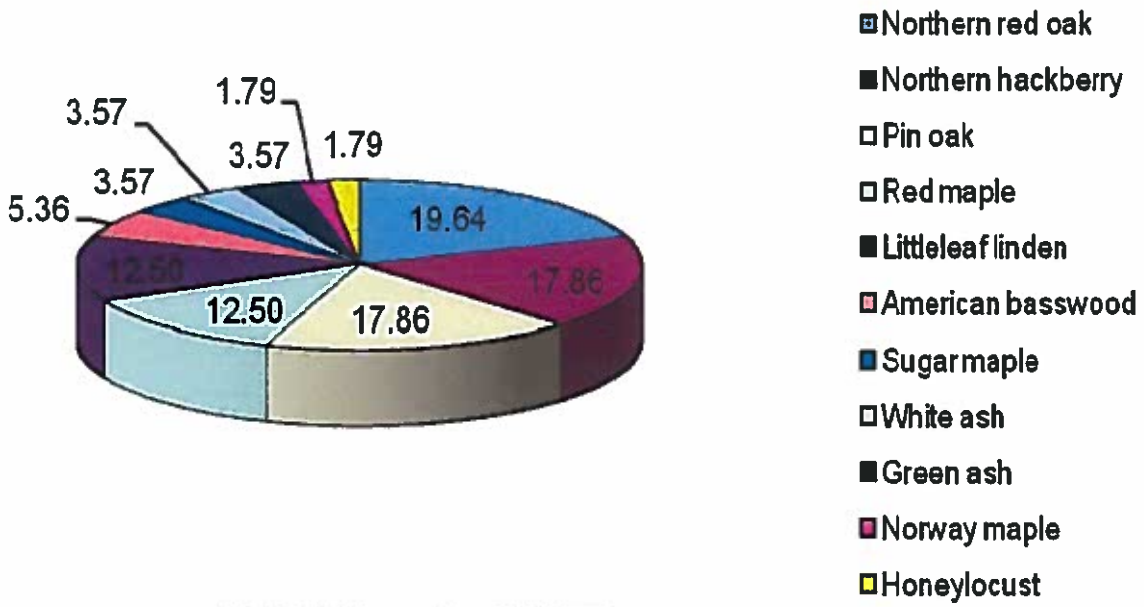
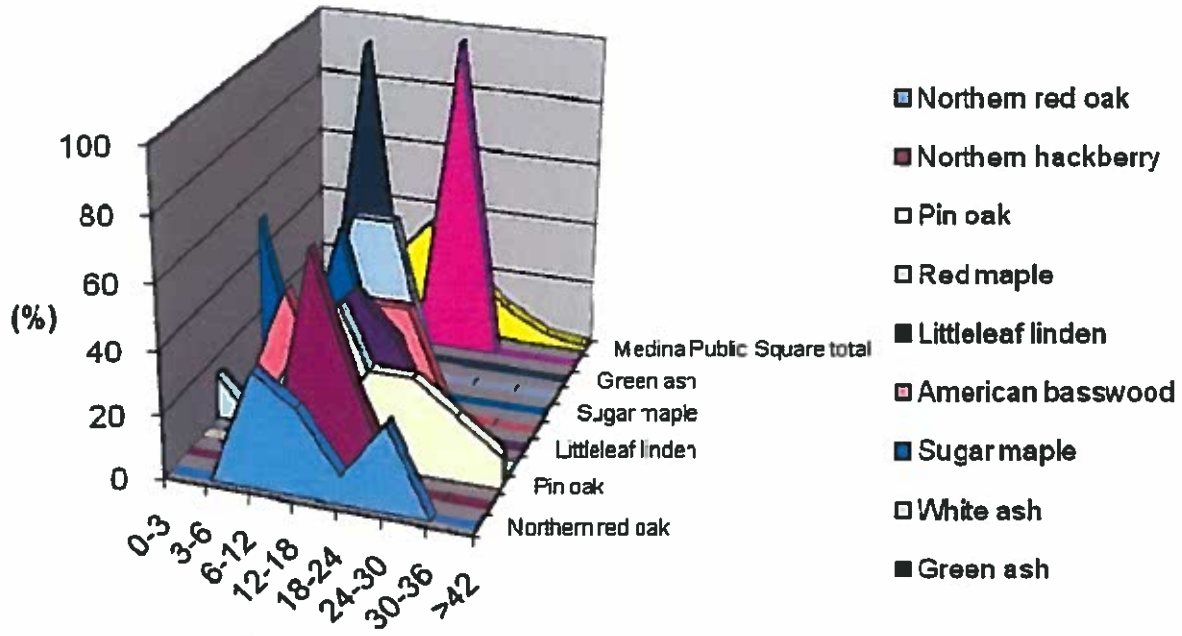
Table 1. Species Distribution of the Medina Public Square's Trees



Species	Percent
Northern red oak	19.64
Northern hackberry	17.86
Pin oak	17.86
Red maple	12.50
Littleleaf linden	12.50
American basswood	5.36
Sugar maple	3.57
White ash	3.57
Green ash	3.57
Norway maple	1.79
Honeylocust	1.79
Total	100.00

Table 2. Relative Age Distribution of the Top 9 Most Commonly Planted Tree Taxa on the Medina Public Square (%)



Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	>42
Northern red oak	0.00	0.00	36.36	27.27	9.09	27.27	0.00	0.00
Northern hackberry	0.00	0.00	0.00	70.00	30.00	0.00	0.00	0.00
Pin oak	0.00	0.00	0.00	10.00	30.00	30.00	20.00	10.00
Red maple	14.29	0.00	28.57	42.86	14.29	0.00	0.00	0.00
Littleleaf linden	0.00	0.00	28.57	42.86	28.57	0.00	0.00	0.00
American basswood	0.00	33.33	0.00	33.33	33.33	0.00	0.00	0.00
Sugar maple	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
White ash	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00
Green ash	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Norway maple	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Medina Public Square total	**3.57**	**1.79**	**21.43**	**35.71**	**21.43**	**10.71**	**3.57**	**1.79**

Table 3. Population of Medina Square's Trees by Scientific Name and Size Class.

Species	DBH Class (in)								
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	>42	Total
Broadleaf Deciduous Large (BDL)									
Quercus rubra	0	0	4	3	1	3	0	0	11
Celtis occidentalis	0	0	0	7	3	0	0	0	10
Quercus palustris	0	0	0	1	3	3	2	1	10
Acer rubrum	1	0	2	3	1	0	0	0	7
Tilia americana	0	1	0	1	1	0	0	0	3
Acer saccharum	1	0	1	0	0	0	0	0	2
Fraxinus americana	0	0	1	1	0	0	0	0	2
Fraxinus pennsylvanica	0	0	2	0	0	0	0	0	2
Subtotal	**2**	**1**	**10**	**16**	**9**	**6**	**2**	**1**	**47**
Broadleaf Deciduous Medium (BDM)									
Tilia cordata	0	0	2	3	2	0	0	0	7
Acer platanoides	0	0	0	0	1	0	0	0	1
Gleditsia triacanthos	0	0	0	1	0	0	0	0	1
Subtotal	**0**	**0**	**2**	**4**	**3**	**0**	**0**	**0**	**9**
Medina Square Totals	**2**	**1**	**12**	**20**	**12**	**6**	**2**	**1**	**56**

Table 4. Importance Values for the Medina Public Square's Most Abundant Trees

Species	Number of Trees	% of Total Trees	Leaf Area (ft2)	% of Total Leaf Area	Canopy Cover (ft2)	% of Total Canopy Cover	Importance Value
Northern red oak	11	19.6	25,553	16.3	8,438	15.8	17.3
Northern hackberry	10	17.9	23,307	14.9	11,329	21.2	18.0
Pin oak	10	17.9	63,977	40.9	17,381	32.5	30.4
Red maple	7	12.5	12,989	8.3	5,242	9.8	10.2
Littleleaf linden	7	12.5	14,146	9.0	4,473	8.4	10.0
American basswood	3	5.4	5,095	3.3	1,875	3.5	4.0
Sugar maple	2	3.6	625	0.4	434	0.8	1.6
White ash	2	3.6	3,207	2.1	1,270	2.4	2.7
Green ash	2	3.6	1,527	1.0	762	1.4	2.0
Norway maple	1	1.8	3,661	2.3	1,213	2.3	2.1
Honeylocust	1	1.8	2,229	1.4	1,099	2.1	1.8
Total	**56**	**100.0**	**156,316**	**100.0**	**53,516**	**100.0**	**100.0**

Table 5. Annual Storm Water Benefits of Medina Square's Trees by Species

Species	Total Rainfall Interception (CCF)	Total	% of Total Tree Numbers	% of Total Dollars	Avg. $/tree
Northern red oak	22.49	$455.94	19.64	6.89	$41.45
Northern hackberry	23.10	$468.30	17.86	17.34	$46.83
Pin oak	47.64	$965.78	17.86	35.77	$96.58
Red maple	11.95	$242.30	12.50	8.97	$34.61
Littleleaf linden	12.61	$255.63	12.50	9.47	$36.52
American basswood	4.60	$93.21	5.36	3.45	$31.07
Sugar maple	0.74	$15.10	3.57	0.56	$7.55
White ash	3.04	$61.68	3.57	2.28	$30.84
Green ash	1.63	$32.95	3.57	1.22	$16.47
Norway maple	3.31	$67.19	1.79	2.49	$67.19
Honeylocust	2.08	$42.19	1.79	1.56	$42.19
Medina Square total	**133.20**	**$2,700.26**	**100.00**	**100.00**	**$48.22**

Table 6. Stored CO2 Benefits of Medina Square's Trees by Species

Species	Total stored CO2 (lbs)	Total ($)	% Total Tree Numbers	% of Total $	Avg. $/tree
Northern red oak	68818	$516.14	19.64	20.50	46.92
Northern hackberry	24183	$181.37	17.86	7.20	18.14
Pin oak	161485	$1,211.14	17.86	48.11	121.11
Red maple	21036	$157.77	12.50	6.27	22.54
Littleleaf linden	29270	$219.53	12.50	8.72	31.36
American basswood	12000	$90.00	5.36	3.57	30.00
Sugar maple	1118	$8.38	3.57	0.33	4.19
White ash	4706	$35.30	3.57	1.40	17.65
Green ash	2069	$15.52	3.57	0.62	7.76
Norway maple	7945	$59.59	1.79	2.37	59.59
Honeylocust	3037	$22.78	1.79	0.90	22.78
Citywide total	**335667**	**$2,517.50**	**100.00**	**100.00**	**44.96**

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

Species	Total Electricity (MWh)	Electricity	Total Natural Gas (MBtu)	Natural Gas	Total	% of Total Tree Numbers	% of Total Dollars	Avg. $/tree
Northern red oak	1.96	$148.46	26.64	$261.10	$409.56	19.64	16.24	$37.23
Northern hackberry	2.78	$211.30	36.88	$361.42	$572.71	17.86	22.70	$57.27
Pin oak	3.28	$248.93	44.15	$432.64	$681.57	17.86	27.02	$68.16
Red maple	1.28	$97.17	16.38	$160.54	$257.71	12.50	10.22	$36.82
Littleleaf linden	1.21	$92.20	16.44	$161.09	$253.30	12.50	10.04	$36.19
American basswood	0.49	$36.85	6.70	$65.64	$102.49	5.36	4.06	$34.16
Sugar maple	0.11	$8.01	1.55	$15.21	$23.22	3.57	0.92	$11.61
White ash	0.36	$27.35	4.17	$40.87	$68.22	3.57	2.70	$34.11
Green ash	0.19	$14.37	2.75	$26.91	$41.27	3.57	1.64	$20.64
Norway maple	0.26	$19.91	3.96	$38.78	$58.69	1.79	2.33	$58.69
Honeylocust	0.28	$21.08	3.34	$32.69	$53.77	1.79	2.13	$53.77
Medina Square total	**12.20**	**$925.62**	**162.95**	**$1,596.89**	**$2,522.51**	**100.00**	**100.00**	**$45.04**

Table 8. Annual Carbon Dioxide Benefits of Medina Square's Trees by Species

Species	Sequestered (lb)	Sequestered ($)	Decomp. Release(lb)	Maintenance Release (lb)	Total Release ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	% of Total Tree Numbers	% of Total Dollars	Avg. $/tree
Northern red oak	2,924.92	$21.94	- 330.33	- 2.15	-$2.49	3,280.99	$24.61	5,873.44	$44.05	19.64	12.87	$4.00
Northern hackberry	2,460.00	$18.45	- 116.08	- 1.95	-$0.89	4,669.59	$35.02	7,011.57	$52.59	17.86	15.37	$5.26
Pin oak	11,978.65	$89.84	- 775.13	- 1.95	-$5.83	5,501.36	$41.26	16,702.93	$125.27	17.86	36.61	$12.53
Red maple	2,706.29	$20.30	- 100.97	- 1.37	-$0.77	2,147.43	$16.11	4,751.39	$35.64	12.50	10.41	$5.09
Littleleaf linden	3,567.88	$26.76	- 140.50	- 1.37	-$1.06	2,037.68	$15.28	5,463.70	$40.98	12.50	11.98	$5.85
American basswood	946.87	$7.10	- 57.60	- 0.59	-$0.44	814.33	$6.11	1,703.02	$12.77	5.36	3.73	$4.26
Sugar maple	168.30	$1.26	- 5.36	- 0.39	-$0.04	176.99	$1.33	339.54	$2.55	3.57	0.74	$1.27
White ash	675.74	$5.07	- 22.59	- 0.39	-$0.17	604.33	$4.53	1,257.09	$9.43	3.57	2.76	$4.71
Green ash	417.59	$3.13	- 9.93	- 0.39	-$0.08	317.50	$2.38	724.77	$5.44	3.57	1.59	$2.72
Norway maple	469.91	$3.52	- 38.14	- 0.20	-$0.29	440.02	$3.30	871.60	$6.54	1.79	1.91	$6.54
Honeylocust	474.26	$3.56	- 14.58	- 0.20	-$0.11	465.82	$3.49	925.30	$6.94	1.79	2.03	$6.94
Medina Square total	**26,790.42**	**$200.93**	**- 1,611.20**	**- 10.92**	**-$12.17**	**20,466.05**	**$153.42**	**45,624.35**	**$342.18**	**100.00**	**100.00**	**$6.11**

Table 9. Annual Air Quality Benefits of Medina Public Square Trees by Species

Species	Deposit O3 (lb)	Deposit NO2 (lb)	Deposit PM10 (lb)	Deposit SO2 (lb)	Total Deposit ($)	Avoid NO2 (lb)	Avoid PM10 (lb)	Avoid VOC (lb)	Avoid SO2 (lb)	Total Avoid ($)	BVOC Emission (lb)	BVOC Emission ($)	Net Total (lb)	Total ($)	% Total Tree Num.	Avg. $/tree
Northern red oak	3.34	0.58	1.66	0.15	$18.10	9.31	1.36	1.29	8.86	$58.07	- 4.75	- 17.80	21.80	$58.37	19.64	$5.31
Northern hackberry	1.87	0.32	1.11	0.08	$10.66	13.20	1.93	1.84	12.63	$82.51	0.00	0.00	33.00	$93.16	17.86	$9.32
Pin oak	6.18	1.08	3.18	0.28	$33.88	15.58	2.27	2.17	14.85	$97.21	- 11.53	- 43.24	34.07	$87.85	17.86	$8.78
Red maple	1.87	0.32	0.90	0.08	$10.05	6.01	0.88	0.84	5.80	$37.67	- 0.67	- 2.51	16.04	$45.21	12.50	$6.46
Littleleaf linden	1.33	0.23	0.70	0.06	$7.29	5.79	0.84	0.81	5.51	$36.13	- 0.69	- 2.60	14.58	$40.83	12.50	$5.83
American basswood	0.33	0.06	0.19	0.01	$1.87	2.33	0.34	0.32	2.20	$14.49	- 0.33	- 1.23	5.46	$15.12	5.36	$5.04
Sugar maple	0.03	0.01	0.03	0.00	$0.20	0.51	0.07	0.07	0.48	$3.17	- 0.03	- 0.13	1.16	$3.24	3.57	$1.62
White ash	0.13	0.02	0.09	0.01	$0.77	1.65	0.25	0.24	1.63	$10.46	0.00	0.00	4.01	$11.22	3.57	$5.61
Green ash	0.05	0.01	0.04	0.00	$0.31	0.92	0.13	0.13	0.86	$5.67	0.00	0.00	2.13	$5.99	3.57	$2.99
Norway maple	0.49	0.08	0.24	0.02	$2.66	1.29	0.18	0.18	1.19	$7.94	- 0.12	- 0.43	3.56	$10.16	1.79	$10.16
Honeylocust	0.25	0.04	0.13	0.01	$1.37	1.28	0.19	0.18	1.26	$8.10	- 0.15	- 0.57	3.20	$8.90	1.79	$8.90
Medina Square Totals	**15.87**	**2.75**	**8.28**	**0.71**	**$87.16**	**57.87**	**8.45**	**8.07**	**55.28**	**$361.42**	**- 18.27**	**- 68.53**	**139.00**	**$380.05**	**100.00**	**$6.79**

Table 10. Annual Aesthetic or Other Benefits of Medina Square Trees by Species

Species	Total ($)	% of Total Tree Numbers	% of Total $	Avg. $/tree
Northern red oak	$236.22	19.64	8.47	$21.47
Northern hackberry	$433.80	17.86	15.55	$43.38
Pin oak	$960.04	17.86	34.42	$96.00
Red maple	$366.45	12.50	13.14	$52.35
Littleleaf linden	$390.64	12.50	14.00	$55.81
American basswood	$80.55	5.36	2.89	$26.85
Sugar maple	$21.80	3.57	0.78	$10.90
White ash	$97.16	3.57	3.48	$48.58
Green ash	$57.11	3.57	2.05	$28.56
Norway maple	$43.05	1.79	1.54	$43.05
Honeylocust	$102.70	1.79	3.68	$102.70
Medina Square Total	**$2,789.53**	**100.00**	**100.00**	**$49.81**

Table 11. Average Annual Benefits of Medina Public Square Trees by Species.

Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	% of Total Dollars
Northern red oak	$409.56	$44.05	$58.37	$455.94	$236.22	$1,204.14	13.79
Northern hackberry	$572.71	$52.59	$93.16	$468.30	$433.80	$1,620.56	18.55
Pin oak	$681.57	$125.27	$87.85	$965.78	$960.04	$2,820.51	32.29
Red maple	$257.71	$35.64	$45.21	$242.30	$366.45	$947.31	10.85
Littleleaf linden	$253.30	$40.98	$40.83	$255.63	$390.64	$981.37	11.24
American basswood	$102.49	$12.77	$15.12	$93.21	$80.55	$304.14	3.48
Sugar maple	$23.22	$2.55	$3.24	$15.10	$21.80	$65.91	0.75
White ash	$68.22	$9.43	$11.22	$61.68	$97.16	$247.72	2.84
Green ash	$41.27	$5.44	$5.99	$32.95	$57.11	$142.76	1.63
Norway maple	$58.69	$6.54	$10.16	$67.19	$43.05	$185.62	2.13
Honeylocust	$53.77	$6.94	$8.90	$42.19	$102.70	$214.51	2.46
Medina Square Total	**$2,522.51**	**$342.18**	**$380.05**	**$2,700.26**	**$2,789.53**	**$8,734.53**	**100.00**

Table 12 Percentage Environmental Benefits for Trees in Medina's Public Square from Five Benefit Categories

Benefits	Total ($)	$/tree
Energy	$2,523	45.05
CO2	$342	6.11
Air Quality	$380	6.79
Storm Water	$2,700	48.21
Aesthetic/Other	$2,790	49.82
Total Benefits	**$8,735**	**155.98**