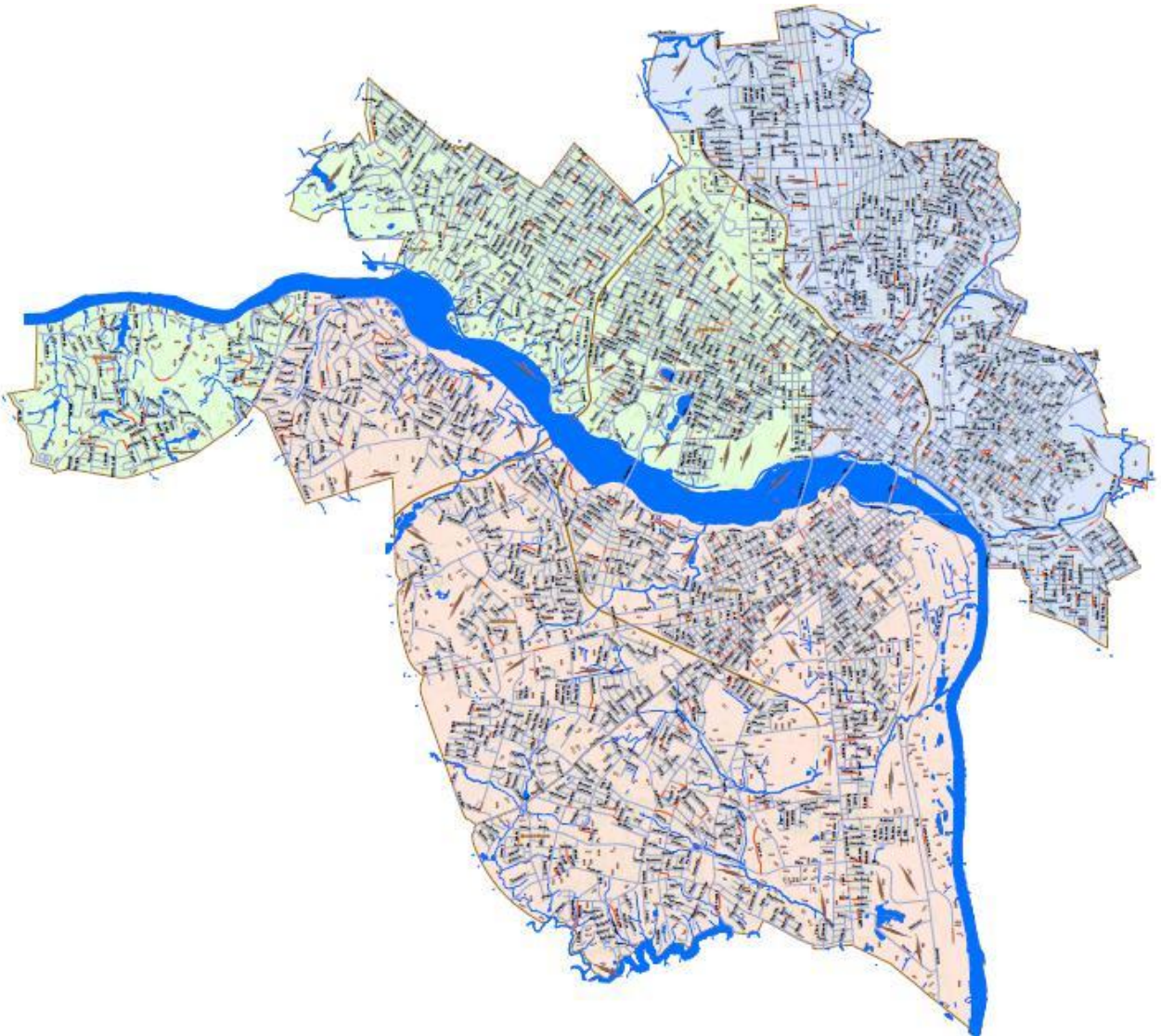


STRATUM Sample Survey of Street Trees
For City of Richmond, Urban Forestry Division



Submitted by:

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STRATUM Introduction

STRATUM (Street Tree Resource Analysis Tool for Urban-Forest Managers) is an easy-to-use, computer-based tool that will enable the City of Richmond to assess its street tree resource. This assessment will assist the Urban Forestry Division to foster support for their program, secure funding, and provide baseline data to improve management of the Urban Forestry Division. STRATUM calculated the following aspects of the street tree resource:

- Structure (e.g., species composition, age distribution, canopy cover)
- Function (environmental and aesthetic benefits)
- Value (annual monetary value of benefits and costs)
- Management Needs (e.g., recommended maintenance, stocking levels, tree conflicts)

Reports were produced for the entire city, for management zones (Council Districts), and by tree type and species when applicable. STRATUM used the regional tree growth models and regional default costs and benefits.

A sample inventory of 4% of the City's street segments was completed to obtain and analyze the data in this report. STRATUM analysis shall provide the City of Richmond with quantifiable justification for the Urban Forestry Division's tree program. The UFD may want to use this data to preserve existing trees or increase its budget.

The STRATUM report confirms the most important question related to UFD tree program: *The accrued benefits of the City of Richmond street trees definitely outweigh their management costs.*

STRATUM quantifies the following benefits in this report:

- Energy conservation
- Air quality improvement
- Carbon dioxide reduction
- Stormwater runoff reduction
- Property value increase

In addition, STRATUM will help the City of Richmond Urban Forestry Division:

- Improve the return on your investment dollar by determining which tree species maximize canopy cover and provide the benefits that are important to your community.
- Determine the management needs of your urban forest to maintain and improve the trees' health.
- Leverage investment from partners for such things as carbon credits or energy conservation.
- Gain public support by demonstrating the value of trees to the quality of life in your community.
- Perform economic evaluations of tree performance using annual budget and expenditure data.
- Assess costs of management - rather than benefits alone - to provide a platform for strategic planning.

Designed to be flexible and adaptive, STRATUM is not GIS-based and requires only basic inventory data; however a GIS shape file was included for the Urban Forestry Division to import into ARC-GIS.

State-of-the-art research provides the scientific foundation for STRATUM’s economic reports. Data on the benefits and costs of maintaining street trees come from extensive field research and laboratory modeling for each of 16 national climate regions. STRATUM can be used to assist you in developing policy, setting priorities, and making decisions about your urban forest.

City Defined

The following data was used to define the City of Richmond for STRATUM analysis. Manipulation of these numbers would make changes in the STRATUM output reports and could therefore be used as a management tool for the Urban Forestry Division.

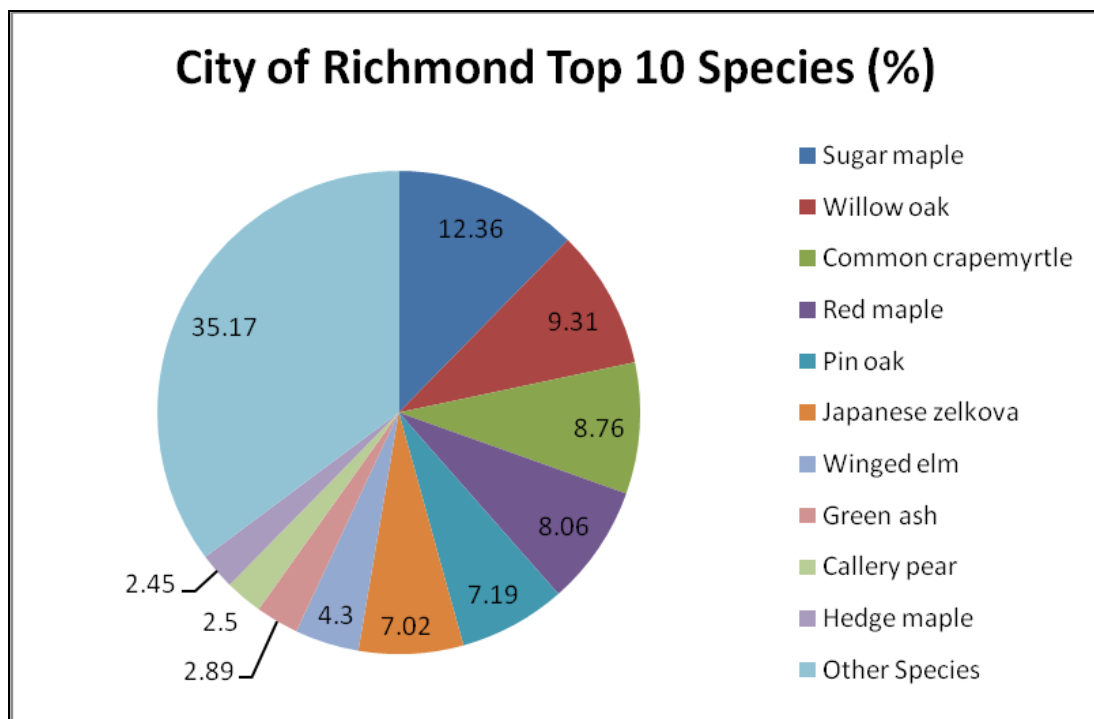
Define City	Amount
Total Municipal Budget (\$)	\$ 650,000,000.00
Population	200,000
Total Land Area (sq mi)	62
Average Street Width (ft)	50
Average Sidewalk Width (ft)	6
Total Linear Miles of Street (mile)	1858

Defined Urban Forestry Costs	Amount
Annual Planting	\$ 250,000.00
Annual Pruning	\$ 593,700.00
Annual Tree and Stump Removal and Disposal	\$ 890,550.00
Annual Pest and Disease Control (\$)	\$ -
Annual Establishment/Irrigation (\$)	\$ -
Annual Price of Repair/mitigation of Infrastructure Damage (\$)	\$ 560,000.00
Annual Price of Litter/Storm Clean-up (\$)	\$ 494,750.00
Average annual Litigation and Settlement due to Tree-Related Claims (\$)	\$ 20,000.00
Annual Expenditure for Program Administration (\$)	\$ 200,000.00
Annual Expenditure for Inspection/Answer Service Requests (\$)	\$ 210,000.00

Findings

- Estimated number of street tree sites was approximately 84,000.
- There were a total number of 80 different species inventoried.
- 10 species counted for approximately 65% of the trees inventoried and 70 species accounted for only 35% of the street tree population.
- Total Citywide Tree Inventory replacement value: \$211,514,285.51.
- Seven species of trees represent 57% of the street trees in the City of Richmond
- 88% of the foliage in all trees inventoried was either in good or fair condition
- 75% of the woody portion of the trees inventoried was either in good or fair condition

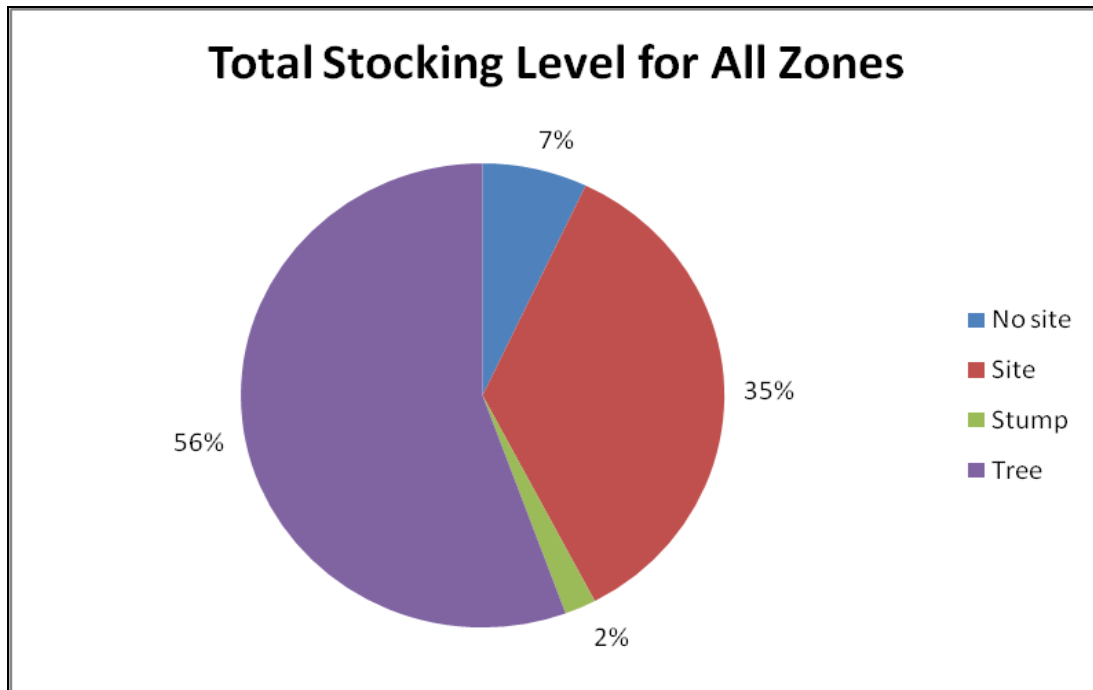
Species Distribution:



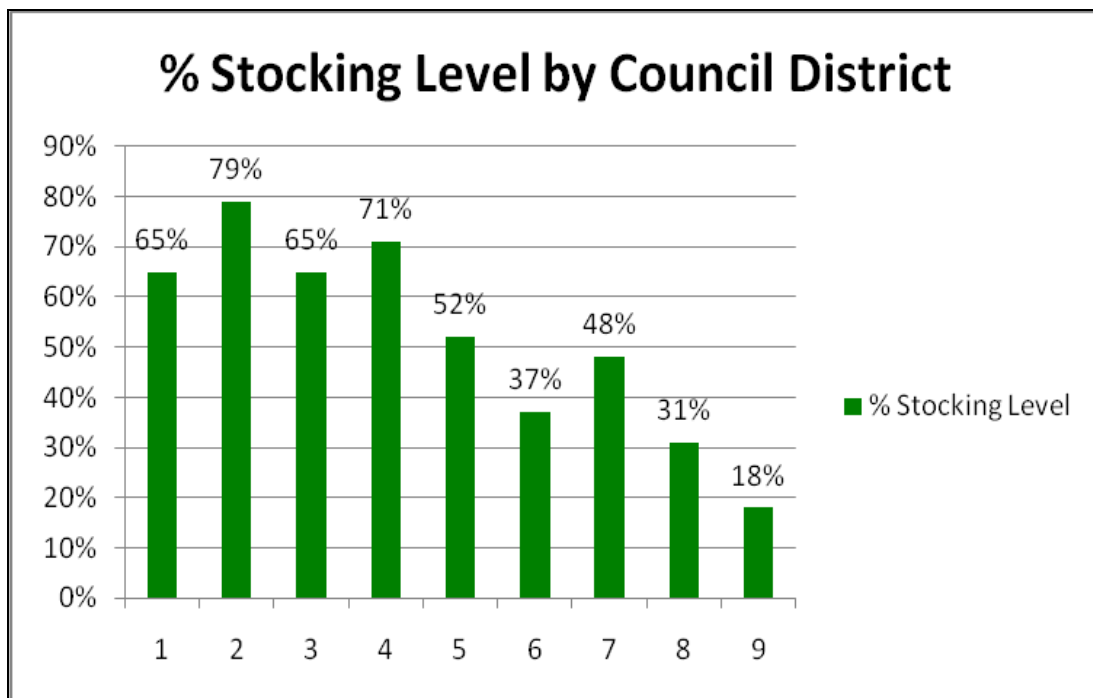
The above Chart was adapted from Appendix 2 which shows the species distribution for the top 10 species inventoried during the Stratum Analysis. It also shows that the seven species of trees represent 57% of the street trees in the City of Richmond. The seven species are represented by only four tree families (Aceraceae – maples, Fagaceae – oaks, Lythraceae – crapemyrtles, and Ulmaceae – elms) and only five genera (*Acer*, *Quercus*, *Lagerstroemia*, *Zelkova*, and *Ulmus*). This type of information will be beneficial for Urban Forestry Managers for species recommendations for future planting projects and to help determine the economic or resource impact of a plant pest or disease that has a specific family or genus host.

For Example: In the United States the Asian Longhorned beetle (ALB) prefers maple species (*Acer* spp.), including boxelder, Norway, red, silver, and sugar maples. Currently, the only effective means to eliminate ALB is to remove infested trees and destroy them by chipping or burning. (Appendix 47). This could be a very big problem for the City's Urban Forest since maple species account for 14.5% of the tree inventory for the entire city, and about 28% for Zone 2, and 24% for Zone 3.

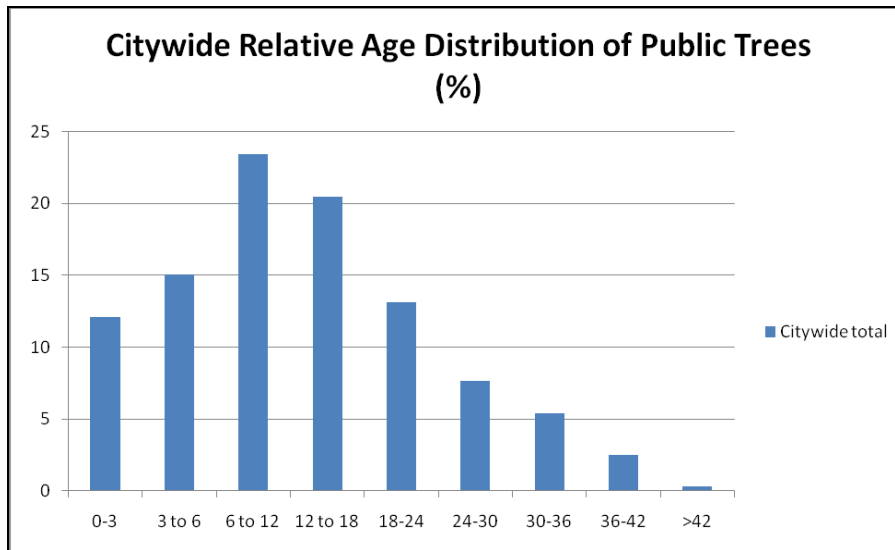
Planting Locations:



Stocking level for all zones is 56%; however, it is greater in areas of the City that have been designed for street trees. For example, Council District 1 has a stocking level of 65%, Council District 2 has a stocking level of 79%, Council District 3 has a stocking level of 65%, and Council District 4 has a stocking level of 71% (see chart 2 below). In contrast, it appears that Council District 9 has a low stocking level of only 18%, but this area of the City is mostly road right-of-ways and does not have the design or locations for street trees.

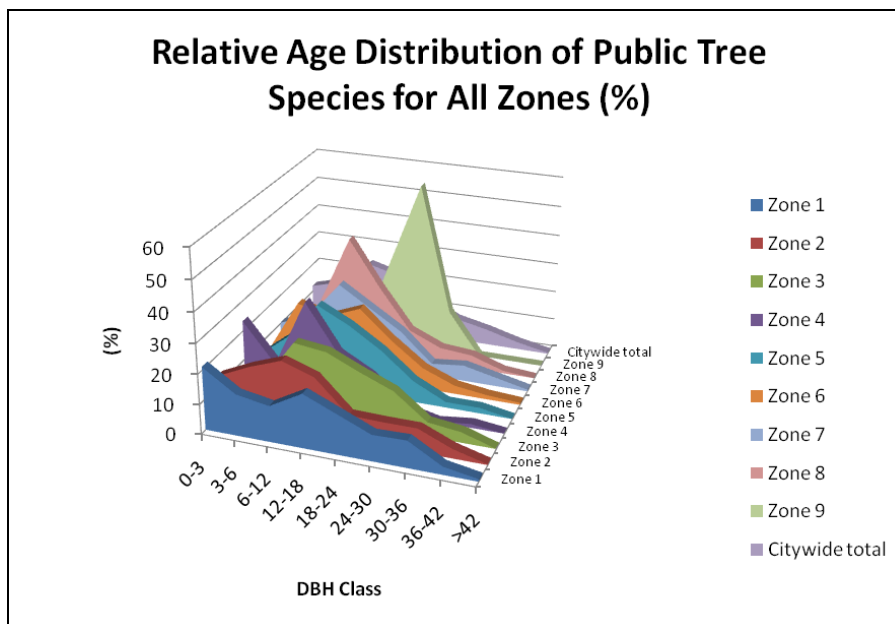


Age Structure:



50% of the existing City Street Trees are 12 inches in diameter or less and 70% are 18 inches or less. It appears in the graph below that inventory shows few small diameter trees, which should indicate that the Urban Forestry Division's Management may concentrate on planting new trees until size classes even off.

The Inventory also shows that there are few larger diameter trees. This may mean the City should plant more trees that mature at larger sizes and the Urban Forestry Division's Management Plan may concentrate on planting trees from larger maturing tree species. There is another possibility that there are current practices with repairs of sidewalks and utilities that may be causing our mature tree numbers to decline.



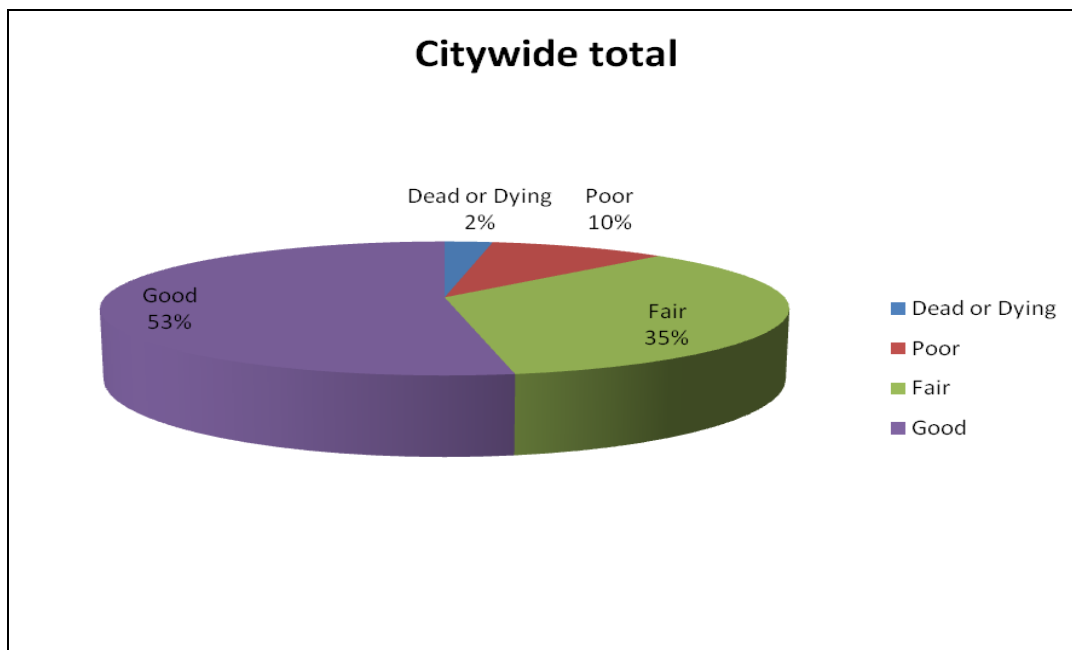
Condition Assessment:

In this inventory Good trees were defined as healthy, vigorous, without signs of insect, disease, or mechanical injury, and they require little or no corrective work. Fair trees are in average condition and vigor for the area, and may be in need of some minor corrective pruning or repair. They may show minor insect injury, disease, or other problems.

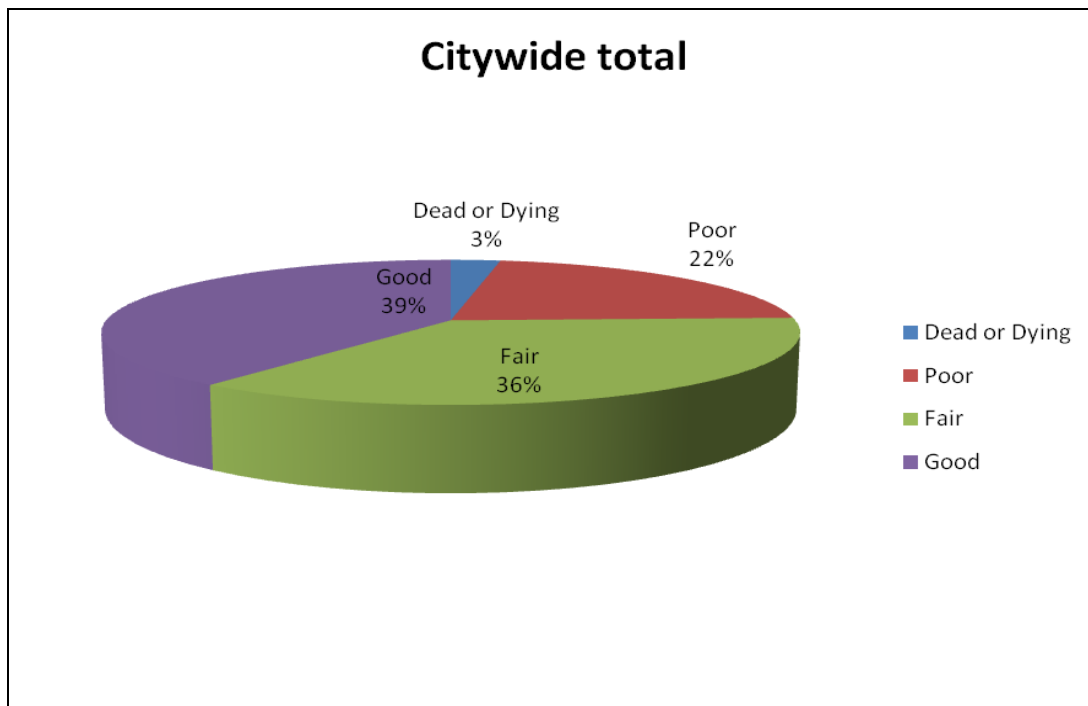
Poor trees were defined as trees that are in a general state of decline. They may have show severe mechanical, insect, or disease damage, but are not dead. Many tall growing species of tree that have been severely pruned over the years under utility lines were categorized as Poor due to the trees poor form and decay in the stems at old pruning cuts. Dead trees exhibited no signs of life.

Below you will find that 88% of the foliage in all trees inventoried was either in good condition or fair condition. Additionally you will find that 75% of the woody portion of the trees inventoried was either in good condition or fair condition.

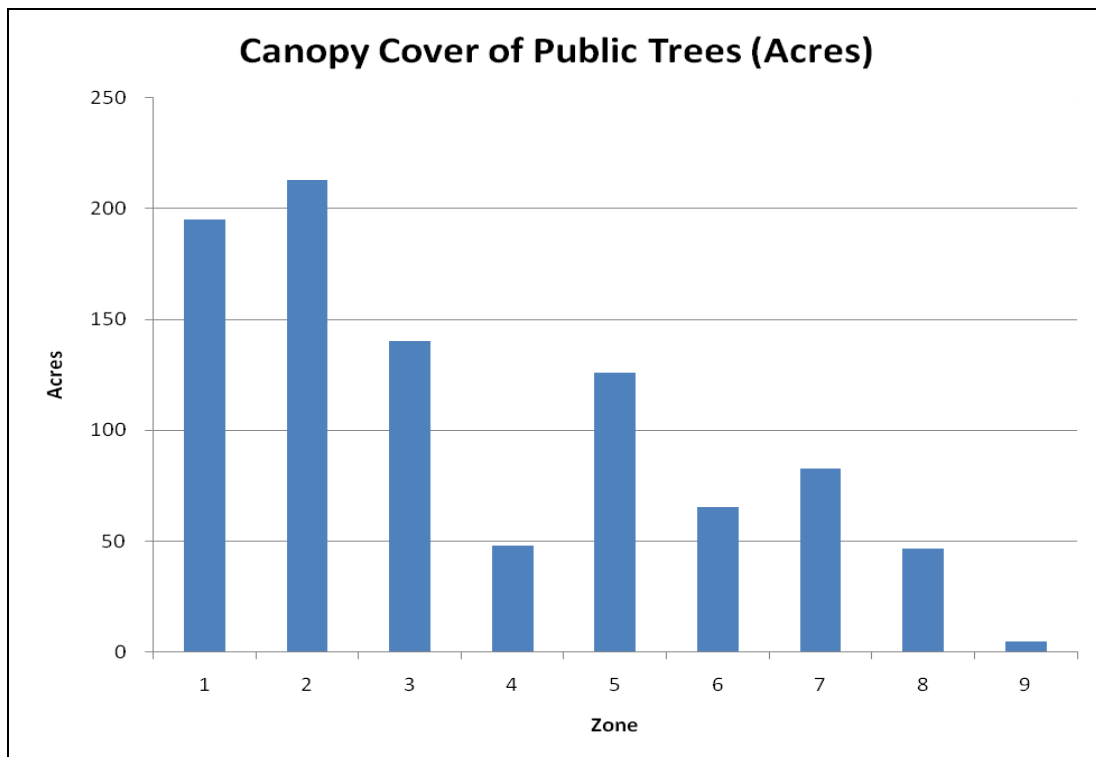
Total Citywide Condition (Foliage) of Public Trees (%)



Total Condition (Woody) of Public Trees (%)



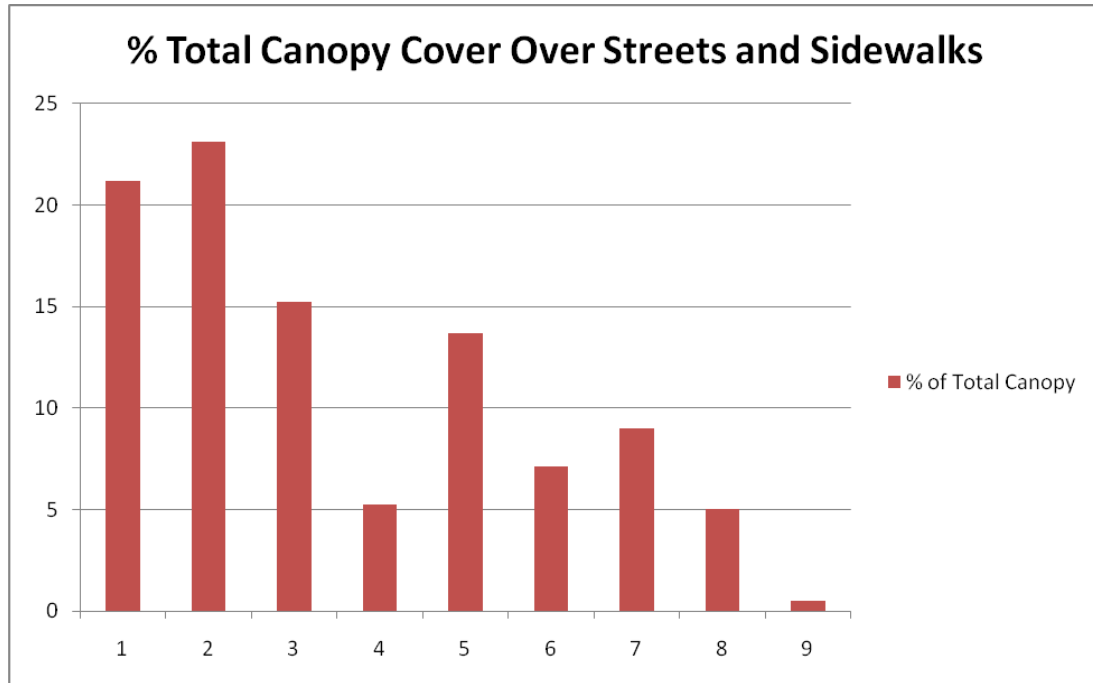
Canopy Cover:



Tree canopy cover, or more precisely, the amount and distribution of leaf area, is the driving force behind the urban forest's ability to produce benefits for the community. The following canopy cover percentages and total acres are for Street Trees only and do not account for trees on private property or

Parks. These Canopy Cover numbers were produced by STRATUM and are based on models and assumptions that are related to species and Diameter at Breast Height (DBH).

As canopy cover increases, so do the benefits afforded by leaf area: climate control and energy savings; improvement of air, soil, and water quality; mitigation of stormwater runoff; reduction of the greenhouse gas carbon dioxide; provision of wildlife habitat; and increased real estate value and community vitality.



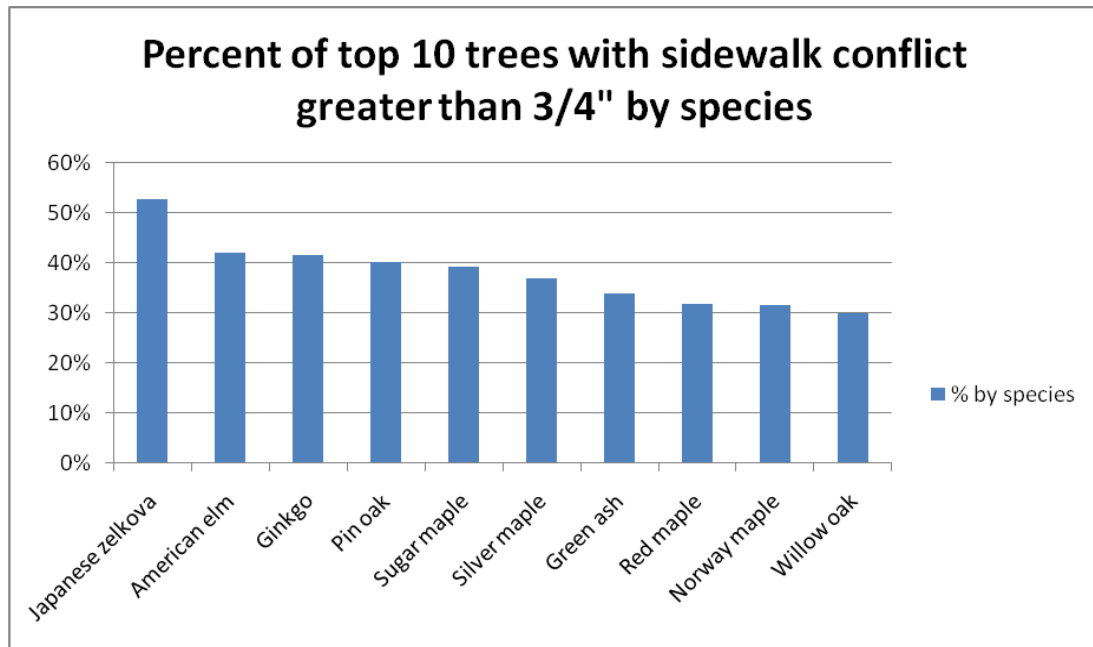
Management Costs:

Below assumptions were made from inventory numbers to help determine potential costs to maintain and/or plant trees. No assumptions were made on the repair or maintenance of sidewalk heaving that was observed during this inventory.

Description	Total Count	Estimated Cost/Item	Potential Cost
None	33,475	\$ -	\$ -
Plant	19,600	\$ 165.00	\$ 3,234,000.00
Young Prune	9,500	\$ 75.00	\$ 712,500.00
Mature Prune	14,250	\$ 480.00	\$ 6,840,000.00
Mature Prune (Priority)	125	\$ 480.00	\$ 60,000.00
Critical Concern		\$ -	\$ -
Scheduled Removal	1,125	\$ 1,200.00	\$ 1,350,000.00
Hazard Removal	125	\$ 1,200.00	\$ 150,000.00
Hazard Evaluation	1,950	\$ 50.00	\$ 97,500.00
Stump Grinding	1,650	\$ 270.00	\$ 445,500.00
Total Potential Cost			\$ 12,889,500.00

Since the Urban Forest is dynamic system impacts from weather conditions, pest problems or abiotic stresses can influence and determine the condition of the Forest. A complete inventory could create a clearer picture and create actual work orders to help address the tree related issues in the Urban Forest.

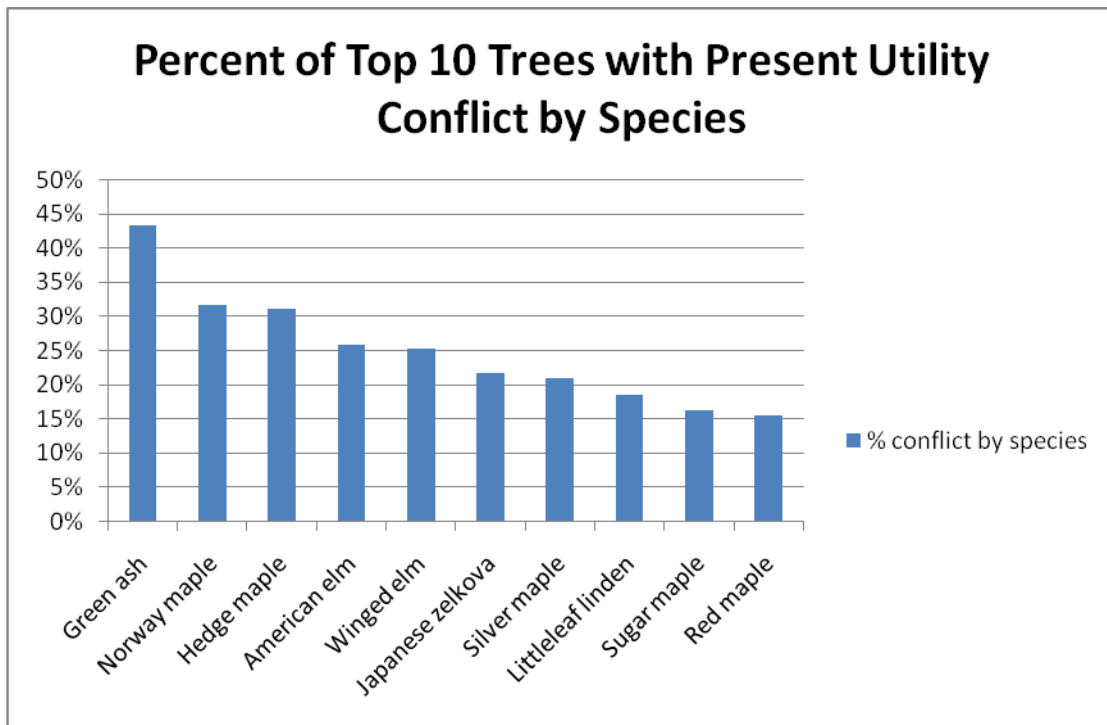
Sidewalk and Utility Conflicts:



Sidewalk issues and trees is a common problem with many municipalities. If managed properly it would appear that the overall tree conditions would improve, mature trees would live longer and improve the relative age distribution throughout the City, increase canopy cover and associated benefits, and most importantly reduce removal, stump grinding and tree planting costs.

The chart above listed the top ten trees in order of having the most problems with sidewalks. This could be related to just mature not having enough room to grow in the locations they have been planted or it could be associated by the species of tree and there root growing characteristics. It appears from this data and my observations that Japanese Zelkova has an aggressive root system that cause many sidewalk problems.

Approximately 25% of all trees inventoried had a sidewalk heave greater than $\frac{3}{4}$ of an inch.



Utility issues and trees are difficult to deal with. Sometimes there could be as many of five contractors touching the same tree; Dominion Virginia Power cutting back from power lines, Department of Public Utilities cutting back from street lights and street light wires, Cable Contractors, Phone Contractors, and lastly Urban Forestry Division; all with different requirements and goals.

Most of the time there are two main entities working on the street trees, they are Dominion Virginia Power and the Urban Forestry Division. If Dominion could also remove dead, dying and diseased limbs and elevate over sidewalks, elevate over roads, and cut back from buildings while working on the trees, it could save the City from having to perform these tasks.

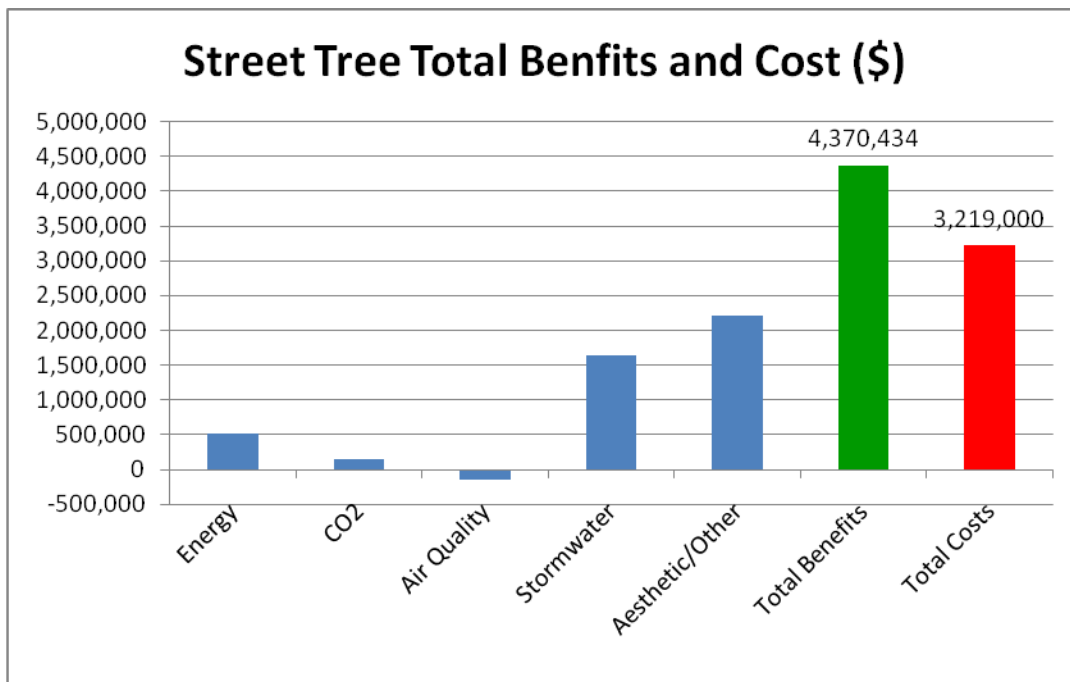
Utilities conflicts or potential conflicts were found on 28% of all trees inventoried; however, 72% had either no lines present (59%) above tree or no conflict with the wires (13%). This indicates that for 13% of the trees inventoried the right tree for that location was planted.

Tree Inventory Value:

Total Citywide Tree Inventory value: \$211,514,285.51. This is an estimate of the full costs of replacing the current street trees in their current condition, should they be removed for some reason. STRATUM follows the method in the Council of Tree and Landscape Appraisers Guide, 9th edition

Total Annual Benefits, Net Benefits, and Costs for Public Trees

Total Energy, CO₂, Air Quality, Stormwater, and Aesthetic benefits were calculated in STRATUM and are found in Appendix 34 through 45.



Benefit–Cost Ratio (BCR) for the City of Richmond Street Trees was 1.3576993. In STRATUM, the BCR represents the return on investment for the care of trees. For example, since the the BCR = 1.3576993, then the city receives \$1.36 in benefits for every dollar spent on tree management annually—a 36% return on investment.

Total Benefits of street trees exceeds total management costs. The management costs also also include indirect costs like litter clean-up and infrastructure repairs.

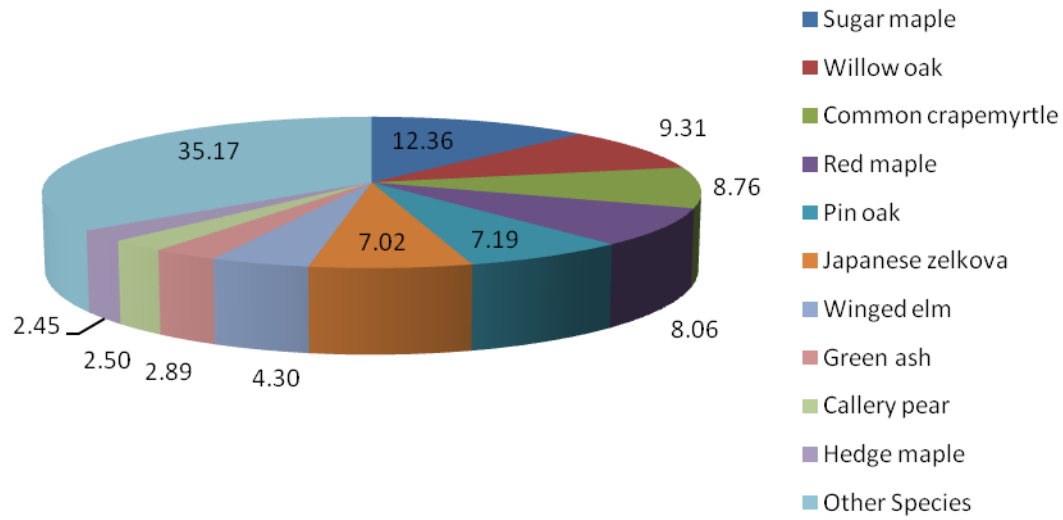
Appendix 1: Annual Management Costs of Public Trees

City of Richmond

Annual Management Costs of Public Trees

Expenditures	Total(\$)	\$/Tree	\$/Capita
Purchasing Trees and Planting	250,000.00	5.28	1.25
Contract Pruning	593,700.00	12.54	2.97
Pest Management	0.00	0.00	0.00
Irrigation	0.00	0.00	0.00
Removal	890,550.00	18.81	4.45
Administration	200,000.00	4.23	1.00
Inspection/Service	210,000.00	4.44	1.05
Infrastructure Repairs	560,000.00	11.83	2.80
Litter Clean-up	494,750.00	10.45	2.47
Liability/Claim	20,000.00	0.42	0.10
Other Cost	0.00	0.00	0.00
Total Expenditures	3,219,000.00	68.01	16.10

Appendix 2: Species Distribution



City of Richmond

Species Distribution of Public Trees (%)

Species	Percent
Sugar maple	12.36
Willow oak	9.31
Common crapemyrtle	8.76
Red maple	8.06
Pin oak	7.19
Japanese zelkova	7.02
Winged elm	4.30
Green ash	2.89
Callery pear	2.50
Hedge maple	2.45
Other Species	35.17
Total	100.00

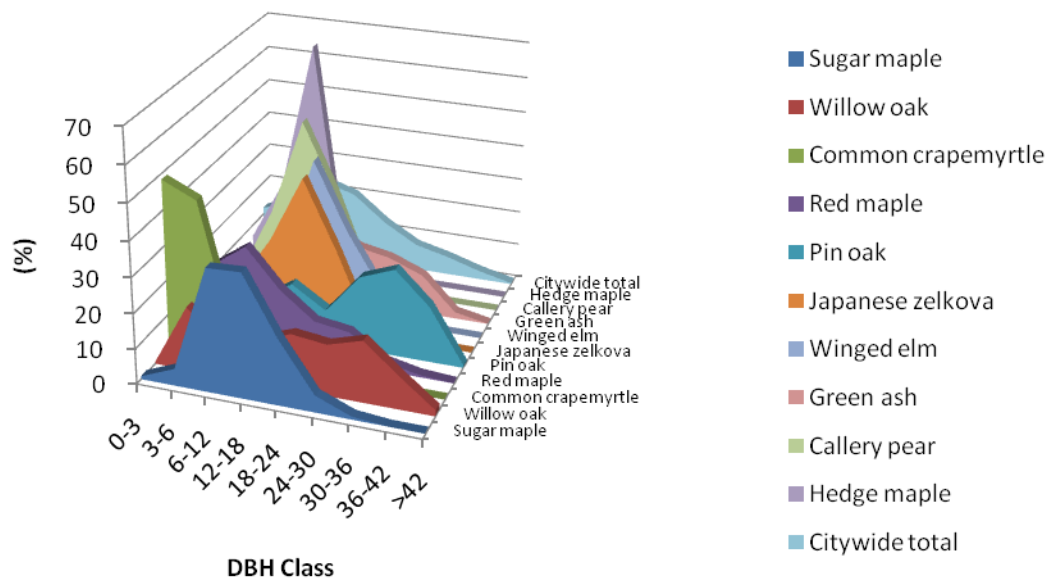
Appendix 3: Species Distribution of Public Trees for the Five Most Abundant Species

City of Richmond

Species Distribution of Public Trees for the Five Most Abundant Species

Zone	1st (%)	2nd (%)	3rd (%)	4th (%)	5th (%)	# of Trees
1	Common crapemyrtle (16.7)	Sugar maple (10.7)	Willow oak (8.5)	Japanese zelkova (7.9)	Ginkgo (6.3)	9,405
2	Sugar maple (21.6)	Willow oak (12.7)	Red maple (10.5)	Common crapemyrtle (10)	Pin oak (7.8)	10,513
3	Red maple (20.7)	American sycamore (14.1)	Pin oak (11)	London planetree (7.5)	Hedge maple (7)	5,849
4	Loblolly pine (11.7)	Unknown shrub (10.4)	Sugar maple (9.1)	Holly (7.1)	Callery pear (7.1)	3,968
5	Sugar maple (17.5)	Japanese zelkova (7.2)	Common crapemyrtle (6.8)	Winged elm (6.8)	Pin oak (6.8)	6,777
6	Willow oak (17.3)	Pin oak (15.1)	Japanese zelkova (8.6)	Hedge maple (7.9)	Common crapemyrtle (7.2)	3,582
7	Japanese zelkova (15.8)	Willow oak (13.3)	Pin oak (9.7)	Sugar maple (9.1)	Littleleaf linden (7.9)	4,252
8	Red maple (14.7)	Winged elm (13.8)	Common crapemyrtle (9.2)	Willow oak (9.2)	Japanese zelkova (8.3)	2,809
9	Loblolly pine (42.9)	Red maple (14.3)	Red mulberry (14.3)	Willow oak (14.3)	Post oak (14.3)	180
Citywide total	Sugar maple (12.4)	Willow oak (9.3)	Common crapemyrtle (8.8)	Red maple (8.1)	Pin oak (7.2)	47,333

Relative Age Distribution of Top 10 Public Tree Species (%)



City of Richmond

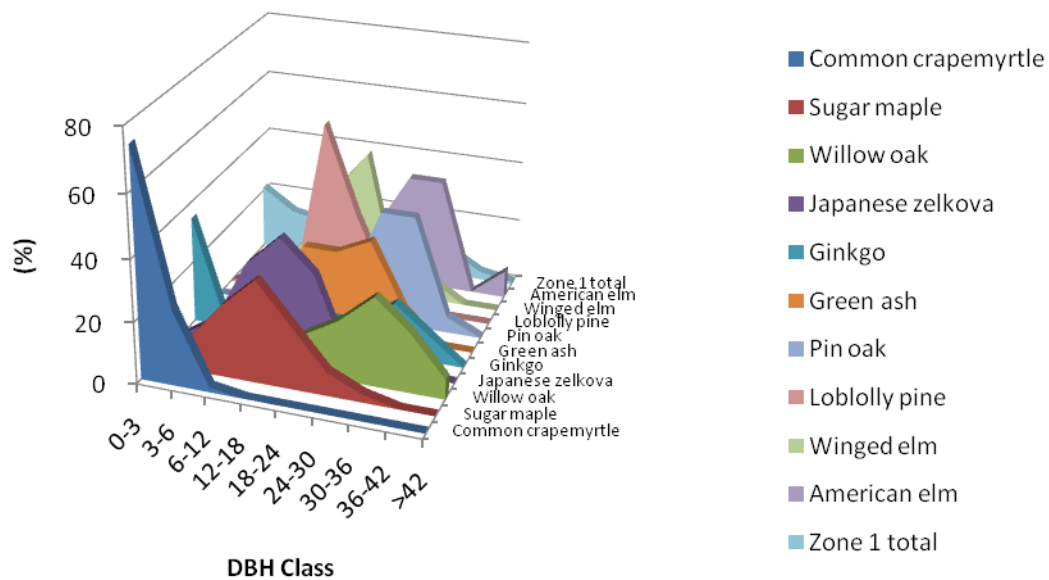
Relative Age Distribution of Top 10 Public Tree Species (%)

DBH class (in)

Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Sugar maple	0.88	4.85	34.80	35.24	18.50	4.85	0.88	0.00	0.00
Willow oak	0.58	18.13	9.94	12.28	15.79	14.62	17.54	9.36	1.75
Common crapemyrtle	48.45	44.10	6.83	0.62	0.00	0.00	0.00	0.00	0.00
Red maple	6.76	22.30	29.05	18.24	10.81	9.46	2.70	0.68	0.00
Pin oak	0.76	0.76	9.85	15.91	9.85	21.21	25.00	15.91	0.76
Japanese zelkova	0.00	9.30	23.26	42.64	23.26	1.55	0.00	0.00	0.00
Winged elm	2.53	1.27	15.19	44.30	25.32	10.13	1.27	0.00	0.00
Green ash	1.89	7.55	18.87	26.42	16.98	15.09	11.32	1.89	0.00
Callery pear	0.00	19.57	47.83	28.26	4.35	0.00	0.00	0.00	0.00
Hedge maple	6.67	24.44	66.67	2.22	0.00	0.00	0.00	0.00	0.00
Citywide total	12.08	15.02	23.41	20.47	13.12	7.68	5.39	2.50	0.33

Appendix 5: Relative Age Distribution of Top 10 Public Tree Species for Zone 1 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 1 (%)



City of Richmond

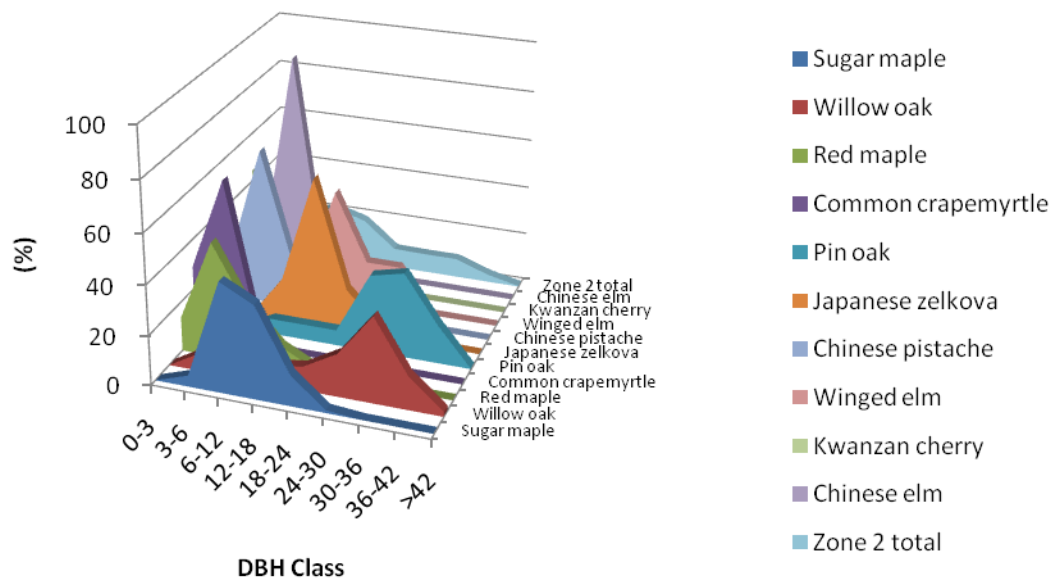
Relative Age Distribution of Top 10 Public Tree Species for Zone 1 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Common crapemyrtle	73.77	24.59	1.64	0.00	0.00	0.00	0.00	0.00	0.00
Sugar maple	2.56	10.26	23.08	33.33	20.51	7.69	2.56	0.00	0.00
Willow oak	0.00	6.45	3.23	3.23	12.90	19.35	29.03	19.35	6.45
Japanese zelkova	0.00	6.90	27.59	37.93	27.59	0.00	0.00	0.00	0.00
Ginkgo	34.78	0.00	0.00	21.74	8.70	8.70	17.39	8.70	0.00
Green ash	0.00	0.00	5.26	26.32	26.32	31.58	10.53	0.00	0.00
Pin oak	0.00	0.00	5.26	5.26	10.53	36.84	36.84	5.26	0.00
Loblolly pine	0.00	5.88	0.00	58.82	29.41	5.88	0.00	0.00	0.00
Winged elm	0.00	0.00	13.33	33.33	46.67	0.00	6.67	0.00	0.00
American elm	0.00	0.00	0.00	0.00	18.18	36.36	36.36	0.00	9.09
Zone 1 total	21.10	13.97	12.05	18.08	13.42	8.77	9.04	2.74	0.82

Appendix 6: Relative Age Distribution of Top 10 Public Tree Species for Zone 2 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 2 (%)



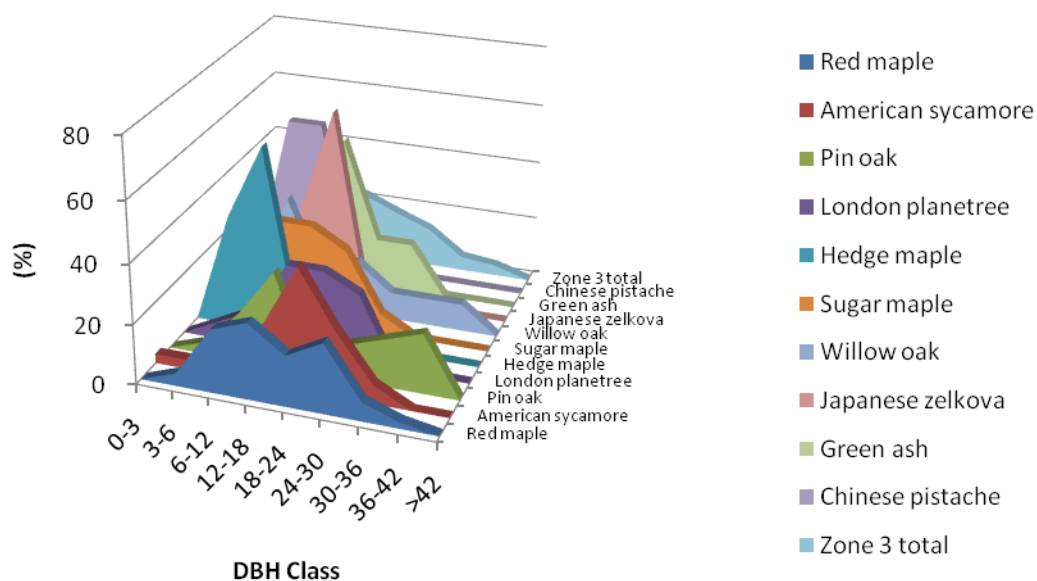
Relative Age Distribution of Top 10 Public Tree Species for Zone 2 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Sugar maple	0.00	4.55	44.32	37.50	12.50	1.14	0.00	0.00	0.00
Willow oak	0.00	7.69	7.69	7.69	9.62	17.31	34.62	13.46	1.92
Red maple	13.95	46.51	23.26	9.30	2.33	4.65	0.00	0.00	0.00
Common crapemyrtle	29.27	65.85	4.88	0.00	0.00	0.00	0.00	0.00	0.00
Pin oak	0.00	0.00	6.25	6.25	6.25	31.25	34.38	15.63	0.00
Japanese zelkova	0.00	0.00	17.39	60.87	17.39	4.35	0.00	0.00	0.00
Chinese pistache	18.18	63.64	18.18	0.00	0.00	0.00	0.00	0.00	0.00
Winged elm	0.00	9.09	9.09	45.45	18.18	18.18	0.00	0.00	0.00
Kwanzan cherry	44.44	0.00	33.33	22.22	0.00	0.00	0.00	0.00	0.00
Chinese elm	11.11	88.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zone 2 total	13.48	18.38	22.30	18.63	8.09	7.84	7.84	3.19	0.25

Appendix 7: Relative Age Distribution of Top 10 Public Tree Species for Zone 3 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 3 (%)



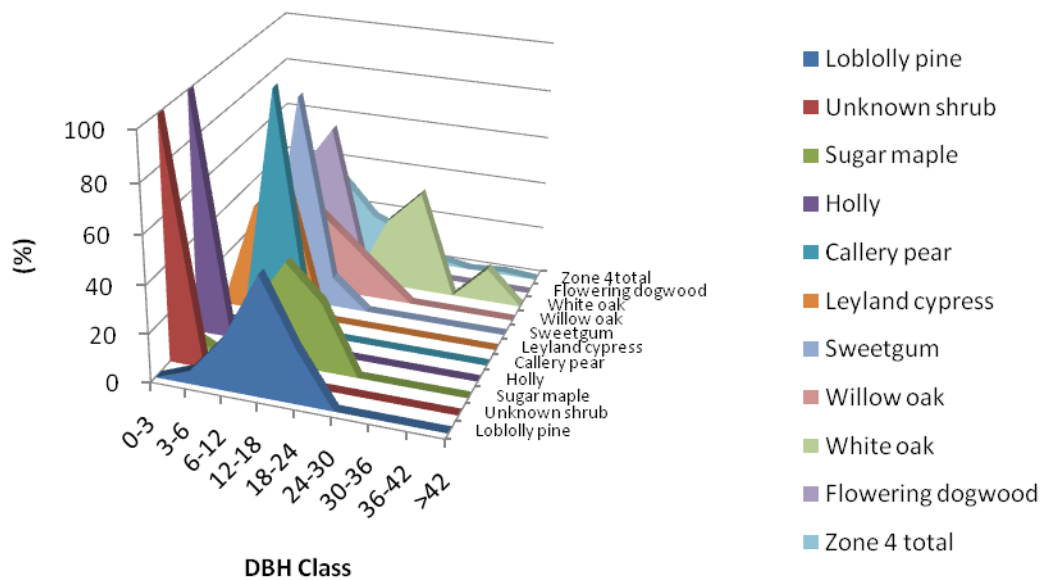
Relative Age Distribution of Top 10 Public Tree Species for Zone 3 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Red maple	0.00	4.26	21.28	25.53	17.02	23.40	6.38	2.13	0.00
American sycamore	3.13	3.13	6.25	18.75	40.63	21.88	6.25	0.00	0.00
Pin oak	0.00	4.00	16.00	32.00	0.00	12.00	16.00	20.00	0.00
London planetree	0.00	5.88	11.76	29.41	29.41	23.53	0.00	0.00	0.00
Hedge maple	0.00	37.50	62.50	0.00	0.00	0.00	0.00	0.00	0.00
Sugar maple	0.00	0.00	33.33	33.33	26.67	6.67	0.00	0.00	0.00
Willow oak	0.00	9.09	36.36	9.09	18.18	9.09	9.09	9.09	0.00
Japanese zelkova	0.00	9.09	27.27	63.64	0.00	0.00	0.00	0.00	0.00
Green ash	0.00	0.00	16.67	50.00	16.67	16.67	0.00	0.00	0.00
Chinese pistache	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
Zone 3 total	5.29	9.25	23.79	22.47	17.62	13.22	4.85	3.52	0.00

Appendix 8: Relative Age Distribution of Top 10 Public Tree Species for Zone 4 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 4 (%)



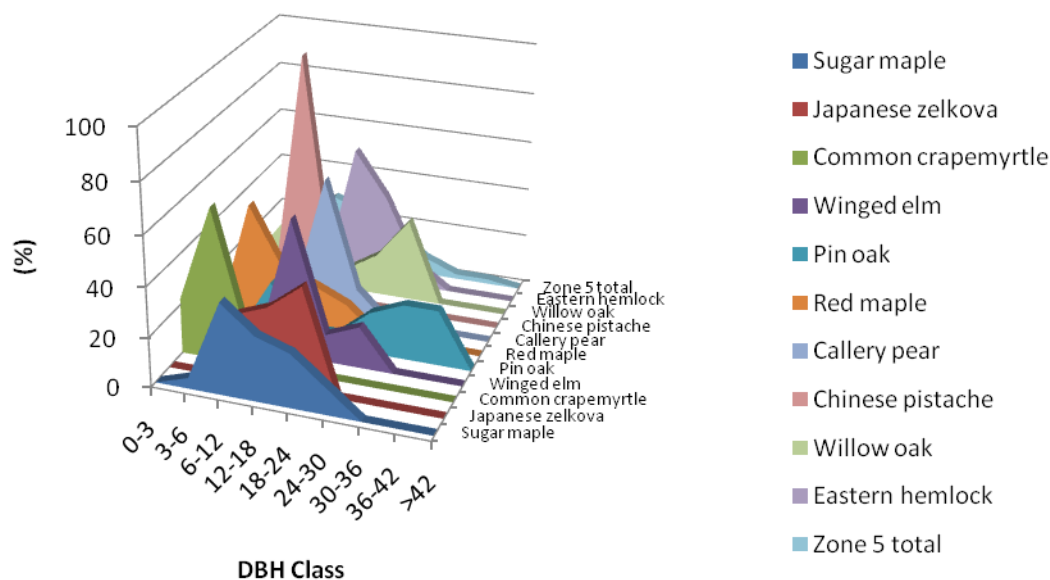
Relative Age Distribution of Top 10 Public Tree Species for Zone 4 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Loblolly pine	0.00	5.56	22.22	50.00	22.22	0.00	0.00	0.00	0.00
Unknown shrub	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugar maple	7.14	0.00	21.43	42.86	28.57	0.00	0.00	0.00	0.00
Holly	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Callery pear	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Leyland cypress	0.00	44.44	55.56	0.00	0.00	0.00	0.00	0.00	0.00
Sweetgum	0.00	0.00	87.50	12.50	0.00	0.00	0.00	0.00	0.00
Willow oak	0.00	25.00	37.50	25.00	12.50	0.00	0.00	0.00	0.00
White oak	0.00	0.00	14.29	0.00	28.57	42.86	0.00	14.29	0.00
Flowering dogwood	0.00	40.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00
Zone 4 total	23.38	10.39	33.12	17.53	11.69	2.60	0.00	1.30	0.00

Appendix 9: Relative Age Distribution of Top 10 Public Tree Species for Zone 5 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 5 (%)



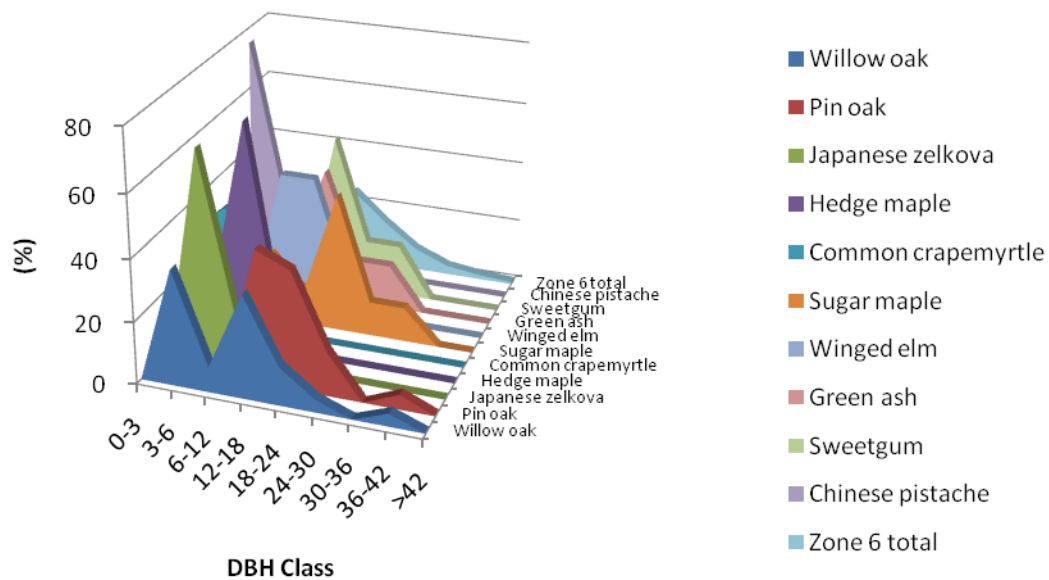
Relative Age Distribution of Top 10 Public Tree Species for Zone 5 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Sugar maple	0.00	4.35	36.96	26.09	21.74	10.87	0.00	0.00	0.00
Japanese zelkova	0.00	0.00	26.32	31.58	42.11	0.00	0.00	0.00	0.00
Common crapemyrtle	22.22	61.11	11.11	5.56	0.00	0.00	0.00	0.00	0.00
Winged elm	11.11	0.00	5.56	55.56	11.11	16.67	0.00	0.00	0.00
Pin oak	5.56	0.00	22.22	5.56	5.56	16.67	22.22	22.22	0.00
Red maple	0.00	47.06	23.53	17.65	11.76	0.00	0.00	0.00	0.00
Callery pear	0.00	25.00	6.25	56.25	12.50	0.00	0.00	0.00	0.00
Chinese pistache	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Willow oak	8.33	25.00	8.33	8.33	16.67	33.33	0.00	0.00	0.00
Eastern hemlock	0.00	0.00	0.00	54.55	36.36	9.09	0.00	0.00	0.00
Zone 5 total	6.84	15.21	28.14	22.81	15.97	7.22	1.90	1.90	0.00

Appendix 10: Relative Age Distribution of Top 10 Public Tree Species for Zone 6 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 6 (%)



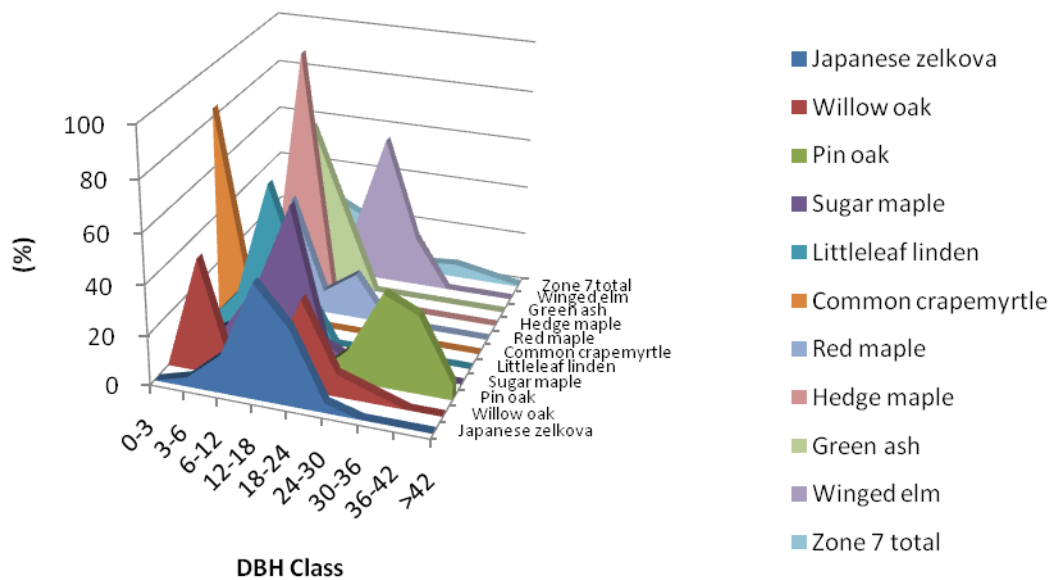
Relative Age Distribution of Top 10 Public Tree Species for Zone 6 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Willow oak	0.00	37.50	8.33	33.33	12.50	4.17	0.00	4.17	0.00
Pin oak	0.00	0.00	0.00	42.86	38.10	14.29	0.00	4.76	0.00
Japanese zelkova	0.00	66.67	16.67	8.33	8.33	0.00	0.00	0.00	0.00
Hedge maple	0.00	18.18	72.73	9.09	0.00	0.00	0.00	0.00	0.00
Common crapemyrtle	30.00	40.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugar maple	0.00	0.00	22.22	11.11	44.44	11.11	11.11	0.00	0.00
Winged elm	0.00	0.00	44.44	44.44	11.11	0.00	0.00	0.00	0.00
Green ash	0.00	14.29	14.29	42.86	14.29	14.29	0.00	0.00	0.00
Sweetgum	0.00	16.67	0.00	50.00	16.67	16.67	0.00	0.00	0.00
Chinese pistache	75.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zone 6 total	5.04	23.02	20.14	24.46	15.11	7.19	2.88	1.44	0.72

Appendix 11: Relative Age Distribution of Top 10 Public Tree Species for Zone 7 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 7 (%)



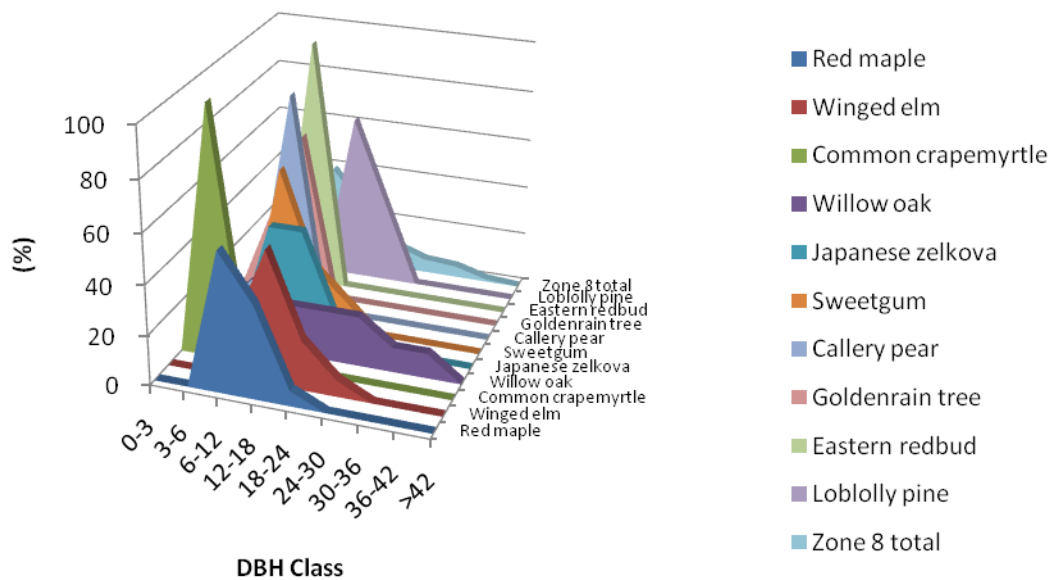
Relative Age Distribution of Top 10 Public Tree Species for Zone 7 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Japanese zelkova	0.00	3.85	15.38	46.15	30.77	3.85	0.00	0.00	0.00
Willow oak	0.00	45.45	0.00	4.55	36.36	9.09	4.55	0.00	0.00
Pin oak	0.00	0.00	12.50	0.00	0.00	12.50	37.50	31.25	6.25
Sugar maple	0.00	6.67	26.67	60.00	6.67	0.00	0.00	0.00	0.00
Littleleaf linden	0.00	15.38	61.54	23.08	0.00	0.00	0.00	0.00	0.00
Common crapemyrtle	83.33	8.33	8.33	0.00	0.00	0.00	0.00	0.00	0.00
Red maple	18.18	9.09	45.45	9.09	18.18	0.00	0.00	0.00	0.00
Hedge maple	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Green ash	0.00	0.00	66.67	33.33	0.00	0.00	0.00	0.00	0.00
Winged elm	0.00	0.00	0.00	20.00	60.00	20.00	0.00	0.00	0.00
Zone 7 total	10.30	14.55	27.27	20.61	13.94	4.24	5.45	3.03	0.61

Appendix 12: Relative Age Distribution of Top 10 Public Tree Species for Zone 8 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 8 (%)



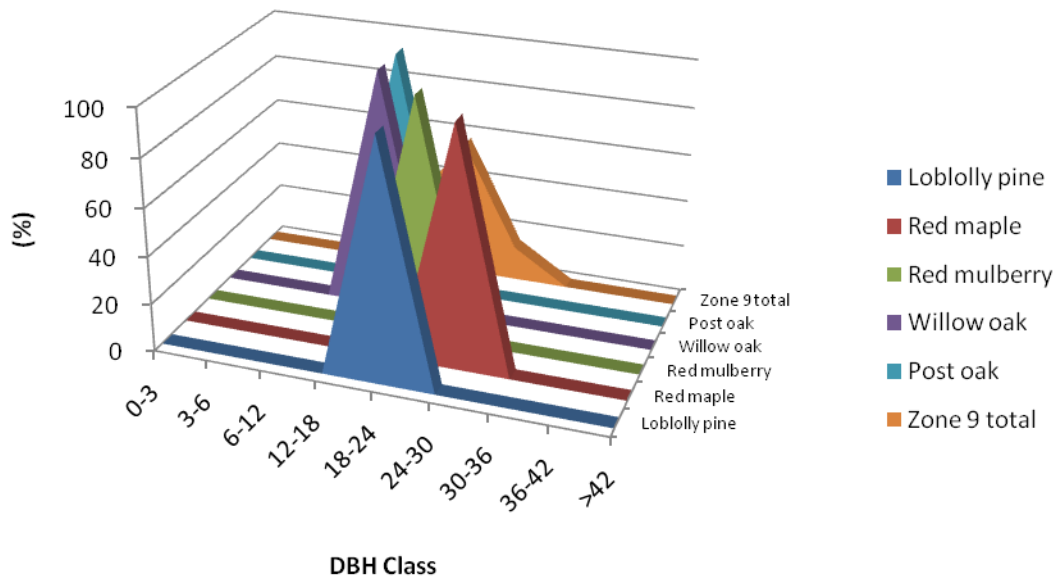
Relative Age Distribution of Top 10 Public Tree Species for Zone 8 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Red maple	0.00	0.00	56.25	37.50	6.25	0.00	0.00	0.00	0.00
Winged elm	0.00	0.00	20.00	53.33	20.00	6.67	0.00	0.00	0.00
Common crapemyrtle	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Willow oak	0.00	0.00	20.00	20.00	20.00	20.00	10.00	10.00	0.00
Japanese zelkova	0.00	0.00	44.44	44.44	11.11	0.00	0.00	0.00	0.00
Sweetgum	0.00	0.00	62.50	25.00	12.50	0.00	0.00	0.00	0.00
Callery pear	0.00	12.50	87.50	0.00	0.00	0.00	0.00	0.00	0.00
Goldenrain tree	0.00	33.33	66.67	0.00	0.00	0.00	0.00	0.00	0.00
Eastern redbud	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Loblolly pine	0.00	0.00	0.00	66.67	33.33	0.00	0.00	0.00	0.00
Zone 8 total	0.00	15.60	39.45	23.85	10.09	5.50	4.59	0.92	0.00

Appendix 13: Relative Age Distribution of Top 10 Public Tree Species for Zone 9 (%)

Relative Age Distribution of Top 10 Public Tree Species for Zone 9 (%)



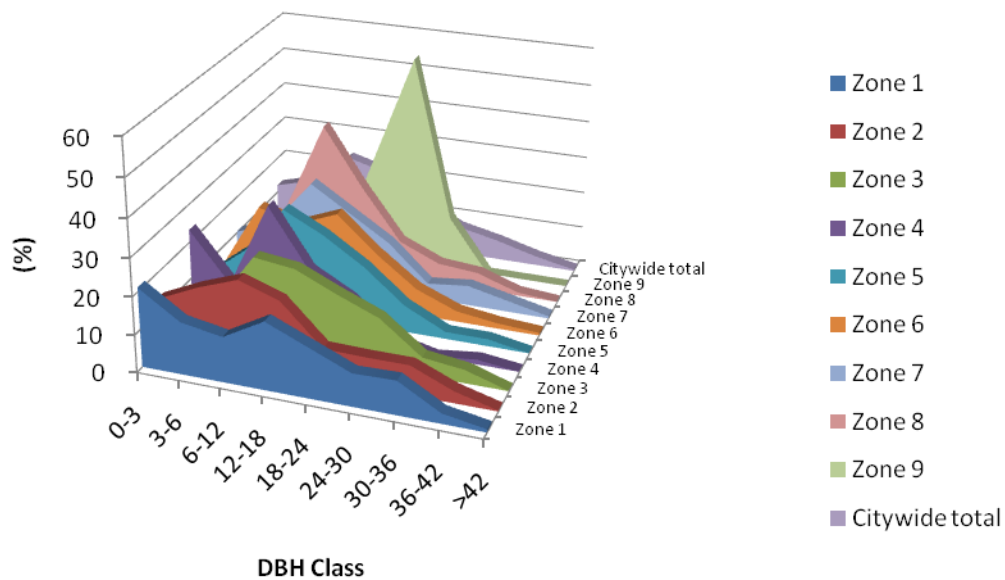
Relative Age Distribution of Top 10 Public Tree Species for Zone 9 (%)

DBH class (in)

Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Loblolly pine	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
Red maple	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
Red mulberry	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
Willow oak	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Post oak	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Zone 9 total	0.00	0.00	0.00	28.57	57.14	14.29	0.00	0.00	0.00

Appendix 14: Relative Age Distribution of Public Tree Species for All Zones (%)

Relative Age Distribution of Public Tree Species for All Zones (%)

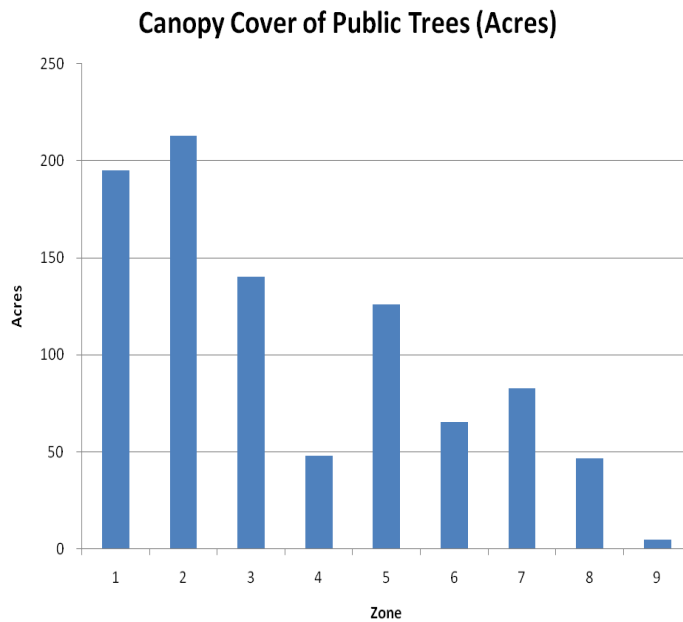


Relative Age Distribution of Public Tree Species for All Zones (%)

DBH class (in)

Zone	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Zone 1	21.10	13.97	12.05	18.08	13.42	8.77	9.04	2.74	0.82
Zone 2	13.48	18.38	22.30	18.63	8.09	7.84	7.84	3.19	0.25
Zone 3	5.29	9.25	23.79	22.47	17.62	13.22	4.85	3.52	0.00
Zone 4	23.38	10.39	33.12	17.53	11.69	2.60	0.00	1.30	0.00
Zone 5	6.84	15.21	28.14	22.81	15.97	7.22	1.90	1.90	0.00
Zone 6	5.04	23.02	20.14	24.46	15.11	7.19	2.88	1.44	0.72
Zone 7	10.30	14.55	27.27	20.61	13.94	4.24	5.45	3.03	0.61
Zone 8	0.00	15.60	39.45	23.85	10.09	5.50	4.59	0.92	0.00
Zone 9	0.00	0.00	0.00	28.57	57.14	14.29	0.00	0.00	0.00
Citywide total	12.08	15.02	23.41	20.47	13.12	7.68	5.39	2.50	0.33

Appendix 15: Canopy Cover of Public Trees (Acres)



City of Richmond

Canopy Cover of Public Trees (Acres)

Zone	Acres	% of Total Canopy
1	195.01	21.16
2	212.95	23.10
3	140.11	15.20
4	48.14	5.22
5	125.89	13.66
6	65.40	7.10
7	82.91	8.99
8	46.51	5.05
9	4.87	0.53
Citywide total	921.81	100.00

	Total Land Area	Total Street and Sidewalk Area	Total Canopy Cover	Canopy Cover as % of Total Land Area	Canopy Cover as % of Total Streets and Sidewalks
Citywide total	39,679.84	13,963.09	921.81	2.32	6.60

Appendix 16: Importance Values for Most Abundant Public Trees

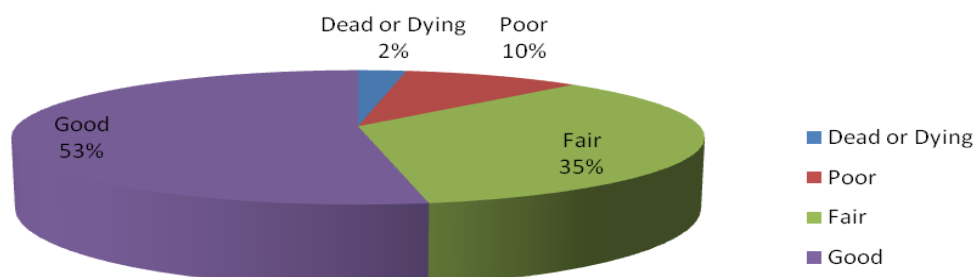
City of Richmond

Importance Values for Most Abundant Public Trees

Species	Number of Trees	% of Total Trees	Leaf Area (ft2)	% of Total Leaf Area	Canopy Cover (ft2)	% of Total Canopy Cover	Importance Value
Sugar maple	5,849	12.36	19,750,568.16	10.17	6,195,546.39	15.43	12.65
Willow oak	4,406	9.31	40,842,445.52	21.03	6,305,532.20	15.70	15.35
Common crapemyrtle	4,148	8.77	161,296.09	0.08	350,702.39	0.87	3.24
Red maple	3,813	8.06	14,003,009.56	7.21	2,880,165.70	7.17	7.48
Pin oak	3,401	7.19	42,170,549.57	21.72	6,281,160.06	15.64	14.85
Japanese zelkova	3,324	7.03	11,210,335.81	5.77	2,474,263.99	6.16	6.32
Winged elm	2,036	4.30	6,920,486.22	3.56	1,841,938.64	4.59	4.15
Green ash	1,366	2.89	8,779,508.97	4.52	1,537,839.64	3.83	3.75
Callery pear	1,185	2.51	971,558.30	0.50	533,598.78	1.33	1.44
Hedge maple	1,160	2.45	899,393.68	0.46	533,171.17	1.33	1.41
American sycamore	1,134	2.40	7,681,430.36	3.96	1,369,796.12	3.41	3.25
Ginkgo	1,056	2.23	3,138,589.32	1.62	830,960.87	2.07	1.97
Loblolly pine	1,056	2.23	2,367,190.50	1.22	806,391.79	2.01	1.82
Chinese pistache	928	1.96	562,203.72	0.29	356,766.74	0.89	1.05
Sweetgum	825	1.74	1,594,618.26	0.82	369,183.07	0.92	1.16
American elm	799	1.69	10,259,847.54	5.28	1,552,108.68	3.87	3.61
Unknown shrub	747	1.58	17,704.62	0.01	53,680.55	0.13	0.57
Littleleaf linden	696	1.47	1,440,646.08	0.74	533,232.07	1.33	1.18
London planetree	567	1.20	2,971,737.23	1.53	569,350.39	1.42	1.38
Norway maple	490	1.03	1,313,588.92	0.68	309,054.39	0.77	0.83
Silver maple	490	1.03	1,381,959.47	0.71	464,712.51	1.16	0.97
Kwanzan cherry	490	1.03	130,058.73	0.07	126,897.90	0.32	0.47
Other trees	7,344	15.52	15,623,984.63	8.05	3,877,958.43	9.66	11.08
Total	47,308	100.00	194,192,711.26	100.00	40,154,012.45	100.00	100.00

Appendix 17: Citywide Condition (Foliage) of Public Trees by Species (%)

Citywide total

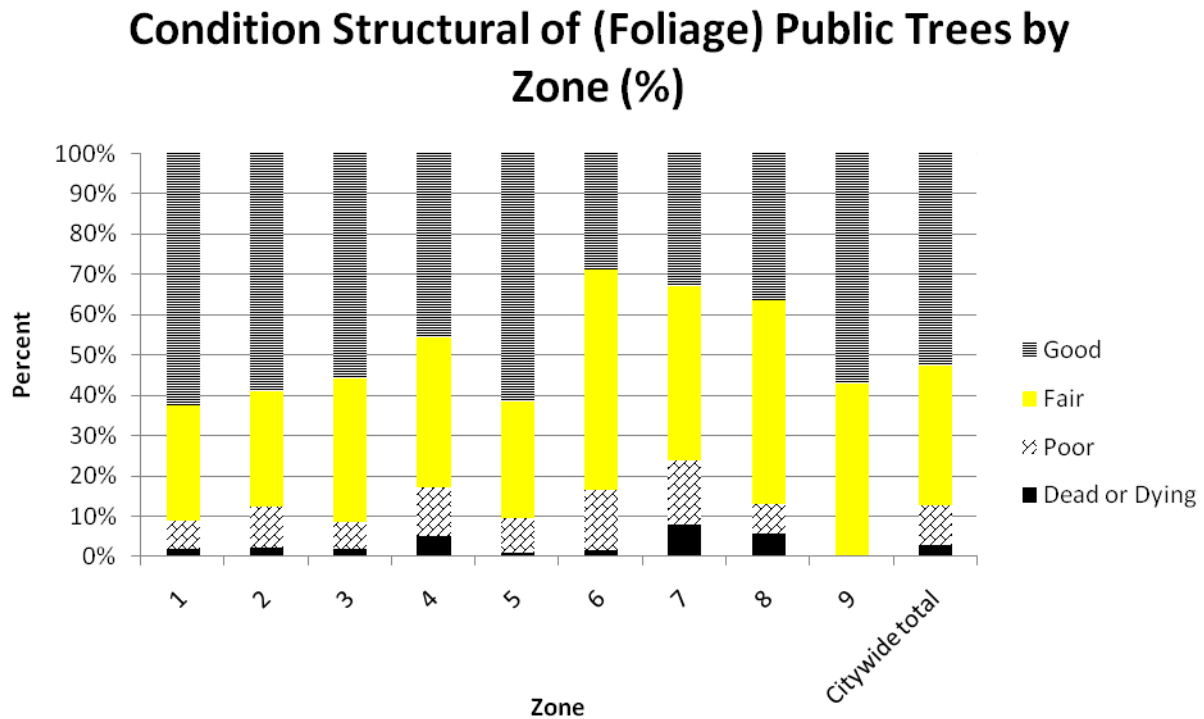


City of Richmond

Condition (Foliage) of Public Trees by Species (%)

Species Name	Dead or Dying	Poor	Fair	Good
Sugar maple	3.52	11.89	36.56	48.02
Willow oak	0.00	11.70	42.11	46.20
Common crapemyrtle	0.63	1.88	22.50	75.00
Red maple	4.05	6.08	39.19	50.68
Pin oak	0.00	24.24	45.45	30.30
Japanese zelkova	2.33	10.85	32.56	54.26
Winged elm	3.80	13.92	44.30	37.97
Green ash	3.77	28.30	41.51	26.42
Callery pear	0.00	19.57	47.83	32.61
Hedge maple	2.22	6.67	53.33	37.78
American sycamore	2.27	2.27	29.55	65.91
Ginkgo	2.44	7.32	26.83	63.41
Loblolly pine	0.00	0.00	29.27	70.73
Chinese pistache	0.00	11.11	8.33	80.56
Sweetgum	0.00	0.00	50.00	50.00
American elm	6.45	9.68	12.90	70.97
Littleleaf linden	14.81	3.70	33.33	48.15
London planetree	4.55	0.00	18.18	77.27
Norway maple	10.53	26.32	26.32	36.84
Kwanzan cherry	5.26	5.26	52.63	36.84
Citywide total	2.64	9.79	34.80	52.78

Appendix 18: Condition Structural of (Foliage) Public Trees by Zone (%)



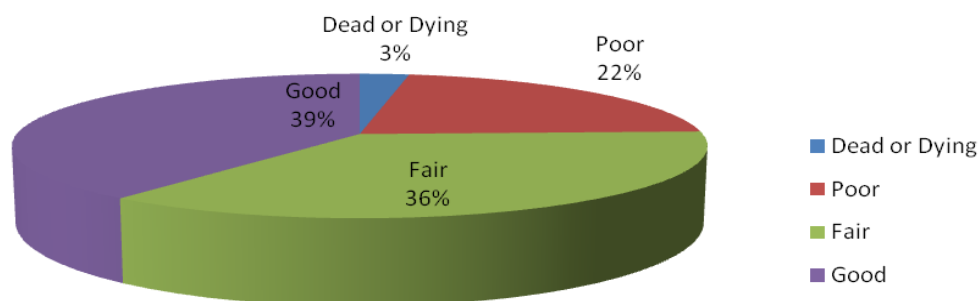
City of Richmond

Condition Structural of (Foliage) Public Trees by Zone (%)

Zone Segment	Dead or Dying	Poor	Fair	Good
1	1.65	7.14	28.57	62.64
2	1.97	10.32	28.50	59.21
3	1.76	6.61	35.68	55.95
4	5.00	12.14	37.14	45.71
5	0.76	8.78	28.63	61.83
6	1.44	15.11	54.68	28.78
7	7.93	15.85	43.29	32.93
8	5.50	7.34	50.46	36.70
9	0.00	0.00	42.86	57.14
Citywide total	2.64	9.79	34.80	52.78

Appendix 19: Condition (Woody) of Public Trees by Species (%)

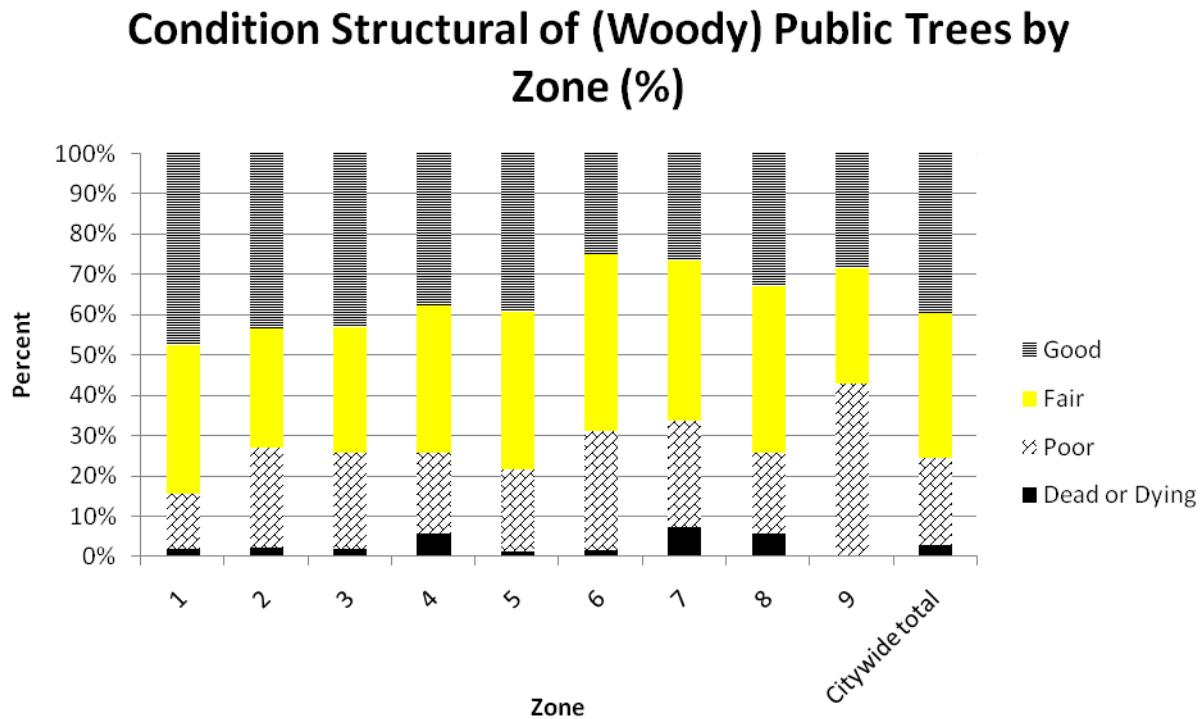
Citywide total



Condition (Woody) of Public Trees by Species (%)

Species Name	Dead or Dying	Poor	Fair	Good
Sugar maple	3.96	37.44	37.44	21.15
Willow oak	0.00	17.54	39.18	43.27
Common crapemyrtle	0.63	7.50	31.25	60.63
Red maple	4.73	33.78	30.41	31.08
Pin oak	0.00	31.06	45.45	23.48
Japanese zelkova	2.33	15.50	37.21	44.96
Winged elm	3.80	30.38	30.38	35.44
Green ash	3.77	20.75	45.28	30.19
Callery pear	0.00	34.78	58.70	6.52
Hedge maple	2.22	26.67	42.22	28.89
American sycamore	2.27	9.09	20.45	68.18
Ginkgo	2.44	19.51	31.71	46.34
Loblolly pine	0.00	4.88	36.59	58.54
Chinese pistache	0.00	5.56	30.56	63.89
Sweetgum	0.00	6.25	71.88	21.88
American elm	6.45	29.03	29.03	35.48
Littleleaf linden	11.11	25.93	37.04	25.93
London planetree	4.55	9.09	9.09	77.27
Norway maple	10.53	47.37	31.58	10.53
Kwanzan cherry	5.26	21.05	31.58	42.11
Citywide total	2.69	21.72	35.95	39.64

Appendix 20: Condition Structural of (Woody) Public Trees by Zone (%)



City of Richmond

Condition Structural of (Woody) Public Trees by Zone (%)

Zone Segment	Dead or Dying	Poor	Fair	Good
1	1.65	13.74	37.09	47.53
2	1.97	24.82	29.73	43.49
3	1.76	23.79	31.28	43.17
4	5.71	20.00	36.43	37.86
5	1.15	20.23	39.31	39.31
6	1.44	29.50	43.88	25.18
7	7.32	26.22	39.63	26.83
8	5.50	20.18	41.28	33.03
9	0.00	42.86	28.57	28.57
Citywide total	2.69	21.72	35.95	39.64

Appendix 21: Summary of Available Planting Sites for Public Trees by Zone

Summary of Available Planting Sites for Public Trees

Zone	No. of Unplanted Sites	No. of Planted Sites	Total No. of Sites	Stocking (%)	No. of Unplanted Sites			
					Small	Medium	Large	Undefined
1	5,153	9,405	14,558	65	0	0	0	0
2	2,731	10,513	13,244	79	0	0	0	0
3	3,092	5,849	8,941	65	0	0	0	0
4	1,598	3,968	5,566	71	0	0	0	0
5	6,313	6,777	13,089	52	0	0	0	0
6	6,004	3,582	9,585	37	0	0	0	0
7	4,664	4,252	8,915	48	0	0	0	0
8	6,364	2,809	9,173	31	0	0	0	0
9	825	180	1,005	18	0	0	0	0
Citywide total	36,743	47,333	84,077	56	0	0	0	0

Appendix 22: Summary of Available Planting Sites for Public Trees by Potential Tree Size by Zone

City of Richmond

Summary of Available Planting Sites for Public Trees by Potential Tree Size by Zone:

Zone	No Site	Site, Small Tree	Site, Medium Tree	Site, Large Tree	No. of Total Unplanted Sites
1	541	1,726	1,804	1,082	5,153
2	335	850	1,288	258	2,731
3	258	1,263	1,340	232	3,092
4	876	541	155	26	1,598
5	773	3,272	1,598	670	6,313
6	825	3,607	1,546	26	6,004
7	361	3,375	618	309	4,664
8	1,211	3,169	1,623	361	6,364
9	593	0	232	0	825
Citywide total	5,772	17,805	10,204	2,963	36,743

Appendix 23: Summary Priority Tasks Need for Public Trees

Summary Priority Tasks Need for Public Trees

Maintenance Type	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	% of Total Population
None	3,375	3,401	5,128	4,123	2,190	747	335	155	26	19,480	41.15
Plant	0	0	0	0	0	0	0	0	0	0	0.00
Young tree (routine)	2,190	3,530	3,710	361	0	0	0	0	0	9,791	20.69
Mature tree (routine)	26	26	1,572	4,303	3,401	2,345	1,933	928	103	14,636	30.92
Mature tree (High Priority)	0	0	0	0	26	52	52	0	0	129	0.27
Critical concern (public safety)	0	0	0	0	0	0	0	0	0	0	0.00
Scheduled Removal	52	155	515	309	26	77	0	0	0	1,134	2.40
Hazard Removal	0	0	0	26	52	26	0	0	0	103	0.22
Stump Grinding	52	0	155	541	515	387	232	103	26	2,010	4.25
Citywide total	5,694	7,112	11,080	9,663	6,210	3,633	2,551	1,185	155	47,282	99.89

Appendix 24: Overhead Utility Lines Conflicts for Most Common Public Species

City of Richmond

Overhead Utility Lines Conflicts for Most Common Public Species

Species	No lines	Present and not conflicting	Present and conflict	Present and potential conflict	Total Number of Conflict
Sugar maple	3,530	618	953	747	5,849
Willow oak	2,860	747	387	412	4,406
Common crapemyrtle	2,577	387	0	1,185	4,148
Red maple	2,242	412	593	567	3,813
Pin oak	2,216	567	283	335	3,401
Japanese zelkova	1,907	335	721	361	3,324
Winged elm	876	412	515	232	2,036
Green ash	387	258	593	129	1,366
Callery pear	1,056	52	26	52	1,185
Hedge maple	515	0	361	283	1,160
American sycamore	618	26	103	387	1,134
Loblolly pine	670	206	52	129	1,056
Ginkgo	721	129	26	180	1,056
Chinese pistache	258	464	0	206	928
Sweetgum	618	103	26	77	825
American elm	438	103	206	52	799
Unknown shrub	593	77	0	77	747
Littleleaf linden	490	0	129	77	696
London planetree	515	26	26	0	567
Norway maple	206	77	155	52	490
Silver maple	155	103	103	129	490
Kwanzan cherry	335	52	0	103	490
Other trees	4,045	1,211	567	1,546	7,369
Citywide total	27,828	6,364	5,823	7,318	47,333

Appendix 25: Total Number of Overhead Utility Lines Conflicts for Public Trees by Zone

City of Richmond

Total Number of Overhead Utility Lines Conflicts for Public Trees

Zone Segment	No lines	Present and not conflicting	Present and conflict	Present and potential conflict	Total Number of Conflict
1	5,385	1,829	953	1,237	9,405
2	6,674	1,778	721	1,340	10,513
3	3,401	438	979	1,031	5,849
4	2,139	747	438	644	3,968
5	3,582	670	1,263	1,263	6,777
6	2,242	387	464	490	3,582
7	2,242	361	644	1,005	4,252
8	2,036	155	335	283	2,809
9	129	0	26	26	180
Citywide total	27,828	6,364	5,823	7,318	47,333

Appendix 26: Total Percentage of Overhead Utility Lines Conflicts for Public Trees

Total Percentage of Overhead Utility Lines Conflicts for Public Trees

Zone Segment	No lines	Present and not conflicting	Present and conflict	Present and potential conflict	% of Conflicts
1	57.26	19.45	10.14	13.15	100.00
2	63.48	16.91	6.86	12.75	100.00
3	58.15	7.49	16.74	17.62	100.00
4	53.90	18.83	11.04	16.23	100.00
5	52.85	9.89	18.63	18.63	100.00
6	62.59	10.79	12.95	13.67	100.00
7	52.73	8.48	15.15	23.64	100.00
8	72.48	5.50	11.93	10.09	100.00
9	71.43	0.00	14.29	14.29	100.00
Citywide total	58.79	13.45	12.30	15.46	100.00

Appendix 27: Sidewalk Heave Conflicts for Most Common Public Species

City of Richmond

Sidewalk Heave Conflicts for Most Common Public Species

Species	None. 0 - 3/4 inch	Low. 3/4 - 1 1/2 inches	Medium. 1 1/2 - 3 inches	High. > 3 inches	Total Number of Conflict
Sugar maple	3,556	1,263	438	593	5,849
Willow oak	3,092	670	258	387	4,406
Common crapemyrtle	3,942	155	52	0	4,148
Red maple	2,602	773	206	232	3,813
Pin oak	2,036	670	335	361	3,401
Japanese zelkova	1,572	618	438	696	3,324
Winged elm	1,598	335	77	26	2,036
Green ash	902	232	155	77	1,366
Callery pear	850	155	129	52	1,185
Hedge maple	1,056	77	26	0	1,160
American sycamore	1,031	77	26	0	1,134
Loblolly pine	979	26	26	26	1,056
Ginkgo	618	180	52	206	1,056
Chinese pistache	696	103	103	26	928
Sweetgum	799	26	0	0	825
American elm	464	77	26	232	799
Unknown shrub	721	26	0	0	747
Littleleaf linden	618	52	26	0	696
London planetree	515	26	26	0	567
Kwanzan cherry	490	0	0	0	490
Norway maple	335	103	52	0	490
Silver maple	309	129	0	52	490
Other trees	6,905	206	129	129	7,369
Citywide total	35,687	5,978	2,577	3,092	47,333

Appendix 28: Total Number of Sidewalk Heave Conflicts for Public Trees by Zone

City of Richmond

Total Number of Sidewalk Heave Conflicts for Public Trees

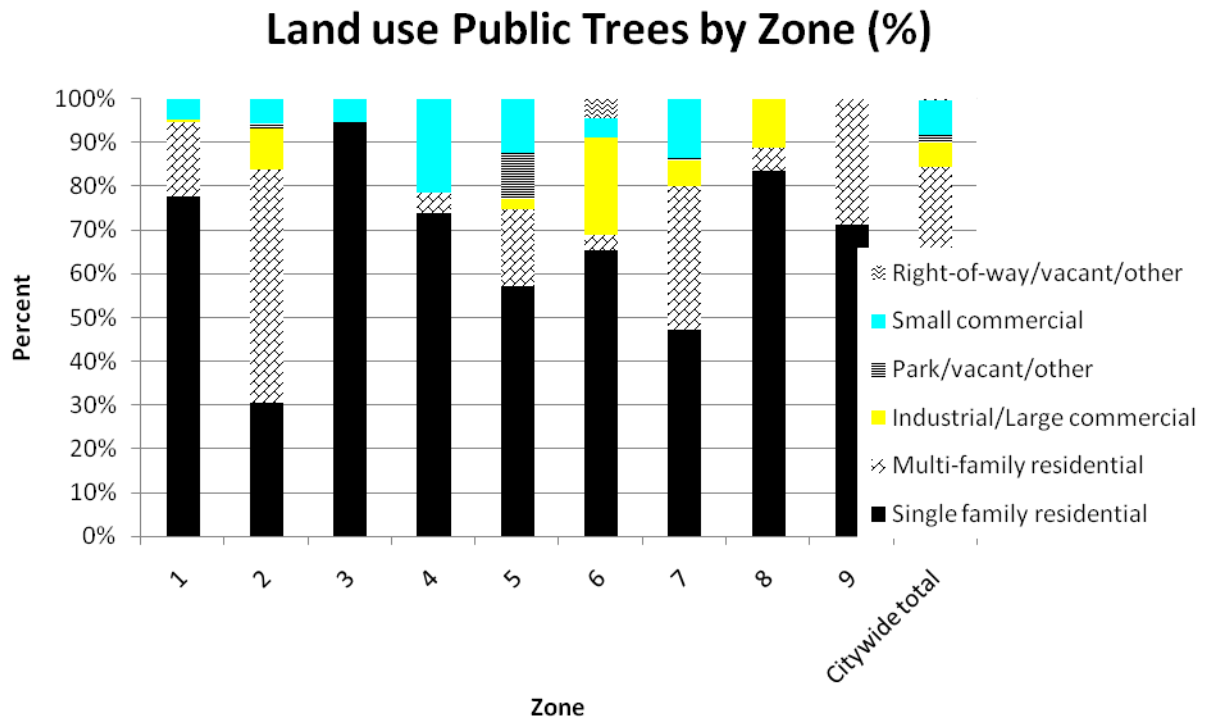
Zone Segment	None. 0 - 3/4 inch	Low. 3/4 - 1 1/2 inches	Medium. 1 1/2 - 3 inches	High. > 3 inches	Total Number of Conflict
1	7,112	928	618	747	9,405
2	7,112	1,933	644	825	10,513
3	4,999	541	129	180	5,849
4	3,762	77	0	129	3,968
5	4,741	1,160	412	464	6,777
6	2,834	258	361	129	3,582
7	2,654	825	309	464	4,252
8	2,293	258	103	155	2,809
9	180	0	0	0	180
Citywide total	35,687	5,978	2,577	3,092	47,333

Appendix 29: Total Percentage of Sidewalk Heave Conflicts for Public Trees by Zone

Total Percentage of Sidewalk Heave Conflicts for Public Trees

Zone Segment	None. 0 - 3/4 inch	Low. 3/4 - 1 1/2 inches	Medium. 1 1/2 - 3 inches	High. > 3 inches	% of Conflicts
1	75.62	9.86	6.58	7.95	100.00
2	67.65	18.38	6.13	7.84	100.00
3	85.46	9.25	2.20	3.08	100.00
4	94.81	1.95	0.00	3.25	100.00
5	69.96	17.11	6.08	6.84	100.00
6	79.14	7.19	10.07	3.60	100.00
7	62.42	19.39	7.27	10.91	100.00
8	81.65	9.17	3.67	5.50	100.00
9	100.00	0.00	0.00	0.00	100.00
Citywide total	75.39	12.63	5.44	6.53	100.00

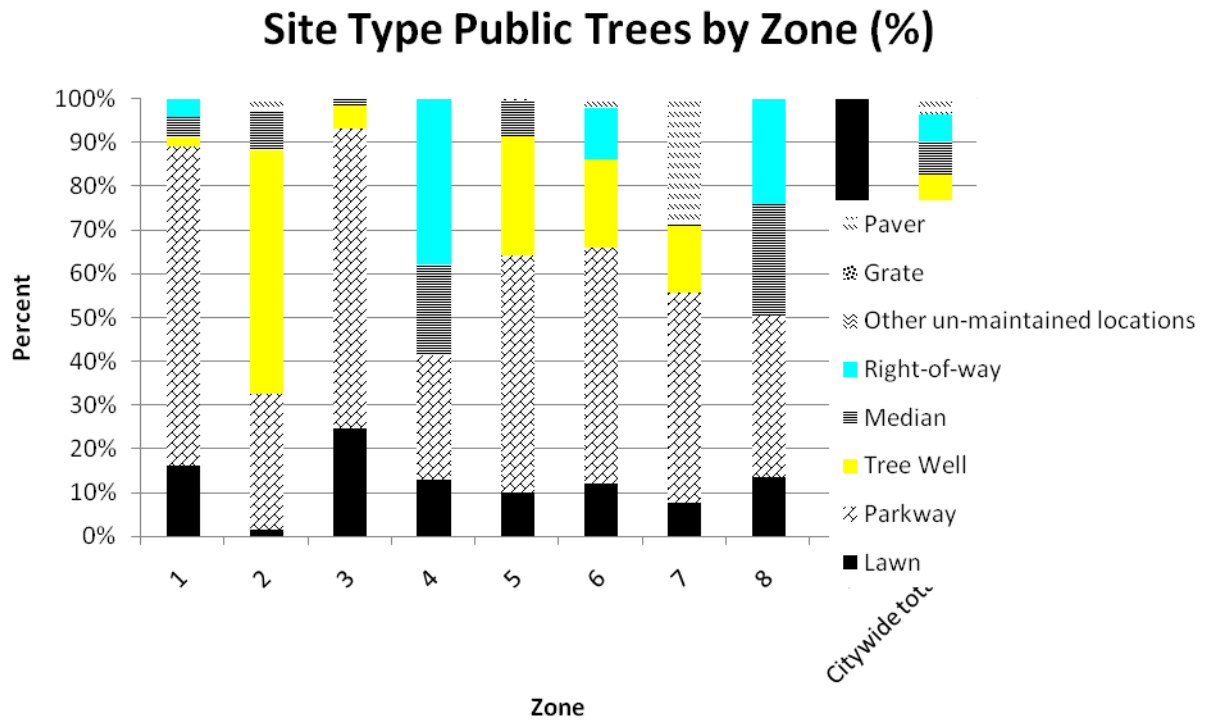
Appendix 30: Land use Public Trees by Zone (%)



City of Richmond
Land use Public Trees by Zone
(%)

Zone	Single family residential	Multi-family residential	Industrial/Large commercial	Park/vacant/other	Small commercial	Right-of-way/vacant/other
1	77.81	16.99	0.55	0.00	4.66	0.00
2	30.64	53.19	9.56	0.98	5.64	0.00
3	94.71	0.00	0.00	0.00	5.29	0.00
4	74.03	4.55	0.00	0.00	21.43	0.00
5	57.41	17.49	2.28	10.65	12.17	0.00
6	65.47	3.60	22.30	0.00	4.32	4.32
7	47.27	32.73	6.06	0.61	13.33	0.00
8	83.49	5.50	11.01	0.00	0.00	0.00
9	71.43	28.57	0.00	0.00	0.00	0.00
Citywide total	62.82	21.72	5.44	1.80	7.89	0.33

Appendix 31: Site Type Public Trees by Zone (%)



City of Richmond

Site Type Public Trees by Zone (%)

Zone	Lawn	Parkway	Tree Well	Median	Right-of-way	Other un-maintained locations	Grate	Paver
1	16.44	72.60	2.19	4.66	4.11	0.00	0.00	0.00
2	1.72	30.88	55.64	8.82	0.00	0.00	0.00	2.94
3	24.67	68.72	5.29	1.32	0.00	0.00	0.00	0.00
4	12.99	28.57	0.00	20.78	37.66	0.00	0.00	0.00
5	10.27	53.99	27.38	7.98	0.00	0.38	0.00	0.00
6	12.23	53.96	20.14	0.00	11.51	0.00	0.00	2.16
7	7.88	47.88	15.15	0.61	0.00	0.00	0.00	28.48
8	13.76	36.70	0.00	25.69	23.85	0.00	0.00	0.00
9	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Citywide total	12.08	50.46	20.25	7.51	6.26	0.05	0.00	3.38

Appendix 32: Replacement Value of Public Trees by Species by DBH Class (in)

City of Richmond

Replacement Value of Public Trees by Species

Species	DBH Class (in)									Total	Standard Error	% of Total
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42			
Sugar maple	5,868.87	126,634.80	2,685,977.68	6,738,919.11	6,547,484.41	2,446,760.96	617,747.45	0.00	0.00	19,169,393.28	(±3,367,170)	9.06
Willow oak	3,300.11	379,946.17	907,974.77	2,887,463.29	6,972,968.44	10,302,987.27	16,932,558.19	12,435,016.74	2,554,560.20	53,376,775.19	(±12,870,103)	25.24
Common crapemyrtle	226,251.42	1,031,418.32	585,450.91	114,733.64	0.00	0.00	0.00	0.00	0.00	1,957,854.30	(±538,805)	0.93
Red maple	32,573.69	440,519.17	1,714,301.72	2,837,688.75	3,418,344.34	5,220,413.43	2,216,603.94	545,234.43	0.00	16,425,679.46	(±3,667,471)	7.77
Pin oak	5,444.74	8,889.55	439,568.18	1,392,092.09	1,648,978.84	5,120,399.43	9,519,706.19	8,529,268.42	352,210.34	27,016,557.78	(±6,937,138)	12.77
Japanese zelkova	0.00	145,106.08	1,275,635.45	6,435,301.95	6,691,892.46	931,295.74	0.00	0.00	0.00	15,479,231.67	(±2,814,202)	7.32
Winged elm	7,686.70	10,741.54	246,244.58	2,333,963.92	2,827,575.89	2,093,136.25	301,443.84	0.00	0.00	7,820,792.72	(±1,707,883)	3.70
Green ash	3,086.42	38,489.59	290,368.88	1,267,166.18	1,577,592.60	2,426,718.55	2,623,524.54	670,940.40	0.00	8,897,887.16	(±2,630,825)	4.21
Callery pear	0.00	102,865.16	610,207.23	1,097,933.56	326,354.36	0.00	0.00	0.00	0.00	2,137,360.31	(±870,420)	1.01
Hedge maple	6,431.39	129,831.75	1,220,173.04	81,243.01	0.00	0.00	0.00	0.00	0.00	1,437,679.19	(±462,684)	0.68
American sycamore	15,533.53	1,481.59	129,602.41	533,082.88	2,457,612.69	2,811,030.09	1,281,136.30	0.00	0.00	7,229,479.50	(±4,731,194)	3.42
Ginkgo	32,370.10	15,899.84	245,143.44	1,411,900.60	1,181,538.54	788,267.55	2,081,071.50	1,520,917.10	0.00	7,277,108.68	(±2,612,563)	3.44
Loblolly pine	0.00	26,646.64	135,977.62	2,485,305.10	2,863,038.42	348,390.29	0.00	0.00	0.00	5,859,358.07	(±2,131,488)	2.77
Chinese pistache	15,232.23	160,829.64	952,368.83	0.00	0.00	0.00	0.00	0.00	0.00	1,128,430.70	(±512,257)	0.53
Sweetgum	5,069.43	111,195.52	344,956.26	479,759.53	317,557.81	284,976.35	414,268.60	0.00	0.00	1,957,783.51	(±607,365)	0.93
American elm	0.00	22,506.26	0.00	28,072.20	471,415.99	1,733,720.90	1,979,715.21	794,745.32	378,388.13	5,408,564.01	(±1,253,282)	2.56
Unknown shrub	84,540.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84,540.96	(±42,042)	0.04
Littleleaf linden	5,444.74	10,371.14	286,205.32	740,239.45	126,844.53	164,337.14	0.00	0.00	0.00	1,333,442.32	(±531,739)	0.63
London planetree	0.00	19,631.09	136,082.53	452,982.35	845,630.17	1,427,138.36	0.00	0.00	0.00	2,881,464.50	(±2,097,197)	1.36
Norway maple	0.00	16,167.92	259,421.36	836,599.46	0.00	522,838.16	0.00	0.00	0.00	1,635,026.91	(±428,191)	0.77
Silver maple	4,263.13	13,040.33	236,317.06	467,231.63	416,866.23	180,316.78	399,976.04	0.00	0.00	1,718,011.21	(±483,666)	0.81
Kwanzan cherry	16,974.79	28,150.24	281,885.24	118,769.76	0.00	0.00	0.00	0.00	0.00	445,780.03	(±222,862)	0.21
Flowering dogwood	6,988.46	71,329.07	219,105.88	277,272.96	177,120.86	0.00	0.00	0.00	0.00	751,817.23	(±248,664)	0.36

Eastern red cedar	16,203.69	43,142.18	294,618.18	0.00	460,131.18	0.00	0.00	0.00	0.00	814,095.22	(±312,136)	0.38
Eastern redbud	3,010.72	28,690.67	433,572.40	0.00	0.00	0.00	0.00	0.00	0.00	465,273.80	(±172,703)	0.22
Holly	36,301.17	0.00	119,193.60	0.00	0.00	0.00	0.00	0.00	0.00	155,494.77	(±130,907)	0.07
Yoshino flowering cherry	23,220.23	35,928.60	87,481.63	0.00	47,566.70	0.00	0.00	0.00	0.00	194,197.15	(±69,368)	0.09
White oak	3,192.87	13,942.72	94,683.88	165,970.74	600,011.90	738,558.30	0.00	1,304,277.77	0.00	2,920,638.19	(±1,205,644)	1.38
Goldenrain tree	0.00	90,091.02	150,141.96	0.00	0.00	0.00	0.00	0.00	0.00	240,232.97	(±143,063)	0.11
Eastern hemlock	0.00	0.00	0.00	559,523.83	754,694.46	268,138.19	0.00	0.00	0.00	1,582,356.48	(±1,549,944)	0.75
Japanese pagoda tree	0.00	0.00	119,829.78	111,068.06	818,275.77	0.00	0.00	0.00	0.00	1,049,173.61	(±695,528)	0.50
Northern red oak	11,838.35	0.00	4,992.91	94,734.52	214,010.59	299,610.33	883,423.63	0.00	643,714.93	2,152,325.25	(±835,281)	1.02
Chinese elm	6,412.94	122,522.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	128,935.26	(±81,644)	0.06
Downy serviceberry	24,362.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24,362.55	(±19,285)	0.01
Leyland cypress	0.00	23,685.90	212,465.04	0.00	0.00	0.00	0.00	0.00	0.00	236,150.94	(±231,314)	0.11
Plum	5,444.74	5,185.57	166,323.09	0.00	0.00	0.00	0.00	0.00	0.00	176,953.41	(±114,380)	0.08
Japanese maple	16,500.53	27,580.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44,081.11	(±26,810)	0.02
Paperbark maple	0.00	0.00	417,177.60	0.00	0.00	0.00	0.00	0.00	0.00	417,177.60	(±408,632)	0.20
Honeylocust	5,176.66	0.00	38,416.07	277,324.58	167,904.46	0.00	0.00	0.00	0.00	488,821.77	(±245,389)	0.23
Tulip tree	3,836.27	0.00	53,877.77	81,243.01	565,277.87	328,692.61	379,104.41	0.00	0.00	1,412,031.95	(±708,841)	0.67
Water oak	0.00	0.00	32,783.32	0.00	469,060.12	391,300.49	411,450.33	531,709.93	0.00	1,836,304.19	(±846,896)	0.87
Northern white cedar	0.00	86,284.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86,284.35	(±84,517)	0.04
Slippery elm	0.00	0.00	51,840.96	160,201.07	126,844.53	250,830.38	0.00	0.00	0.00	589,716.94	(±270,575)	0.28
European hornbeam	6,114.90	46,126.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52,241.03	(±33,865)	0.02
Amur maple	7,672.53	0.00	76,062.73	0.00	0.00	0.00	0.00	0.00	0.00	83,735.27	(±50,075)	0.04
Kousa dogwood	14,916.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14,916.13	(±8,920)	0.01
Crabapple	0.00	0.00	42,068.33	152,978.19	0.00	0.00	0.00	0.00	0.00	195,046.52	(±191,051)	0.09
Post oak	0.00	0.00	0.00	128,225.15	175,288.07	288,323.00	332,283.95	0.00	0.00	924,120.17	(±450,136)	0.44
Black locust	0.00	0.00	3,983.67	20,078.22	90,830.80	0.00	0.00	0.00	0.00	114,892.68	(±112,539)	0.05
American hornbeam	3,836.27	17,071.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20,907.57	(±15,242)	0.01
Chinese magnolia; Saucer magnolia	0.00	0.00	94,901.05	0.00	0.00	0.00	0.00	0.00	0.00	94,901.05	(±92,957)	0.04
Sawtooth oak	3,836.27	0.00	107,755.54	0.00	0.00	0.00	0.00	0.00	0.00	111,591.81	(±81,354)	0.05
Southern red oak	0.00	0.00	0.00	0.00	652,980.03	0.00	0.00	0.00	0.00	652,980.03	(±367,938)	0.31

Tree of heaven	0.00	0.00	0.00	42,068.33	111,068.06	0.00	0.00	0.00	0.00	153,136.39	(±105,874)	0.07
Northern hackberry	0.00	0.00	31,975.92	0.00	0.00	0.00	399,339.44	0.00	0.00	431,315.37	(±298,198)	0.20
White ash	0.00	0.00	0.00	52,798.59	248,324.76	0.00	0.00	0.00	0.00	301,123.35	(±208,187)	0.14
Star magnolia	388.25	16,167.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16,556.17	(±11,446)	0.01
Black tupelo	3,568.19	0.00	0.00	0.00	0.00	421,560.22	0.00	0.00	0.00	425,128.40	(±293,920)	0.20
Eastern hophornbeam	0.00	0.00	91,909.14	0.00	0.00	0.00	0.00	0.00	0.00	91,909.14	(±63,543)	0.04
Eastern white pine	0.00	0.00	0.00	66,290.10	126,844.53	0.00	0.00	0.00	0.00	193,134.63	(±133,527)	0.09
Carolina laurelcherry	3,275.65	11,884.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15,160.47	(±10,481)	0.01
Black cherry	10,202.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10,202.71	(±9,994)	0.00
English oak	0.00	22,417.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22,417.01	(±21,958)	0.01
Boxelder	0.00	0.00	0.00	0.00	0.00	133,944.18	0.00	0.00	0.00	133,944.18	(±131,201)	0.06
Pignut hickory	0.00	0.00	52,162.06	0.00	0.00	0.00	0.00	0.00	0.00	52,162.06	(±51,094)	0.02
Mockernut hickory	0.00	0.00	53,877.77	0.00	0.00	0.00	0.00	0.00	0.00	53,877.77	(±52,774)	0.03
Common persimmon	0.00	13,933.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13,933.93	(±13,649)	0.01
European beech	0.00	0.00	45,299.23	0.00	0.00	0.00	0.00	0.00	0.00	45,299.23	(±44,371)	0.02
Black ash	0.00	0.00	51,018.26	0.00	0.00	0.00	0.00	0.00	0.00	51,018.26	(±49,973)	0.02
American holly	0.00	13,790.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13,790.29	(±13,508)	0.01
Black walnut	0.00	0.00	0.00	0.00	231,167.67	0.00	0.00	0.00	0.00	231,167.67	(±226,432)	0.11
Privet	2,329.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,329.49	(±2,282)	0.00
Red mulberry	0.00	0.00	0.00	0.00	177,120.86	0.00	0.00	0.00	0.00	177,120.86	(±173,493)	0.08
Blue spruce	3,432.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,432.15	(±3,362)	0.00
Eastern cottonwood	0.00	0.00	0.00	162,539.32	0.00	0.00	0.00	0.00	0.00	162,539.32	(±159,210)	0.08
Scarlet oak	0.00	0.00	0.00	0.00	163,177.18	0.00	0.00	0.00	0.00	163,177.18	(±159,835)	0.08
Sassafras	0.00	0.00	0.00	15,085.31	0.00	0.00	0.00	0.00	0.00	15,085.31	(±14,776)	0.01
Corkscrew willow	0.00	14,827.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14,827.52	(±14,524)	0.01
Baldcypress	3,300.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,300.11	(±3,233)	0.00
American basswood	4,908.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,908.58	(±4,808)	0.00
Viburnum	2,329.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,329.49	(±2,282)	0.00
Citywide total	702,672.15	3,544,964.24	16,131,380.30	35,107,850.47	45,069,396.11	39,923,684.96	40,773,353.57	26,332,110.10	3,928,873.60	211,514,285.51	(±16,440,960)	100.00

Appendix 33: Replacement Value of Public Trees by Zone by DBH Class (in)

City of Richmond

Replacement Value of Public Trees by Zone

DBH Class(in)

Zone	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42	Total	Standard Error	% of Total
1	232,288.50	713,243.58	1,732,947.93	6,757,706.52	9,529,832.05	9,059,702.08	13,845,553.91	7,104,238.36	2,136,721.77	51,112,234.71	(±8,297,091)	24.16
2	181,400.90	1,038,604.89	3,496,955.15	7,389,531.10	6,418,151.62	8,747,381.34	14,395,824.02	7,125,610.77	796,226.56	49,589,686.34	(±12,317,439)	23.45
3	44,082.46	259,775.42	2,326,374.01	4,694,466.70	6,842,389.91	8,888,689.96	4,474,088.47	3,872,950.20	0.00	31,402,817.14	(±12,972,825)	14.85
4	107,207.31	165,638.10	1,739,986.81	2,550,246.89	3,627,214.92	1,038,168.63	0.00	1,398,909.39	0.00	10,627,372.06	(±2,745,252)	5.02
5	65,818.71	525,295.79	3,016,325.54	5,480,021.57	7,833,191.88	5,399,033.94	2,114,392.73	2,571,174.53	0.00	27,005,254.70	(±4,695,849)	12.77
6	17,441.80	386,726.85	915,183.14	2,902,302.36	3,481,994.88	2,230,517.87	1,460,013.94	1,341,880.80	643,714.93	13,379,776.57	(±2,615,881)	6.33
7	54,432.46	231,126.88	1,439,582.14	2,740,353.79	4,486,893.90	2,187,883.30	2,727,897.85	1,908,299.35	352,210.34	16,128,680.01	(±1,602,778)	7.63
8	0.00	224,552.72	1,464,025.59	2,374,165.59	2,073,705.19	1,940,991.62	1,755,582.65	1,009,046.70	0.00	10,842,070.07	(±1,391,685)	5.13
9	0.00	0.00	0.00	219,055.95	776,021.75	431,316.21	0.00	0.00	0.00	1,426,393.91	(±441,585)	0.67
Citywide total	702,672.15	3,544,964.24	16,131,380.30	35,107,850.47	45,069,396.11	39,923,684.96	40,773,353.57	26,332,110.10	3,928,873.60	211,514,285.51	(±16,432,010)	100.00

Appendix 34: Stored CO2 Benefits of Public Trees by Species

City of Richmond

Stored CO2 Benefits of Public Trees by Species

Species	Total stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Sugar maple	23,595,047.78	176,962.86	(±31,084)	12.36	9.12	30.25
Willow oak	56,413,467.76	423,101.01	(±102,017)	9.31	21.81	96.03
Common crapemyrtle	233,417.74	1,750.63	(±482)	8.77	0.09	0.42
Red maple	15,576,063.50	116,820.48	(±26,083)	8.06	6.02	30.63
Pin oak	58,791,554.50	440,936.66	(±113,221)	7.19	22.73	129.64
Japanese zelkova	13,082,303.20	98,117.27	(±17,838)	7.03	5.06	29.52
Winged elm	9,339,371.80	70,045.29	(±15,296)	4.30	3.61	34.41
Green ash	11,454,209.97	85,906.57	(±25,400)	2.89	4.43	62.91
Callery pear	1,920,717.45	14,405.38	(±5,866)	2.51	0.74	12.15
Hedge maple	1,007,423.71	7,555.68	(±2,432)	2.45	0.39	6.52
American sycamore	9,817,811.73	73,633.59	(±48,188)	2.40	3.80	64.95
Ginkgo	4,877,344.23	36,580.08	(±13,133)	2.23	1.89	34.63
Loblolly pine	3,266,285.89	24,497.14	(±8,911)	2.23	1.26	23.19
Chinese pistache	608,571.01	4,564.28	(±2,072)	1.96	0.24	4.92
Sweetgum	1,225,221.74	9,189.16	(±2,851)	1.74	0.47	11.14
American elm	14,135,016.16	106,012.62	(±24,565)	1.69	5.46	132.72
Unknown shrub	8,358.31	62.69	(±31)	1.58	0.00	0.08
Littleleaf linden	1,988,568.17	14,914.26	(±5,947)	1.47	0.77	21.44
London planetree	3,693,051.86	27,697.89	(±20,159)	1.20	1.43	48.86
Norway maple	1,508,591.96	11,314.44	(±2,963)	1.03	0.58	23.11
Silver maple	2,241,256.71	16,809.43	(±4,732)	1.03	0.87	34.34
Kwanzan cherry	594,753.57	4,460.65	(±2,230)	1.03	0.23	9.11
Other street trees	10,570,584.59	174,780.92	(±20,013)	15.52	9.01	23.80
Citywide total	258,682,530.96	1,940,118.98	(±150,805)	100.00	100.00	41.01

Appendix 35: Stored CO2 Benefits of Public Trees by Zone

City of Richmond

Stored CO2 Benefits of Public Trees by Zone

Zone	Total stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
1	60,381,352.59	452,860.14	(±73,513)	19.83	23.34	48.28
2	63,143,079.64	473,573.10	(±117,629)	22.22	24.41	45.05
3	40,534,498.05	304,008.74	(±125,589)	12.36	15.67	51.98
4	10,476,941.69	78,577.06	(±20,298)	8.39	4.05	19.80
5	30,187,432.34	226,405.74	(±39,369)	14.32	11.67	33.41
6	17,363,776.27	130,228.32	(±25,461)	7.57	6.71	36.36
7	23,640,147.30	177,301.10	(±17,619)	8.99	9.14	41.70
8	11,784,722.17	88,385.42	(±11,345)	5.94	4.56	31.47
9	1,170,580.92	8,779.36	(±2,718)	0.38	0.45	48.67
Citywide total	258,682,530.96	1,940,118.98	(±150,805)	100.00	100.00	41.01

Appendix 36: Annual CO2 Benefits of Public Trees by Species

City of Richmond Annual CO2 Benefits of Public Trees by Species

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total (\$)	Standard Error	% of Total Tree No.	% of Total \$	Avg. \$/tree
Sugar maple	2,052,742.65	15,395.57	- 81,184.34	- 6,109.56	- 654.70	610,715.34	4,580.37	2,576,164.10	19,321.23	(±3,394)	12.36	12.66	3.30
Willow oak	2,597,128.09	19,478.46	- 193,419.08	- 6,838.48	- 1,501.93	604,885.86	4,536.64	3,001,756.39	22,513.17	(±5,428)	9.31	14.75	5.11
Crapemyrtle	57,869.72	434.02	- 832.76	- 1,048.25	- 14.11	30,168.21	226.26	86,156.91	646.18	(±178)	8.77	0.42	0.16
Red maple	1,377,067.34	10,328.01	- 54,272.68	- 3,504.64	- 433.33	282,020.61	2,115.15	1,601,310.63	12,009.83	(±2,682)	8.06	7.87	3.15
Pin oak	2,531,809.47	18,988.57	- 201,572.52	- 6,506.77	- 1,560.59	601,488.84	4,511.17	2,925,219.02	21,939.14	(±5,633)	7.19	14.37	6.45
Japanese zelkova	1,281,506.22	9,611.30	- 44,853.61	- 3,490.36	- 362.58	252,536.37	1,894.02	1,485,698.62	11,142.74	(±2,026)	7.03	7.30	3.35
Winged elm	986,490.41	7,398.68	- 32,023.95	- 2,482.10	- 258.80	189,714.86	1,422.86	1,141,699.22	8,562.74	(±1,870)	4.30	5.61	4.21
Green ash	701,196.69	5,258.98	- 39,273.05	- 1,830.87	- 308.28	150,377.84	1,127.83	810,470.61	6,078.53	(±1,797)	2.89	3.98	4.45
Callery pear	233,188.62	1,748.91	- 6,773.80	- 905.44	- 57.59	51,958.99	389.69	277,468.38	2,081.01	(±847)	2.51	1.36	1.76
Hedge maple	246,658.08	1,849.94	- 3,743.04	- 645.52	- 32.91	50,634.37	379.76	292,903.89	2,196.78	(±707)	2.45	1.44	1.89
Am. sycamore	632,611.40	4,744.59	- 33,665.50	- 1,605.22	- 264.53	133,203.27	999.02	730,543.94	5,479.08	(±3,586)	2.40	3.59	4.83
Ginkgo	447,776.80	3,358.33	- 16,771.86	- 1,002.55	- 133.31	79,980.60	599.85	509,982.99	3,824.87	(±1,373)	2.23	2.51	3.62
Loblolly pine	323,307.95	2,424.81	- 11,198.69	- 1,256.76	- 93.42	83,472.18	626.04	394,324.68	2,957.44	(±1,076)	2.23	1.94	2.80
Chinese pistache	155,887.51	1,169.16	- 2,405.25	- 442.72	- 21.36	33,662.16	252.47	186,701.71	1,400.26	(±636)	1.96	0.92	1.51
Sweetgum	130,421.55	978.16	- 4,201.25	- 651.23	- 36.39	38,704.90	290.29	164,273.97	1,232.05	(±382)	1.74	0.81	1.49
American elm	633,766.85	4,753.25	- 48,462.91	- 1,593.99	- 375.43	147,735.26	1,108.01	731,445.22	5,485.84	(±1,271)	1.69	3.59	6.87
Unknown shrub	4,587.31	34.40	- 66.87	- 82.83	- 1.12	4,180.45	31.35	8,618.07	64.64	(±32)	1.58	0.04	0.09
Littleleaf linden	370,001.61	2,775.01	- 6,871.40	- 625.52	- 56.23	52,109.40	390.82	414,614.09	3,109.61	(±1,240)	1.47	2.04	4.47
London planetree	274,823.25	2,061.17	- 12,661.89	- 714.07	- 100.32	56,410.59	423.08	317,857.88	2,383.93	(±1,735)	1.20	1.56	4.21
Norway maple	165,715.16	1,242.86	- 5,172.32	- 465.57	- 42.28	32,310.06	242.33	192,387.34	1,442.91	(±378)	1.03	0.95	2.95
Silver maple	208,892.43	1,566.69	- 7,712.03	- 508.42	- 61.65	44,909.78	336.82	245,581.77	1,841.86	(±519)	1.03	1.21	3.76
Kwanzan cherry	55,533.51	416.50	- 2,044.43	- 257.06	- 17.26	11,598.13	86.99	64,830.16	486.23	(±243)	1.03	0.32	0.99
Other trees	1,909,322.58	14,319.92	- 80,393.59	- 5,438.52	- 643.74	370,766.77	2,780.75	2,194,257.23	16,456.93	(±1,884)	15.52	10.78	2.24
Citywide total	17,378,305.20	130,337.29	- 889,576.82	- 48,006.43	- 7,031.87	3,913,544.86	29,351.59	20,354,266.81	152,657.00	(±11,866)	100.00	100.00	3.23

Appendix 37: Annual CO2 Benefits of Public Trees by Zone

City of Richmond

Annual CO2 Benefits of Public Trees by Zone

Zone	Sequestered (lb)	Sequestered (\$)	Decomposition Release(lb)	Maintenance Release (lb)	Total Release (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
1	3,545,071.72	26,588.04	- 207,320.98	- 9,851.84	- 1,628.80	821,214.13	6,159.11	4,149,113.03	31,118.35	(±5,051)	19.83	20.38	3.32
2	3,784,734.89	28,385.51	- 217,568.24	- 10,551.24	- 1,710.90	897,457.55	6,730.93	4,454,072.96	33,405.55	(±8,298)	22.22	21.88	3.18
3	2,783,599.05	20,876.99	- 139,270.99	- 7,023.56	- 1,097.21	596,709.64	4,475.32	3,234,014.14	24,255.11	(±10,020)	12.36	15.89	4.15
4	925,667.77	6,942.51	- 36,022.50	- 2,959.09	- 292.36	207,092.22	1,553.19	1,093,778.39	8,203.34	(±2,119)	8.39	5.37	2.07
5	2,415,155.36	18,113.67	- 103,942.80	- 6,717.94	- 829.96	536,016.41	4,020.12	2,840,511.04	21,303.83	(±3,704)	14.32	13.96	3.14
6	1,307,249.83	9,804.37	- 59,670.13	- 3,579.09	- 474.37	281,630.45	2,112.23	1,525,631.05	11,442.23	(±2,237)	7.57	7.50	3.19
7	1,601,742.68	12,013.07	- 81,290.59	- 4,293.16	- 641.88	351,795.30	2,638.46	1,867,954.24	14,009.66	(±1,392)	8.99	9.18	3.30
8	915,178.91	6,863.84	- 40,477.17	- 2,762.01	- 324.29	200,598.84	1,504.49	1,072,538.57	8,044.04	(±1,033)	5.94	5.27	2.86
9	99,904.99	749.29	- 4,013.42	- 268.49	- 32.11	21,030.32	157.73	116,653.40	874.90	(±271)	0.38	0.57	4.85
Citywide total	17,378,305.20	130,337.29	- 889,576.82	- 48,006.43	- 7,031.87	3,913,544.86	29,351.59	20,354,266.81	152,657.00	(±11,866)	100.00	100.00	3.23

Appendix 38: Annual Air Quality Benefits of Public Trees by Species

City of Richmond Annual Air Quality Benefits of Public Trees by Species

Species	Deposition O3 (lb)	Deposition NO2 (lb)	Deposition PM10 (lb)	Deposition SO2 (lb)	Total Deposition (\$)	Avoided NO2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	Avoided SO2 (lb)	Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total (\$)	Standard Error	% of Total Tree Numbers	Avg. \$/tree
Sugar maple	937.75	402.26	969.48	191.61	11,568.52	1,507.61	296.83	291.63	3,303.98	18,948.38	- 1,221.61	- 7,647.30	6,679.53	22,869.59	(±4,017)	12.36	3.91
Willow oak	1,146.83	539.84	1,318.59	264.75	14,852.51	1,450.90	289.80	285.35	3,252.71	18,419.13	- 16,092.45	- 100,738.74	- 7,543.68	- 67,467.09	(±16,268)	9.31	- 15.31
Common crapemyrtle	67.59	24.06	62.78	10.77	777.88	80.75	15.11	14.73	163.11	980.07	0.00	0.00	438.91	1,757.95	(±484)	8.77	0.42
Red maple	555.10	197.62	515.58	88.49	6,388.40	691.70	136.63	134.30	1,523.71	8,713.27	- 812.49	- 5,086.16	3,030.63	10,015.50	(±2,236)	8.06	2.63
Pin oak	1,142.40	537.75	1,313.50	263.73	14,795.10	1,435.81	287.49	283.19	3,231.34	18,258.88	- 16,615.74	- 104,014.53	- 8,120.54	- 70,960.55	(±18,221)	7.19	- 20.86
Japanese zelkova	450.01	211.83	517.41	103.89	5,828.06	628.13	123.37	121.16	1,371.20	7,881.15	- 4,417.02	- 27,650.53	- 890.02	- 13,941.32	(±2,535)	7.03	- 4.19
Winged elm	355.00	126.38	329.72	56.59	4,085.54	452.97	91.19	89.90	1,028.17	5,782.33	0.00	0.00	2,529.93	9,867.88	(±2,155)	4.30	4.85
Green ash	279.70	131.66	321.59	64.57	3,622.34	366.23	72.62	71.43	811.70	4,625.79	- 3,459.24	- 21,654.84	- 1,339.75	- 13,406.71	(±3,964)	2.89	- 9.82
Callery pear	127.65	53.66	130.33	27.98	1,567.22	129.89	25.39	24.92	281.42	1,624.38	0.00	0.00	801.24	3,191.60	(±1,300)	2.51	2.69
Hedge maple	102.76	36.58	95.44	16.38	1,182.61	127.75	24.80	24.31	273.68	1,589.80	- 3.82	- 23.93	697.87	2,748.48	(±885)	2.45	2.37
American sycamore	249.13	117.27	286.45	57.51	3,226.52	325.42	64.42	63.35	719.38	4,105.66	- 3,026.58	- 18,946.41	- 1,143.64	- 11,614.23	(±7,601)	2.40	- 10.24
Ginkgo	160.15	57.01	148.75	25.53	1,843.13	195.56	38.71	38.06	432.18	2,466.93	- 13.34	- 83.50	1,082.61	4,226.56	(±1,517)	2.23	4.00
Loblolly pine	399.20	135.27	290.77	79.61	4,381.58	195.50	39.86	39.37	452.55	2,517.72	- 2,241.39	- 14,031.08	- 609.28	- 7,131.78	(±2,594)	2.23	- 6.75
Chinese pistache	68.76	24.48	63.86	10.96	791.33	85.30	16.51	16.18	181.89	1,059.40	- 2.39	- 14.96	465.55	1,835.77	(±833)	1.96	1.98
Sweetgum	71.15	25.33	66.09	11.34	818.87	95.75	18.87	18.54	210.08	1,204.01	- 904.11	- 5,659.72	- 386.97	- 3,636.84	(±1,128)	1.74	- 4.41
American elm	282.29	132.88	324.57	65.17	3,655.95	353.57	70.70	69.62	793.97	4,491.83	- 4,042.51	- 25,306.13	- 1,949.75	- 17,158.34	(±3,976)	1.69	- 21.48
Unknown shrub	12.84	4.19	10.91	2.03	142.72	11.82	2.15	2.08	22.69	140.50	0.00	0.00	68.71	283.22	(±141)	1.58	0.38
Littleleaf linden	102.77	36.59	95.45	16.38	1,182.74	128.70	25.34	24.90	282.11	1,617.71	- 6.12	- 38.33	706.12	2,762.13	(±1,101)	1.47	3.97
London planetree	103.55	48.74	119.06	23.91	1,341.09	138.63	27.38	26.91	305.26	1,746.02	- 1,170.90	- 7,329.85	- 377.46	- 4,242.74	(±3,088)	1.20	- 7.48
Norway maple	56.21	26.46	64.63	12.98	727.97	80.52	15.81	15.52	175.64	1,009.96	- 517.57	- 3,239.99	- 69.81	- 1,502.06	(±393)	1.03	- 3.07
Silver maple	89.56	31.89	83.19	14.28	1,030.76	110.47	21.77	21.40	242.52	1,389.52	- 78.20	- 489.54	536.88	1,930.75	(±544)	1.03	3.94
Kwanzan cherry	30.36	9.90	25.78	4.81	337.37	30.17	5.74	5.61	62.67	370.54	0.00	0.00	175.05	707.91	(±354)	1.03	1.45
Other street trees	889.33	343.96	838.50	172.25	10,505.29	909.15	179.48	176.41	2,000.92	11,447.95	- 3,357.77	- 21,019.61	2,152.24	933.63	(±107)	15.52	0.13
Citywide total	7,680.10	3,255.61	7,992.43	1,585.51	94,653.50	9,532.27	1,889.98	1,858.86	21,122.87	120,390.92	- 57,983.25	- 362,975.14	- 3,065.62	- 147,930.71	(±11,499)	100.00	- 3.13

Appendix 39: Annual Air Quality Benefits of Public Trees by Zone

City of Richmond

Annual Air Quality Benefits of Public Trees by Zone

Species	Depositi on O3 (lb)	Depositi on NO2 (lb)	Depositi on PM10 (lb)	Depositi on SO2 (lb)	Total Depositi on (\$)	Avoided NO2 (lb)	Avoided PM10 (lb)	Avoided VOC (lb)	Avoided SO2 (lb)	Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total (\$)	Standard Error	% of Total Tree Number s	Avg. \$/tre e
1	1,684.36	710.72	1,732.72	349.92	20,691.64	1,986.29	395.29	389.00	4,427.31	25,151.39	14,100.55	- 88,269.44	2,424.94	- 42,426.41	(±-6,887)	19.83	- 4.52
2	1,655.61	731.23	1,796.43	353.54	20,803.43	2,185.73	433.13	425.96	4,839.21	27,594.75	15,014.50	- 93,990.74	2,593.65	- 45,592.56	(±-11,325)	22.22	- 4.34
3	1,123.85	479.98	1,193.97	229.33	13,929.85	1,453.12	288.15	283.41	3,220.60	18,354.14	- 8,657.18	- 54,193.94	- 384.77	- 21,909.95	(±-9,051)	12.36	- 3.75
4	497.14	194.84	463.28	100.24	5,883.51	508.39	100.45	98.74	1,120.41	6,405.46	- 2,227.61	- 13,944.84	855.89	- 1,655.87	(±-428)	8.39	- 0.42
5	1,073.76	439.09	1,076.18	214.52	13,011.51	1,309.35	259.29	254.97	2,895.78	16,522.63	- 5,046.73	- 31,592.50	2,476.21	- 2,058.36	(±-358)	14.32	- 0.30
6	516.96	222.87	552.82	106.67	6,432.58	688.69	136.32	134.04	1,522.05	8,687.91	- 4,032.67	- 25,244.53	- 152.24	- 10,124.03	(±-1,979)	7.57	- 2.83
7	658.37	287.69	711.76	138.41	8,241.63	859.16	170.07	167.23	1,899.00	10,838.86	- 5,698.05	- 35,669.77	- 806.35	- 16,589.27	(±-1,649)	8.99	- 3.90
8	403.46	164.72	409.19	79.60	4,897.24	490.91	97.15	95.53	1,084.67	6,192.17	- 2,776.26	- 17,379.40	48.96	- 6,289.99	(±-807)	5.94	- 2.24
9	66.57	24.47	56.07	13.29	762.10	50.63	10.13	9.98	113.84	643.61	- 429.71	- 2,689.98	- 84.73	- 1,284.26	(±-398)	0.38	- 7.12
Citywide total	7,680.10	3,255.61	7,992.43	1,585.51	94,653.50	9,532.27	1,889.98	1,858.86	21,122.87	120,390.92	57,983.25	362,975.14	3,065.62	147,930.71	(±-11,499)	100.00	- 3.13

Appendix 40: Annual Stormwater Benefits of Public Trees by Species

City of Richmond

Annual Stormwater Benefits of Public Trees by Species

Species	Total Rainfall Interception (Gal)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Sugar maple	19,430,261.11	192,372.96	(±33,791)	12.36	11.75	32.89
Willow oak	31,461,340.60	311,488.92	(±75,106)	9.31	19.03	70.69
Common crapemyrtle	537,399.49	5,320.62	(±1,464)	8.77	0.33	1.28
Red maple	11,766,302.14	116,494.49	(±26,011)	8.06	7.12	30.55
Pin oak	32,132,865.67	318,137.49	(±81,689)	7.19	19.43	93.54
Japanese zelkova	9,874,428.84	97,763.64	(±17,774)	7.03	5.97	29.41
Winged elm	6,456,502.46	63,923.82	(±13,960)	4.30	3.90	31.40
Green ash	7,084,032.73	70,136.80	(±20,737)	2.89	4.28	51.36
Callery pear	1,308,279.46	12,952.87	(±5,275)	2.51	0.79	10.93
Hedge maple	1,238,668.80	12,263.67	(±3,947)	2.45	0.75	10.58
American sycamore	6,253,600.56	61,914.95	(±40,519)	2.40	3.78	54.61
Ginkgo	2,981,226.94	29,516.20	(±10,597)	2.23	1.80	27.94
Loblolly pine	3,315,033.86	32,821.12	(±11,940)	2.23	2.00	31.07
Chinese pistache	804,195.74	7,962.09	(±3,614)	1.96	0.49	8.58
Sweetgum	1,444,522.59	14,301.77	(±4,437)	1.74	0.87	17.35
American elm	7,870,054.52	77,918.96	(±18,056)	1.69	4.76	97.55
Unknown shrub	78,618.49	778.38	(±387)	1.58	0.05	1.04
Littleleaf linden	1,570,494.08	15,548.97	(±6,200)	1.47	0.95	22.35
London planetree	2,482,039.62	24,573.90	(±17,885)	1.20	1.50	43.35
Norway maple	1,184,762.51	11,729.96	(±3,072)	1.03	0.72	23.96
Silver maple	1,446,106.10	14,317.45	(±4,031)	1.03	0.87	29.25
Kwanzan cherry	242,176.51	2,397.71	(±1,199)	1.03	0.15	4.90
Other street trees	14,383,926.27	142,410.77	(±16,306)	15.52	8.70	19.39
Citywide total	165,346,839.09	1,637,047.50	(±127,247)	100.00	100.00	34.60

Appendix 41: Annual Stormwater Benefits of Public Trees by Zone

City of Richmond

Annual Stormwater Benefits of Public Trees by Zone

Zone	Total rainfall interception(Gal)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
1	36,762,199.02	363,971.07	(±59,084)	19.83	22.23	38.81
2	38,866,814.26	384,808.21	(±95,581)	22.22	23.51	36.60
3	26,382,417.90	261,204.09	(±107,906)	12.36	15.96	44.66
4	7,715,622.82	76,389.98	(±19,733)	8.39	4.67	19.25
5	20,031,241.50	198,323.08	(±34,486)	14.32	12.11	29.27
6	11,676,334.31	115,603.75	(±22,602)	7.57	7.06	32.28
7	14,878,268.90	147,305.10	(±14,638)	8.99	9.00	34.65
8	8,094,962.59	80,145.70	(±10,287)	5.94	4.90	28.54
9	938,977.79	9,296.53	(±2,878)	0.38	0.57	51.54
Citywide total	165,346,839.09	1,637,047.50	(±127,247)	100.00	100.00	34.60

Appendix 42: Annual Aesthetic/Other Benefit of Public Trees by Species

City of Richmond

Annual Aesthetic/Other Benefit of Public Trees by Species

Species	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Sugar maple	321,458.92 (±56,465)		12.36	14.55	54.96
Willow oak	321,225.70 (±77,453)		9.31	14.54	72.90
Common crapemyrtle	9,263.19 (±2,549)		8.77	0.42	2.23
Red maple	212,402.76 (±47,425)		8.06	9.62	55.70
Pin oak	300,325.87 (±77,116)		7.19	13.60	88.30
Japanese zelkova	194,232.80 (±35,312)		7.03	8.79	58.44
Winged elm	85,099.40 (±18,584)		4.30	3.85	41.81
Green ash	93,798.43 (±27,733)		2.89	4.25	68.68
Callery pear	22,817.11 (±9,292)		2.51	1.03	19.25
Hedge maple	29,923.99 (±9,630)		2.45	1.35	25.81
American sycamore	83,172.34 (±54,431)		2.40	3.77	73.36
Ginkgo	46,017.42 (±16,521)		2.23	2.08	43.56
Loblolly pine	44,356.07 (±16,136)		2.23	2.01	41.99
Chinese pistache	20,763.04 (±9,425)		1.96	0.94	22.38
Sweetgum	32,799.55 (±10,175)		1.74	1.48	39.78
American elm	74,342.43 (±17,227)		1.69	3.37	93.07
Unknown shrub	1,954.32 (±972)		1.58	0.09	2.62
Littleleaf linden	28,939.18 (±11,540)		1.47	1.31	41.60
London planetree	38,152.52 (±27,768)		1.20	1.73	67.30
Norway maple	26,315.16 (±6,892)		1.03	1.19	53.75
Silver maple	23,269.38 (±6,551)		1.03	1.05	47.53
Kwanzan cherry	3,164.64 (±1,582)		1.03	0.14	6.46
Other street trees	195,166.75 (±22,347)		15.52	8.84	26.58
Citywide total	2,208,961.00 (±171,702)		100.00	100.00	46.69

Appendix 43: Annual Aesthetic/Other Benefit of Public Trees by Zone

City of Richmond

Annual Aesthetic/Other Benefit of Public Trees by Zone

Zone	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total (\$)	Avg \$/tree
1	428,753.21 (±69,600)		19.83	19.41	45.71
2	493,132.91 (±122,488)		22.22	22.32	46.91
3	365,571.73 (±151,021)		12.36	16.55	62.50
4	126,357.18 (±32,640)		8.39	5.72	31.84
5	278,876.71 (±48,493)		14.32	12.62	41.15
6	175,572.84 (±34,326)		7.57	7.95	49.02
7	202,460.86 (±20,119)		8.99	9.17	47.62
8	124,963.10 (±16,040)		5.94	5.66	44.49
9	13,272.44 (±4,109)		0.38	0.60	73.59
Citywide total	2,208,961.00 (±171,702)		100.00	100.00	46.69

Appendix 44: Annual Energy Benefits of Public Trees by Species

City of Richmond

Annual Energy Benefits of Public Trees by Species

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/tree
Sugar maple	722.60	54,845.16	26,953.43	28,193.29	83,038.45	(±14,586)	12.36	15.98	14.20
Willow oak	715.70	54,321.65	22,605.82	23,645.69	77,967.34	(±18,799)	9.31	15.00	17.70
Common crapemyrtle	35.69	2,709.25	2,095.43	2,191.82	4,901.07	(±1,349)	8.77	0.94	1.18
Red maple	333.69	25,326.80	12,075.95	12,631.44	37,958.24	(±8,475)	8.06	7.30	9.95
Pin oak	711.68	54,016.58	21,777.94	22,779.73	76,796.31	(±19,719)	7.19	14.78	22.58
Japanese zelkova	298.80	22,678.98	11,528.68	12,059.00	34,737.98	(±6,316)	7.03	6.68	10.45
Winged elm	224.47	17,037.30	6,720.49	7,029.63	24,066.93	(±5,256)	4.30	4.63	11.82
Green ash	177.93	13,504.65	6,141.75	6,424.27	19,928.92	(±5,892)	2.89	3.83	14.59
Callery pear	61.48	4,666.17	2,518.01	2,633.84	7,300.00	(±2,973)	2.51	1.40	6.16
Hedge maple	59.91	4,547.21	2,615.33	2,735.64	7,282.84	(±2,344)	2.45	1.40	6.28
American sycamore	157.61	11,962.29	5,541.52	5,796.43	17,758.72	(±11,622)	2.40	3.42	15.66
Ginkgo	94.63	7,182.64	3,381.13	3,536.67	10,719.31	(±3,848)	2.23	2.06	10.15
Loblolly pine	98.76	7,496.20	2,592.64	2,711.90	10,208.11	(±3,713)	2.23	1.96	9.66
Chinese pistache	39.83	3,023.02	1,785.02	1,867.14	4,890.16	(±2,220)	1.96	0.94	5.27
Sweetgum	45.80	3,475.89	1,714.84	1,793.72	5,269.61	(±1,635)	1.74	1.01	6.39
American elm	174.80	13,267.33	5,441.70	5,692.01	18,959.35	(±4,393)	1.69	3.65	23.74
Unknown shrub	4.95	375.42	356.47	372.86	748.29	(±372)	1.58	0.14	1.00
Littleleaf linden	61.66	4,679.67	2,337.59	2,445.12	7,124.79	(±2,841)	1.47	1.37	10.24
London planetree	66.74	5,065.94	2,419.25	2,530.54	7,596.48	(±5,529)	1.20	1.46	13.40
Norway maple	38.23	2,901.60	1,486.27	1,554.64	4,456.24	(±1,167)	1.03	0.86	9.10
Silver maple	53.14	4,033.11	1,968.97	2,059.54	6,092.66	(±1,715)	1.03	1.17	12.44
Kwanzan cherry	13.72	1,041.57	702.53	734.85	1,776.41	(±888)	1.03	0.34	3.63
Other street trees	438.69	33,296.63	16,084.40	16,824.29	50,120.92	(±5,739)	15.52	9.64	6.83
Citywide total	4,630.50	351,455.06	160,845.17	168,244.05	519,699.11	(±40,396)	100.00	100.00	10.99

Appendix 45: Annual Energy Benefits of Public Trees by Zone

City of Richmond

Annual Energy Benefits of Public Trees by Zone

Zone	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Tree Numbers	% of Total \$	Avg. \$/Tree
1	971.66	73,748.96	32,337.93	33,825.47	107,574.43	(±17,463)	19.83	20.70	11.47
2	1,061.87	80,595.98	36,930.55	38,629.36	119,225.34	(±29,614)	22.22	22.94	11.34
3	706.03	53,587.38	24,426.63	25,550.26	79,137.64	(±32,693)	12.36	15.23	13.53
4	245.03	18,597.87	8,940.95	9,352.24	27,950.11	(±7,220)	8.39	5.38	7.04
5	634.21	48,136.84	22,440.43	23,472.69	71,609.53	(±12,452)	14.32	13.78	10.57
6	333.22	25,291.76	11,803.62	12,346.58	37,638.35	(±7,359)	7.57	7.24	10.51
7	416.24	31,592.90	14,700.03	15,376.24	46,969.14	(±4,668)	8.99	9.04	11.05
8	237.35	18,014.74	8,471.19	8,860.86	26,875.60	(±3,450)	5.94	5.17	9.57
9	24.88	1,888.62	793.84	830.36	2,718.98	(±842)	0.38	0.52	15.07
Citywide total	4,630.50	351,455.06	160,845.17	168,244.05	519,699.11	(±40,396)	100.00	100.00	10.99

Appendix 46: Total Annual Benefits, Net Benefits, and Costs for Public Trees

City of Richmond

Total Annual Benefits, Net Benefits, and Costs for Public Trees

Benefits	Total (\$)	Standard Error Total	\$/tree	Standard Error Per Tree	\$/capita	Standard Error Per Capita
Energy	519,699	(±40,396)	10.99	(±.85)	2.60	(±.2)
CO2	152,657	(±11,866)	3.23	(±.25)	0.76	(±.06)
Air Quality	- 147,931	(±11,499)	- 3.13	(±-.24)	- 0.74	(±-.06)
Stormwater	1,637,048	(±127,247)	34.60	(±2.69)	8.19	(±.64)
Aesthetic/Other	2,208,961	(±171,702)	46.69	(±3.63)	11.04	(±.86)
Total Benefits	4,370,434	(±339,528)	92.38	(±7.18)	21.85	(±1.7)
Cost						
Planting	250,000		5.28		1.25	
Contract Pruning	593,700		12.55		2.97	
Pest Management	0		0.00		0.00	
Irrigation	0		0.00		0.00	
Removal	890,550		18.82		4.45	
Administration	200,000		4.23		1.00	
Inspection/Service	210,000		4.44		1.05	
Infrastructure Repairs	560,000		11.84		2.80	
Litter Clean-up	494,750		10.46		2.47	
Liability/Claims	20,000		0.42		0.10	
Other Costs	0		0.00		0.00	
Total Costs	3,219,000		68.04		16.10	
Net Benefits	1,151,434	(±339,528)	24.34	(±7.18)	5.76	(±1.7)
Benefit-cost ratio	1.3576993	(±.11)				



United States
Department of Agriculture
Forest Service
Animal and Plant
Health Inspection Service
NA-PH-01-00 GEN
Revised August 2008

Asian Longhorned Beetle (*Anoplophora glabripennis*): A New Introduction

The Asian longhorned beetle (ALB) has been discovered attacking trees in the United States. Tunneling by beetle larvae girdles tree stems and branches. Repeated attacks lead to dieback of the tree crown and, eventually, death of the tree. ALB probably travelled to the United States inside solid wood packing material from China. The beetle has been intercepted at ports and found in warehouses throughout the United States.

This beetle is a serious pest in China, where it kills hardwood trees in roadside plantings, shelterbelts, and plantations. In the United States the beetle prefers maple species (*Acer* spp.), including *boxelder*, *Norway*, *red*, *silver*, and *sugar maples*. Other preferred hosts are *birches*, *Ohio buckeye*, *elms*, *horsechestnut*, and *willows*. Occasional to rare hosts include *ashes*, *European mountain ash*, *London planetree*, *mimosa*, and *poplars*. A complete list of host trees in the United States has not been determined.

Currently, the only effective means to eliminate ALB is to remove infested trees and destroy them by chipping or burning. To prevent further spread of the insect, quarantines are established to avoid transporting infested

trees and branches from the area. Early detection of infestations and rapid treatment response are crucial to successful eradication of the beetle.

The ALB has one generation per year. Adult beetles are usually present from July to October, but can be found later in the fall if temperatures are warm. Adults usually stay on the trees from which they emerged or they may disperse short distances to a new host to feed and reproduce. Each female usually lays 36-90 eggs during her lifetime. Some are capable of laying more than that. The eggs hatch in 10-15 days. The larvae feed under the bark in the living tissue of the tree for a period of time and then bore deep into the wood where they pupate. The adults emerge from pupation sites by boring a tunnel in the wood and creating a round exit hole in the tree.

For more information about Asian longhorned beetle in the United States, visit these U.S. Department of Agriculture Web sites:

www.na.fs.fed.us/fhp/alb/

www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhbl/index.shtml

If you suspect an Asian longhorned beetle infestation, please collect an adult beetle in a jar, place the jar in the freezer, and immediately notify any of these officials or offices in your State:

- State Department of Agriculture:
 - State Plant Regulatory Official
 - State Entomologist
- U.S. Department of Agriculture:
 - Animal and Plant Health Inspection Service, Plant Protection and Quarantine
 - Forest Service
- County Cooperative Extension Office
- State Forester or Department of Natural Resources

Asian Longhorned Beetle

WHAT TO LOOK FOR:



1. Adult beetles. Individuals are $\frac{1}{4}$ to $1\frac{1}{4}$ inches long, with jet black body and mottled white spots on the back. The long antennae are $1\frac{1}{2}$ to $2\frac{1}{2}$ times the body length with distinctive black and white bands on each segment. The feet have a bluish tinge.



2. Oval to round pits in the bark. These egg-laying sites or niches are chewed out by the female beetle, and a single egg is deposited in each niche.



3. Oozing sap. In the summer, sap may flow from egg niches, especially on maple trees, as the larvae feed inside the tree.



4. Accumulation of coarse sawdust around the base of infested trees, where branches meet the main stem, and where branches meet other branches. This sawdust is created by the beetle larvae as they bore into the main tree stem and branches.



5. Round holes, $\frac{1}{8}$ inch in diameter or larger, on the trunk and on branches. These exit holes are made by adult beetles as they emerge from the tree.

Photo Sources:

USDA Forest Service

USDA Animal and Plant Health Inspection Service

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Published by:
USDA Forest Service
Northeastern Area
State and Private Forestry
Newtown Square, PA 19071
www.na.fs.fed.us



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