Urban Tree Canopy Assessment and Planting Plan

Town of Easton, Maryland

January 2014

Prepared for:
Town of Easton, Maryland
Planning and Zoning Office
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Easton, Maryland 21601

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Project Team

National Fish and Wildlife Foundation provided funding, oversight, and direction.

Town of Easton provided information regarding existing town plans and the urban forest program budget.

Davey Resource Group, a division of The Davey Tree Expert Company, completed the 2013 partial street and park tree inventory, *Urban Tree Canopy Assessment and Planting Plan*, *Tree Maintenance Plan*, and *Regulations and Policy Review and Recommendations Report*.

Easton Steering Committee

Zach Smith
Planning and Zoning Office

Brian Hause
Engineering Office

Roger Bollman, Will Cook, and Bruce Phillips
Tree Board Members

Vision Statement

Easton's vision to promote and preserve the urban forest and improve the management of public trees was a fundamental inspiration for this project. This vision will ensure canopy continuity, which will reduce stormwater runoff and improve air quality, public health, and aesthetic values.

Acknowledgments

The Town of Easton is thankful for the grant funding they received from the National Fish and Wildlife Foundation Chesapeake Bay Stewardship Fund.

NFWF's Chesapeake Bay Stewardship Fund is dedicated to protecting and restoring the Bay by helping local communities clean up and restore their polluted rivers and streams.

Funding

This project was made possible through grants from the National Fish and Wildlife Foundation Chesapeake Bay Stewardship Fund with major funding provided by the United States Environmental Protection Agency (FC.R142).

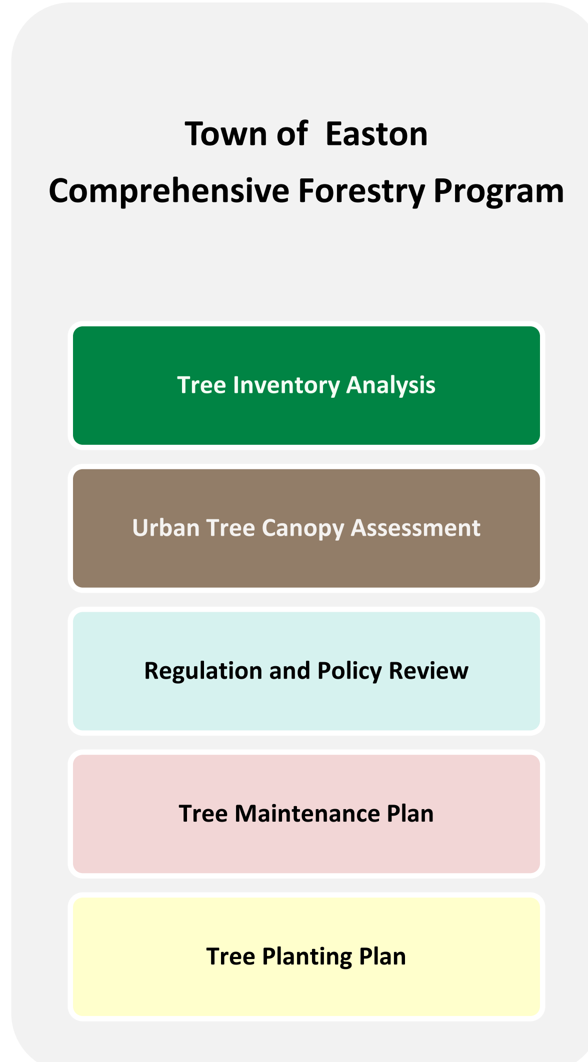
Introduction

Stormwater runoff is a major concern in urban areas because it pollutes water. When rain falls in undeveloped areas, the water is absorbed and filtered by soil and plants. However, when rain falls on our roofs, streets, and parking lots, it does not always soak into the ground. In most urban areas, stormwater is drained through engineered collection systems and discharged into nearby water bodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, degrading the quality of the receiving waters. Higher flows can also cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure.

The Town of Easton values tremendously the Chesapeake Bay and the tributaries that flow through the community. The Town is dedicated to stewardship of the Bay and doing whatever it can do to contribute positively to the improvement and protection of this vitally important resource. Like many other communities within the Bay's watershed, Easton believes that the Bay and its tributaries are central to the community's framework and environment.

To help build community capacity and improve water quality, the Town of Easton created this Comprehensive Forestry Program for their community to enable them to positively impact water quality through tree planting and maintenance initiatives. Tree canopy cover, as well as individual trees, increases rainfall absorption to decrease runoff; removes pollutants from water through the natural biological processes; absorbs, diverts, cleanses, and retards runoff from entering surface and ground waters; and improves aquatic and terrestrial wildlife habitat. This Comprehensive Forestry Program will provide a full understanding of existing tree canopy conditions within the community, identify targets for tree canopy cover preservation and creation that most impact water quality, and create a clear program of implementation to meet the targets.

This coordinated program will allow the Town to focus on installing trees in strategic areas that positively influence water quality and to maintain all trees, existing and new, so that they provide the most ecosystem benefits to the community. Additionally, this program will enable the Town to identify opportunities to convert turf to trees and implement green infrastructure, such as bio-retention features, in and adjacent to public rights-of-way.



Purpose

The purpose of Easton's program is to assess the existing conditions of trees and tree cover and develop a program that identifies problems, highlights objectives, and provides solutions to greatly improve the following within the community:

1) The quality of trees

2) The quantity of trees

3) Water quality

Scope

The program includes specific planting and maintenance projects that will be implemented by the Town in a coordinated manner to efficiently and effectively realize objectives. Also included is a review and update of regulations and policies aimed at promoting and encouraging the planting and preservation of trees on private property and ensuring compliance with Maryland law.

The scope of work includes:

- Assessing urban tree canopy (UTC) to determine existing coverage of tree cover within the watershed and locating areas for improvement.
- Collecting and analyzing tree inventory data to understand the existing conditions of trees to make future management directives.
- Developing tree maintenance and planting plans based on the data gathered to help guide tree management so that the quality of the urban forest and watershed are improved and the number of trees is increased in the community.
- Reviewing Town policies and regulations about trees and making recommendations to modify those in need, and promoting and encouraging the planting and preservation of trees.

Summary

The Town of Easton contracted Davey Resource Group to provide an assessment of existing UTC and identify areas to plant trees that will improve the quality of the urban forest and watershed.

Davey Resource Group provided the Town with digital imagery showing detailed leaf-on conditions which was utilized to classify five land cover classes—tree canopy, pervious, impervious, bare soil, and open water. Statistics for each land cover class were generated townwide and by watershed, parcel boundary, and land use. The project area was the corporate limits of Easton, Maryland, approximately 11.39 square miles, or 7,287 acres (Figure 1).

The Town's 2010 UTC cover is 27%; pervious covers 48% of the land area; impervious, 22%; bare soil, 1%; and open water, 2%.

The Town of Easton's existing UTC is a vital asset providing a value of $8 million in ecosystem benefits. For every dollar spent on trees the Town of Easton receives $3.28 in return.

Three watersheds, Lower Choptank, Upper Choptank, and Miles River, are found within the corporate limits of Easton. Most of the Town's land (5,042 acres) lie in the Lower Choptank watershed. Tree canopy cover is the highest in the Lower Choptank watershed (29%) and the lowest in the Miles River watershed (21%). There are 7,175 parcels in the Town of Easton. Over 50% of them have tree canopy cover less than 20%.

Within the Town there are approximately 2,899 acres identified as potential plantable areas. This includes areas of pervious and bare soil surfaces within land uses designated as highways, streets, parks, agricultural, and residential. Land uses, such as cemeteries, golf courses, utility rights-of-way, and recreational fields, were excluded from the analysis.

To identify and prioritize planting areas in the Town that can decrease the amount of stormwater runoff, the UTC assessment, along with analysis of other environmental factors influencing runoff potential, was performed using geographic information systems (GIS).

Figure 1. 2010 aerial image of the Town of Easton, Maryland.

The Town of Easton aspires to increase the urban tree canopy to between 35% to 40% over the next 40 years. Increasing tree canopy cover to 40% in 40 years will require 30,360 private and public trees to be planted in the next 10 years. This can be achieved by planting a mix of small, medium, and large trees within the Town's rights-of-way, parks, along highway corridors, adjacent to public parking lots, parks, residential and commercial areas, and in future-developed agricultural lands. This endeavor will require an ambitious tree planting effort of both public and private trees, in conjunction with preservation and maintenance of existing tree canopy.

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Assignment

The assignment by the Town of Easton was to provide digital imagery showing detailed leaf-on conditions that translated into individual GIS layers for different land cover classifications. Five land cover GIS layers were provided to the Town and included tree canopy (trees/forest/shrub); pervious (grass and low-lying vegetation); impervious (buildings, roads, and other impervious); bare soil; and open water.

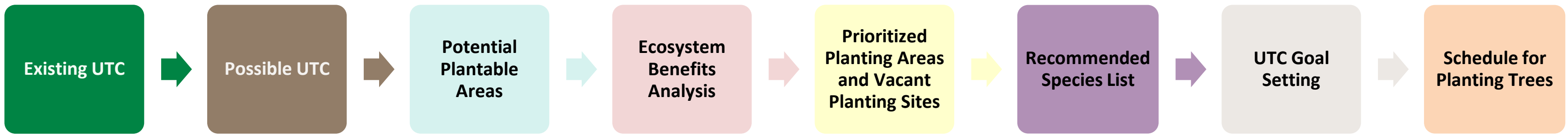
The area and percentage of UTC and preferred plantable area were calculated and are spatially explicit for the Town limits, watershed and parcel boundaries, and by land use.

Identification of prioritized plantable areas, which are spaces where the addition of tree canopy would influence stormwater runoff, was performed using GIS analysis. These areas were ranked from Very Low to Very High risk based on modeled runoff potential and are illustrated on a map. The number of acres of prioritized plantable areas were calculated and presented with the number vacant planting sites collected during the May 2013 inventory.

A planting plan with a schedule for increasing canopy based on tree inventory data and the UTC assessment was provided. A recommended species list that addresses any biodiversity concerns identified during the inventory was provided.

The estimated ecosystem services the existing UTC provides in stormwater runoff reduction, air quality improvement, and carbon sequestration was projected.

A large wall map of the prioritized plantable area and vacant planting sites that can be displayed at public meetings and be a useful visual and field tool for Town staff was provided.



Methods

The 2010 National Agricultural Imagery Program (NAIP) leaf-on, multispectral imagery acquired and processed by the United States Department of Agriculture (USDA) was used as the primary source to identify the Town's current land cover. Remote sensing and GIS software extensions provided the automated feature-extraction tool used to generate the baseline percentage of the final existing tree canopy and land cover layers. In order to reflect current-day ground conditions, Davey Resource Group conducted manual field verification on the UTC data to reflect any canopy changes as of May 2013. No significant loss of canopy was noted.

Land cover data for tree canopy, pervious, impervious, open water, and bare soil were generated. Tree canopy cover is the area of land surface that is covered by the tree's leaf-covered branches as seen from above. Pervious cover allows rainfall to infiltrate the soil and includes grasses and low-lying vegetation typically found in parks, golf courses, and residential lawns. Impervious land cover is an area that does not allow rainfall to infiltrate and typically includes buildings, roads, and parking lots. Open water includes all lakes, ponds, streams, wetlands, and other mappable water features. Bare soil includes areas such as vacant lots, construction areas, and baseball fields. Bare soils are considered a pervious surface. Possible plantable area is equal to the total of pervious and bare soil acreage.

The potential plantable area was determined by identifying reasonable "real world" areas to plant trees. These areas include the pervious surfaces and bare soils within highways, streets, parks, residential parcels, and agricultural land.

Stormwater modeling was used to identify prioritized plantable area. To identify and prioritize risk, Davey Resource Group assessed a number of environmental features, including proximity to canopy and hardscape, soil permeability, location within a floodplain, slope, and road and population densities. Prioritized plantable area includes areas of pervious surfaces and bare soils within land uses designated as highways, streets, parks, residential parcels, and agricultural land. Land uses, such as cemeteries, golf courses, utility rights-of-way, and recreational fields, were excluded from the analysis and are referred to as other pervious surfaces. Prioritized plantable areas were identified using grid analysis and the assumption that the planting area was a regular polygon shape greater than 100 square feet. Irregular planting areas (polygons) less than 100 square feet were eliminated from the analysis.

The results of the urban tree canopy analysis were used with the i-Tree Vue model (Ellis, Binkley, and Nowak 2011) and CITYGreen (American Forests 2002) to assess and quantify the ecosystem benefits of the Town's UTC resource. Estimated ecosystem benefits, including carbon storage, carbon sequestration, pollution removal, and stormwater runoff values, were calculated.

To increase readability of the report, percentages were rounded to whole numbers and equal 100 within the text, and results reported in tables and maps were shown to the hundredth place.

GIS source file information and clipping of boundaries may result in variations in acreage. Land use acreage and percentages were calculated using land use and parcel data. The parcel data reduce the amount of land assessed because it does not include areas of right-of-way.

Detailed methodologies for each assessment are presented in Appendix A. Individual UTC assessment summaries for the townwide analysis, as well as for the watershed, are in Appendix B. The parcel analysis data are available only on CD-ROM due to the large number of parcels identified.

Urban Tree Canopy Assessment

Land Cover Analysis

Townwide

The results of the UTC assessment using 2010 imagery are provided below in Table 1 and Figures 2 and 3. In Table 1 and Figure 3, impervious is subdivided into buildings, roads, and other impervious. Other impervious includes paved surfaces such as parking lots, driveways, and sidewalks. The boundary of the Town of Easton covers approximately 7,287 acres (11.39 square miles). Based on the results, the tree canopy coverage of this area is 27%. Pervious—grass and low-lying vegetation—covers 48% of the total land area. Impervious land cover types (buildings, roads, and other impervious) make up 22% of the total land area acres. Bare soil and open water make up the remaining 3%.

Table 1. Results of Land Cover Classification

Land Cover Classification	Acres	Percentage
Tree Canopy	1,967.57	27.00
Pervious Grass & Low-Lying Vegetation	3,469.09	47.61
Impervious		
Other Impervious	620.82	8.52
Roads	516.26	7.08
Buildings	451.29	6.20
Open Water	156.88	2.15
Bare Soil	104.82	1.44
Total	7,286.73	100.00

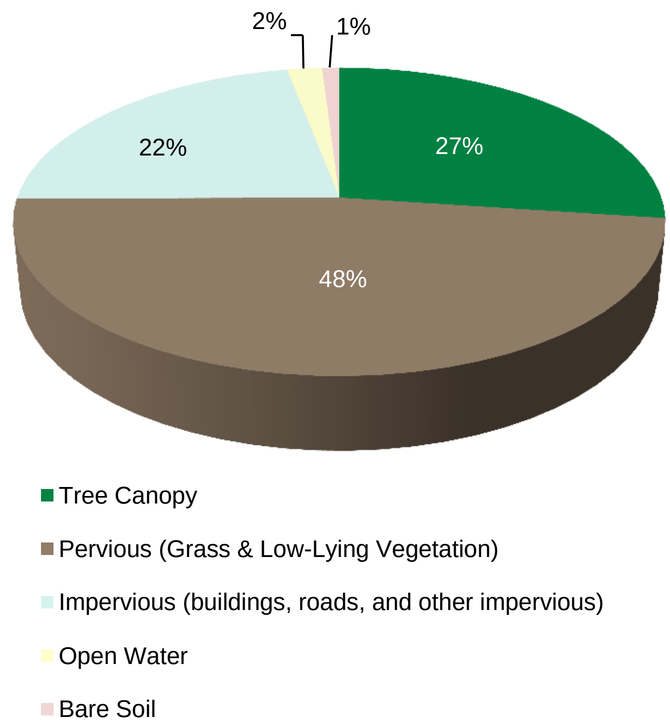


Figure 2. Percentages of land cover classes.

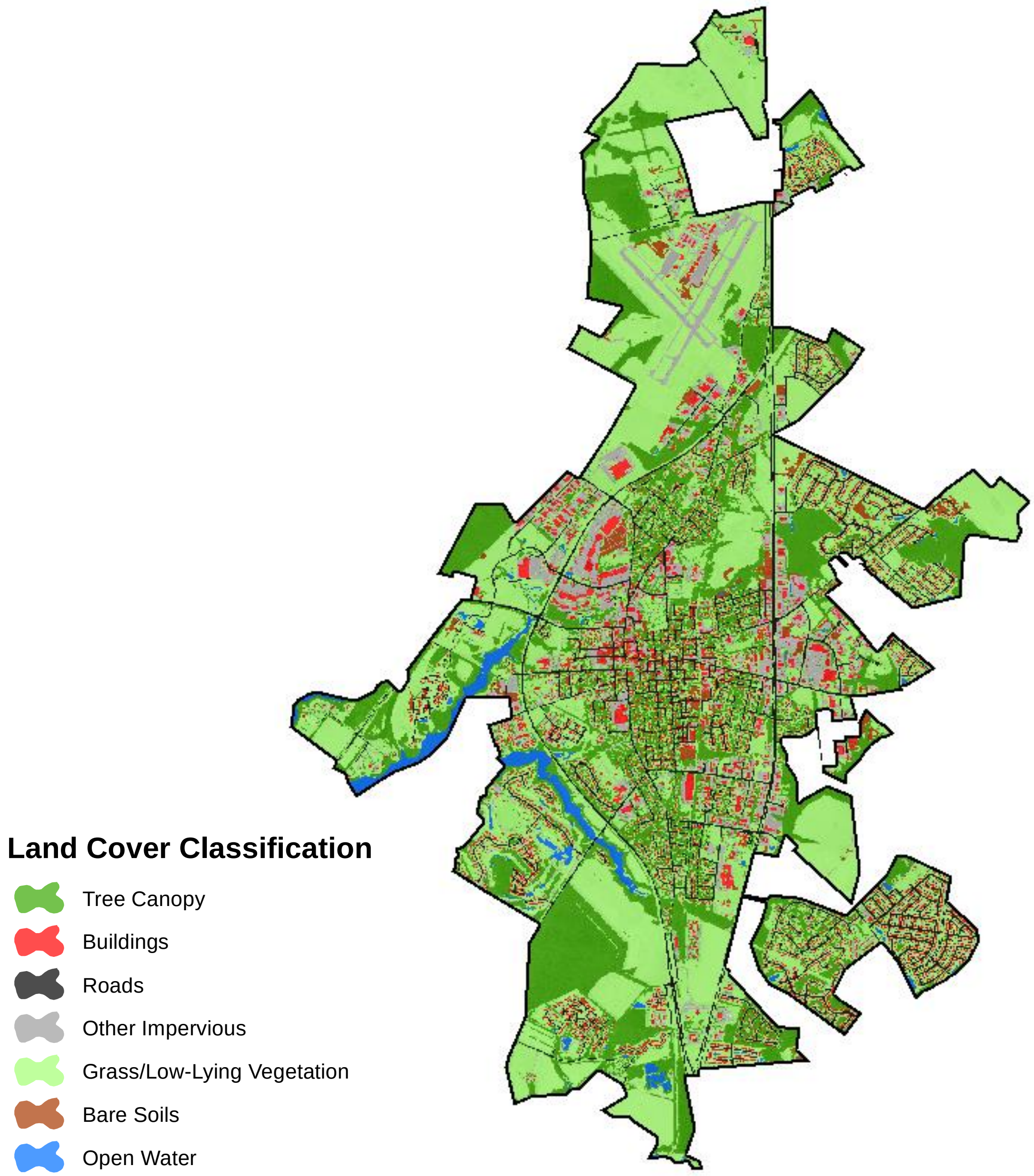


Figure 3. 2010 Town of Easton UTC assessment results.

Watershed

The Town of Easton is part of the Upper Eastern Shore and Choptank River Basins that drain into the Chesapeake Bay. Three subwatersheds—Lower Choptank, Miles River, and Upper Choptank—include all the brooks, streams, rivers, and wetlands within the Town (Figure 4).

Analysis of land cover classes within the Town of Easton's three different watersheds indicates that the Lower Choptank watershed has the highest percentage of tree canopy cover and the highest amount of impervious surface. The Miles River watershed has the lowest percentage of tree canopy and the highest amount of pervious surface. The results of the land cover analysis for each watershed is provided in Table 2.

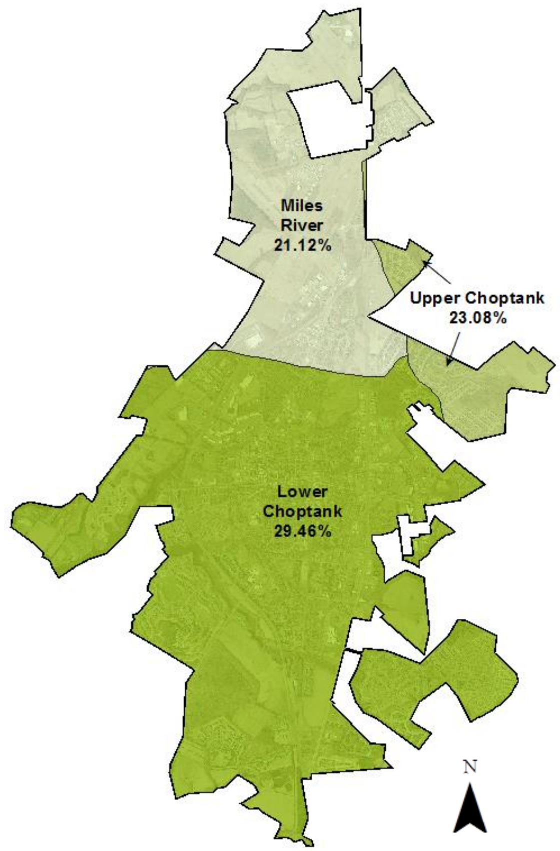


Figure 4. Percentages of UTC based on watersheds.

Table 2. Watershed Land Cover Classification Results

Watershed	Acres	Tree Canopy		Impervious		Pervious		Bare Soil		Open Water	
		Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage
Lower Choptank	5,042.09	1,485.32	29.46	1,223.40	24.26	2,117.04	41.99	66.77	1.32	149.57	2.97
Miles River	1,825.08	385.44	21.12	281.78	15.44	1,124.74	61.63	29.14	1.60	3.99	0.22
Upper Choptank	419.55	96.81	23.08	83.20	19.83	227.31	54.18	8.91	2.12	3.32	0.79

Parcel

A land cover analysis at the parcel level was also completed (Figure 5). As shown in Table 3, of the 7,175 parcels within the Town of Easton, over 50% have tree canopy coverage less than or equal to 20%.

Table 3. Parcels based on Range of Tree Canopy

Number of Parcels	Percentage of Parcels	Range of Tree Canopy Percentages
3,755	52.33	0.00–20.00
1,289	17.97	20.01–40.00
1,092	15.22	40.01–60.00
648	9.03	60.01–80.00
391	5.45	80.01–100.00

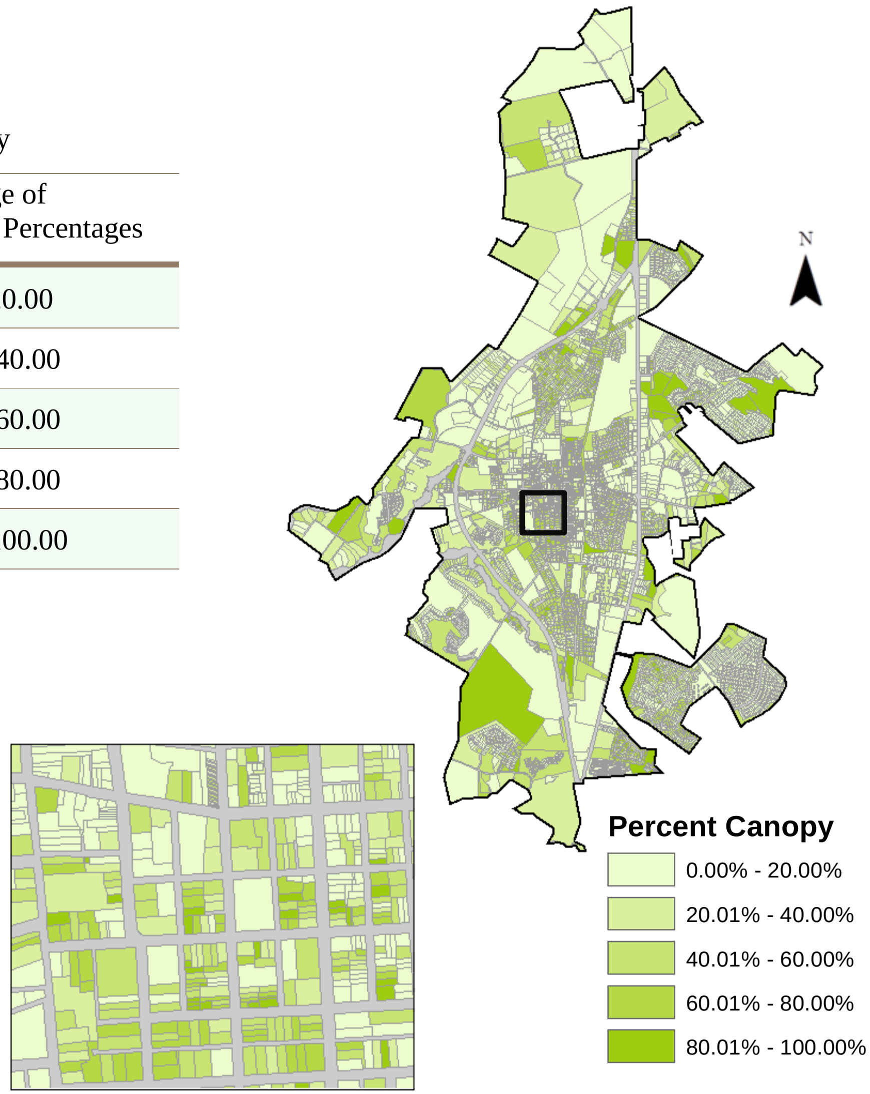


Figure 5. UTC assessment based on parcels.

Land Use

Land use designations within the Town of Easton include agricultural, commercial, exempt, industrial, mixed use, residential, and unknown (Figure 6). When categorizing the parcels based on land use, the analysis found that mixed use and residential have the highest percentage of tree canopy, while commercial and exempt areas contain the lowest tree canopy coverage percentages (Table 4).

Commercial land uses have the lowest percent of tree canopy and largest percent of impervious surfaces. Adding tree canopy to these areas may require retrofitting with green infrastructure. Current research shows increased social and economic benefits to consumers and retailers when commercial areas have trees (Wolf 1998a,1998b, 1998c, 1999, 2000, 2003).

Parcels designated as exempt include schools. Increasing tree canopy around schools will provide benefits to students and teachers. Research shows that children with Attention Deficit Hyperactivity Disorder show fewer symptoms when they have access to nature, and exposure to trees and nature aids concentration by reducing mental fatigue (Faber Taylor, Kuo, and Sullivan 2001; Kuo and Faber Taylor 2004).

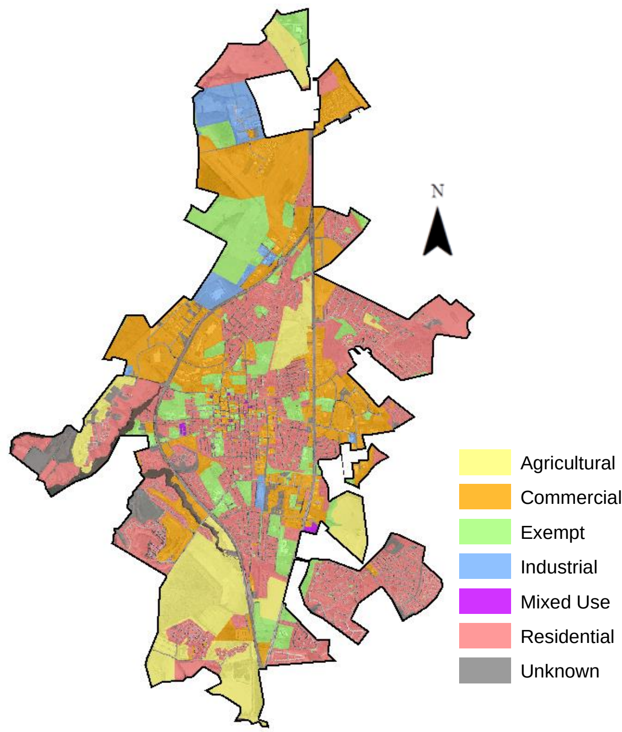


Figure 6. Town of Easton land use designations.

Table 4. Land Cover Results Based On Land Use

Land Use	Acres	Percentage	Tree Canopy		Impervious		Pervious		Bare Soil		Open Water	
			Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage
Agriculture	1,026.08	16.18	344.65	33.59	7.47	0.73	652.90	63.63	7.47	0.73	13.60	1.32
Commercial	1,643.95	25.93	355.51	21.63	482.87	29.37	729.84	44.40	58.37	3.55	17.35	1.06
Exempt	898.17	14.17	214.28	23.86	167.39	18.64	501.03	55.78	14.02	1.56	1.44	0.16
Industrial	257.92	4.07	67.93	26.34	43.75	16.96	141.94	55.03	3.87	1.50	0.43	0.17
Mixed Use	13.84	0.22	4.72	34.14	2.29	16.59	5.71	41.31	0.73	5.28	0.37	2.69
Residential	2,239.70	35.33	764.36	34.13	346.63	15.48	1,104.00	49.29	11.83	0.53	12.88	0.58
Unknown	260.12	4.10	81.73	31.42	32.74	12.59	136.94	52.64	3.26	1.25	5.46	2.10

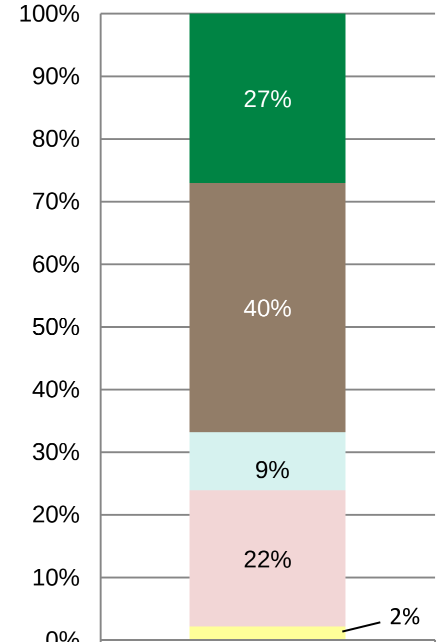
Existing UTC and Potential Plantable Areas

Townwide

The Town of Easton's existing tree canopy is 27%. Whether the Town of Easton wants to increase or maintain tree canopy, knowing where opportunities for tree planting exist will help them reach their goals and objectives.

While it is theoretically possible that all pervious and bare soil could represent future tree canopy, considering all land use in these cover classes is understandably not practical nor is it realistic for urban forest planning and management. Land uses such as cemeteries, golf courses, utility rights-of-way, and recreational fields were excluded from the analysis and are referred to as other pervious surfaces. In Easton, 2,899 acres were identified as potential plantable areas (Figure 7). Because this was a GIS exercise, prior to implementing tree planting at any of the identified areas, further assessment of the planting area is needed to determine the presence of other constraints, such as utilities.

Reaching a UTC target will require the Town of Easton to preserve the existing tree canopy within all land uses, public and private, while expanding the urban forest in designated preferred plantable areas.



	Acres
Existing Tree Canopy	1,968
Potential Plantable Areas	2,899
Other Pervious Surfaces	675
Impervious Surfaces	1,588
Open Water	157

Figure 7. UTC cover within the Town of Easton.

Land Use

Agricultural land contains the largest percentage of potential plantable areas. Industrial, mixed use, and residential also contain large percentages of plantable areas and would benefit from street tree plantings (Table 5).

Areas designated as exempt contain educational facilities. Even though a smaller percentage of area is available for planting on land designated as exempt, the shade and social benefits trees provide greatly enhance school grounds. Nature experiences are important for encouraging imagination and creativity, cognitive and intellectual development, and social relationships (Wolf and Flora 2010).

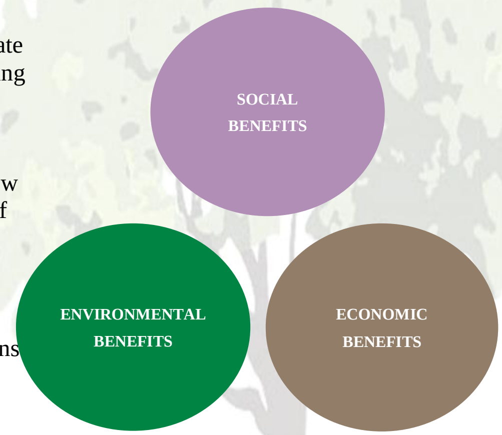
Table 5. Comparison of Existing UTC and Potential Plantable Areas Based On Land Use

Land Use	Acres	Tree Canopy		Potential Plantable Areas	
		Acres	Percentage	Acres	Percentage
Agricultural	1,026.08	344.65	33.59	653.52	63.69
Commercial	1,643.95	355.51	21.63	485.84	29.55
Exempt	898.17	214.28	23.86	283.87	31.61
Industrial	257.92	67.93	26.34	145.85	56.55
Mixed Use	13.84	4.72	34.14	6.47	46.76
Residential	2,239.70	764.36	34.13	1,039.34	46.41
Unknown	260.12	81.73	31.42	96.43	37.07

Benefits of the Urban Forest

The urban forest plays an important role in supporting and improving the quality of life in the Town of Easton. A tree's shade and beauty contribute to the quality of life there and soften the often-hard appearance of urban landscapes and streetscapes. When properly maintained and sustained through time, trees provide abundant environmental, economic, and social benefits to a community far in excess of the resources invested in their planting and maintenance (Figure 8).

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001b).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see nature from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a). Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).



- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini-reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. 100 mature tree crowns intercept ~100,000 gallons of rainfall per year (U.S. Forest Service 2003a)
- Trees help reduce noise levels, cleanse atmospheric pollutants, produce oxygen, and absorb carbon dioxide.
- Trees can reduce street-level air pollution by up to 60% (Coder 1996). Lovasi (2008) suggested that children who live on tree-lined streets have lower rates of asthma.
- Trees stabilize soil and provide a habitat for wildlife.

- Trees increase residential property values an average of 7% when present in the yard or neighborhood. Commercial property rental rates were 7% higher when trees were on the property (Wolf 2007).
- Trees moderate temperatures in the summer and winter, saving on heating and cooling expenses (North Carolina State Univ. 2012, Heisler 1986)
- On average, consumers will pay about 11% more for goods in landscaped areas, with this figure being as high as 50% for convenience goods (Wolf 1998a, Wolf 1999, and Wolf 2003).
- Consumers also feel that the quality of the products is better in business districts having trees than those considered barren (Wolf 1998a).
- The quality of landscaping along the routes leading to the business district had a positive influence on consumers' perceptions of the area (Wolf 2000).

Figure 8. Economic, environmental, and social benefits of trees.

Return on Investment of Trees

Knowing the benefits and costs associated with trees will help the Town of Easton quantify the return on the investment of their urban forest. The benefits and costs presented in the *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting* (McPherson et al. 2006) were used to estimate the benefit-cost ratio of Easton's urban forest.

Table 6 illustrates that for every dollar spent on the trees the Town of Easton receives $3.28 in return.

Table 6. Benefit and Costs Associated
With 100 Trees Over 40 Years

Benefits:	Energy Air Quality Runoff Real Estate	= $335,000
Costs:	Planting Pruning Removal/Disposal Sidewalk Repair Litter Administrative	= $102,000
Benefit-Cost Ratio:		3.28

Ecosystem Benefits Analyses

Trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. In addition, trees provide numerous economical and social benefits.

The ecosystem benefits of the Town of Easton's UTC resource were quantified using the i-Tree Vue and CITYGreen models. i-Tree Vue estimates carbon storage and sequestration and air pollutant removal. Air pollutants included in estimates are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10}), and sulfur dioxide (SO_2). TR-55 hydrologic equations created by the USDA were used to model stormwater runoff.

Data analysis shows Easton's existing UTC provides an estimated $8,018,508 in annual benefits and savings to the community. Easton's entire urban forest removes 158,410 pounds of pollutants from the air annually, a benefit valued at $672,297. Additionally, the community's urban forest stores approximately 246,672 tons of carbon and each year sequesters approximately 7,885 tons of carbon dioxide; these benefits are valued at $5,281,988 (storage) and $168,831 (annual carbon sequestration). Trees also intercept over 28,135,218 cubic feet of runoff every year, a benefit valued at $1,895,392. Table 7 illustrates the total annual ecosystem benefits that the existing UTC provides to Easton.

Table 7. Annual Ecosystem Benefits Provided by Easton's UTC

Ecosystem Factor		2010 UTC 27.00%	
		Units	Value
Air Quality[1] (pounds)	CO	2,575	$1,867
	NO_2	31,163	$159,121
	O_3	72,993	$372,712
	SO_2	17,407	$21,760
	PM_{10}	34,272	$116,837
	Subtotal	158,410	$672,297
Carbon[1] (tons)	Storage	246,672	$5,281,988
	Sequestration	7,885	$168,831
	Subtotal	254,557	$5,450,819
Stormwater** (cubic feet)	Runoff	28,135,218	$1,895,392*
	Subtotal	28,135,218	$1,895,392**
	Total		$8,018,508

1 Air pollution and carbon values are derived using i-Tree Vue and stormwater values are calculated in CITYGreen.

* Stormwater values are calculated based on the cost of building man-made structures to hold peak runoff flows.

** Annual stormwater costs are derived by taking the actual cost of the man-made structures financed at 6% interest.

A Closer Look at Stormwater Benefits

Urban trees help manage stormwater runoff depth, time of concentration, peak flow, and volume (Figure 9). With the presence of trees in the urban environment, there is less need for investment in man-made stormwater structures to accommodate peak flows during storm events. Using TR-55 hydrologic equations, Davey Resource Group has captured how Easton benefits from having urban trees.

Easton's trees intercept an additional 0.51 inch of runoff depth that would not otherwise be captured. This additional rainfall abstraction increases the time of concentration by slowing down the time it takes for the stormwater flows to reach pre-storm flow rates. The gain of 2.05 hours in time of runoff concentration decreases the peak flow rates by 602 cubic feet per second. By reducing these peak flow rates, Easton benefits from slower runoff velocities, which reduces the amount of soil erosion and sediment deposition and reduces overall runoff volumes by 13,283,715 cubic feet of stormwater (Table 8).

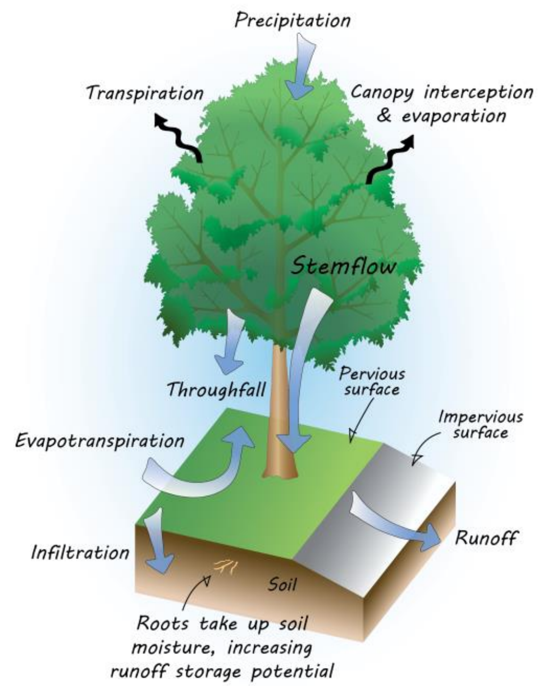


Figure 9. Stormwater benefit process.

Table 8. Stormwater Runoff Benefits Based On 2010 UTC of 27%

Stormwater Factor	2010 UTC of 27.00%		
	Without Trees	With Tree Canopy	Gain or Loss
Runoff Depth (inches)	1.57	1.06	Reduced by 0.51
Time of Concentration (hours)	7.90	9.95	Increased to 2.05
Peak Flow (cubic feet per second)	1,274	672	Reduced by 602
Runoff Volume (cubic feet)	41,418,933	28,135,218	Reduced by 13,283,715

Tree Planting Plan

This tree planting plan was developed using the results of the UTC assessment and the May 2013 street tree inventory. Possible plantable areas and vacant tree planting sites were prioritized based on runoff modeling. A recommended species list that addresses any biodiversity concerns identified during the inventory was provided.

To identify and prioritize runoff risk potential, Davey Resource Group assessed a number of environmental features, including proximity to canopy and hardscape, soil permeability, location within a floodplain, slope, and road and population densities (Figure 10). Each feature was assessed using separate grid maps. Values between zero and four (with zero having the lowest runoff risk potential) were assigned to each feature/grid assessed. The grids were overlain and the values were averaged to determine the runoff risk potential at an area on the map. A runoff priority ranging from Very Low to Very High was assigned to areas on the map based on the calculated average.

An explanation of the seven environmental factors used to prioritize future planting sites is provided in Appendix A.

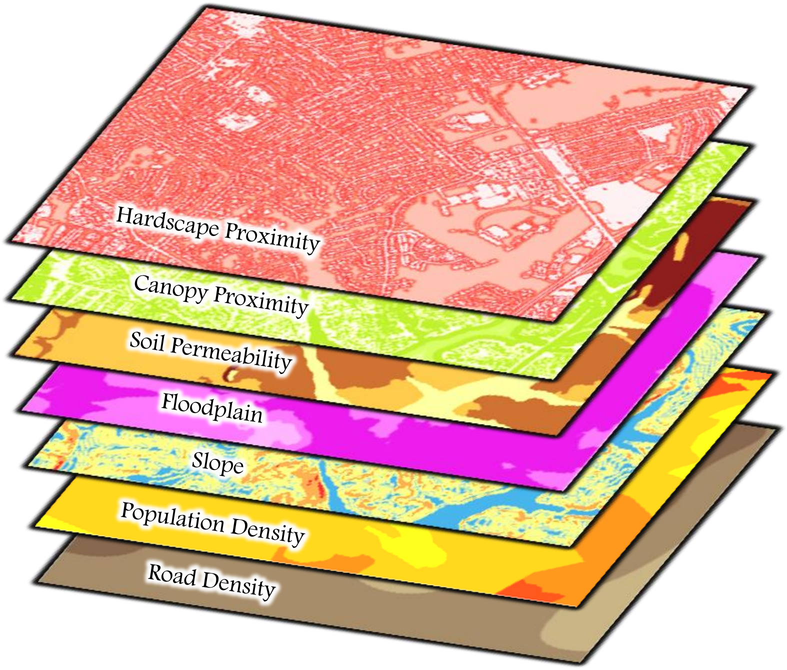


Figure 10. Environmental features used to prioritize runoff potential.

Prioritized Vacant Planting Sites

A total of 1,186 vacant planting sites were identified during the May 2013 street tree inventory conducted by Davey Resource Group. This was a partial inventory of the Town, and not all vacant planting sites and street trees were collected.

Vacant planting sites were categorized as either small or large. At the Town's direction, a space size of 4 feet by 8 feet or larger was defined as a large vacant planting site, and a space size of 3 feet by 4 feet was defined as a small vacant planting site.

Under the Town's direction, areas lacking trees and areas of full or partial cement were considered for tree planting, if consistent with the existing streetscape. If planted, the site will be modified to accommodate trees. Vacant planting site specifications are included in Appendix C.

Vacant planting sites were prioritized based on where they were located within the prioritized plantable area. Figure 11 shows the vacant planting sites as blue squares and their proximity to the prioritized plantable areas.

Prioritized vacant planting sites are presented in Table 9.

The GIS data layer was provided along with this report on CD-ROM.

Figure 11. Prioritized plantable areas and vacant planting sites (blue squares).

Table 9. Prioritized Vacant Planting Sites

Runoff Risk	Vacant Planting Site		
	Total	Large	Small
Very High	50	18	32
High	397	189	208
Moderate	415	250	165
Low	292	174	118
Very Low	32	25	7
Total	1,186	656	530

Tree Planting

Planting trees is a worthwhile goal as long as tree species are carefully selected and correctly planted. Without upfront planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the community. Appendix D contains additional information about tree planting and tree care.

When planning for a tree planting program:

- Consider the specific purpose of the tree planting.
- Assess the site and know its limitations, for example, overhead wires, confined spaces, and/or soil type.
- Select the species or cultivar that best matches site conditions.
- Examine trees before buying them, and buy for quality.

Trees and Utilities

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide (Figure 12). Trees come in many different shapes and sizes, and often change dramatically over their lifetime. Some grow tall, some grow wide, and some have extensive root systems. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating some shade may be a priority, but it is important to consider how a tree may impact existing utility lines as it grows taller, wider, and deeper. If at maturity, the tree's canopy will likely reach overhead lines, it is best to choose another tree or a different location. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

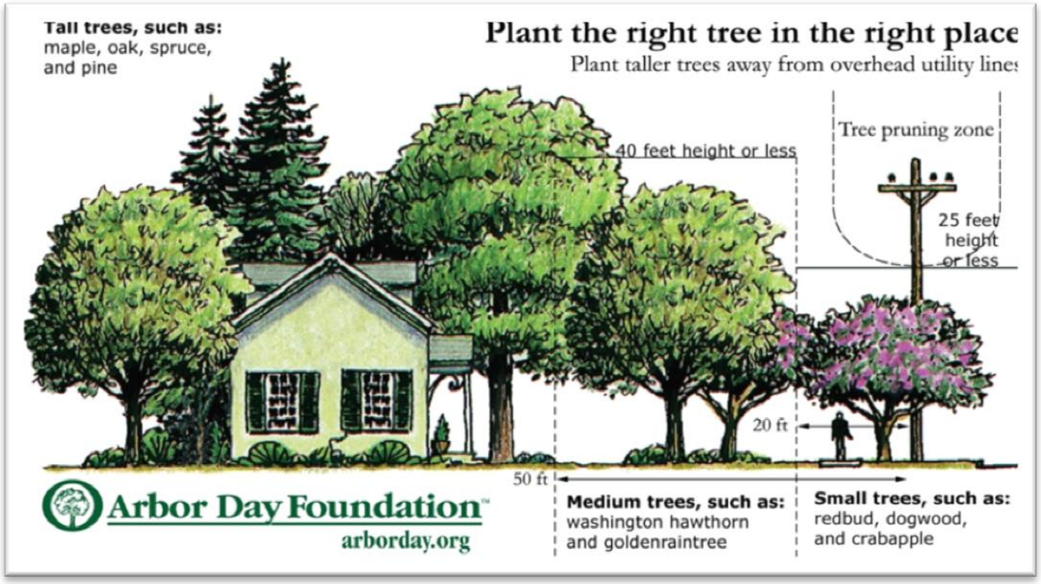


Figure 12. Choosing the right tree for the right place.

Species Diversity

Species diversity affects maintenance costs, planting goals, canopy continuity, and the Town's ability to respond to threats from invasive pests or diseases. Davey Resource Group recommends that no single species represent more than 10% and no genus represent more than 20% of the total population. Due to the increased threat of exotic invasive pests and diseases, it is advisable that Easton consider adopting a species diversity policy that limits a single species to no more than 10% and genus to no more than 20% of the population. A variety of species types can decrease the impact of species-specific pests and diseases by limiting the number of trees that are susceptible. Additionally, a wide variety of tree species may help to limit the impacts from a number of weather events as different trees respond differently to stress.

According to the Maryland Department of Natural Resources, oak wilt (*Ceratocystis fagacearum*) is a known threat in Garrett and Allegany Counties, Maryland, but is not currently progressing eastward through the state. *Quercus* spp. (oak) trees make up 35% of the street ROW and park tree population; therefore, any pest or disease affecting oaks would cause a severe threat to the public tree population. The Town should monitor oak trees for oak wilt.

Figure 13 compares the percentages of the most common species identified during the inventory to the 10% Rule. *Quercus palustris* (pin oak), *Pyrus calleryana* (Callery pear), and *Acer rubrum* (red maple) exceed the recommended 10% maximum for a single species in a population comprising 19%, 15%, and 11% of the inventoried tree population, respectively.

	pin oak	callery pear	red maple	willow oak	Japanese zelkova
Town of Easton	19%	15%	11%	10%	4%
10% Rule	10%	10%	10%	10%	10%

Figure 13. Comparison of the most common inventoried species to the 10% rule.

Tree Species Recommendations

The Town of Easton is located in USDA Hardiness Zone 7b, which identifies a climatic region where the average annual minimum temperature is between 5°F and 10°F. Tree species selected for planting in Easton should be appropriate for this zone. Appendix E lists tree species recommended for planting based on inventory findings; this list provides expected height at maturity for each species and is designed to promote species diversity.

Durability and Low Maintenance

Tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on site characteristics below ground (soil texture, soil structure, drainage, soil pH, nutrients, road salt, and root spacing). Matching a species to its favored soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well-matched to their environmental site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall.

Species-Specific Characteristics

A major consideration for street trees is the amount of litter dropped by mature trees. Trees such as *Ailanthus altissima* (tree-of-heaven) have weak wood and typically drop many small branches during a growing season. Others, such as *Liquidambar styraciflua* (American sweetgum), drop high volumes of fruit. In certain species, such as *Ginkgo biloba* (ginkgo), female trees produce offensive/large fruit; male trees, however, produce no fruit. Furthermore, a few species of trees, including *Crataegus* sp. (hawthorn) and *Robinia pseudoacacia* (black locust), may have substantial thorns. These species should be avoided in high-traffic areas.

Seasonal Color

Seasonal color should also be considered when planning tree plantings. Flowering varieties are particularly welcome in the spring, and deciduous trees that display bright colors in autumn can add a great deal of interest to surrounding landscapes.

Setting a Goal for Increasing Urban Tree Canopy

The amount of tree canopy drives the amount of benefits that an urban forest provides. Whether the Town of Easton wants to increase or maintain tree canopy, setting goals will help organize tree planting programs and direct tree preservation. Establishing realistic and achievable tree canopy goals will help capitalize on the environmental, economic, and social benefits trees provide to the community.

Maryland's Natural Forest Preservation Act of 2013 sets a goal of maintaining 40% canopy cover that now exists in the state. Maryland recognizes that maintaining and increasing canopy will limit sediment and other pollutants in streams and, ultimately, the Chesapeake Bay.

American Forests, a recognized leader in conservation and urban forestry, has also established canopy goals for metropolitan areas. These goals are an accepted standard and can be used as a general guideline or target for communities to achieve.

Similar to Maryland, American Forests recommends cities set a canopy cover goal of 40% overall. American Forests further recommends the core central business district should strive for 15% coverage, urban neighborhoods and fringe business areas for 25%. Suburbs, which have more growing space for trees, should be able to reach a tree canopy of 50%.

American Forests Recommended Canopy Cover For Metropolitan Areas East of the Mississippi River	
• Average of all Zones:	40%
• Suburban Residential Zones:	50%
• Urban Residential Zones:	25%
• Central Business Districts:	15%

It is recommended that the Town of Easton strive to obtain a goal of 40% tree canopy coverage. Achieving this goal will require an ambitious tree planting effort of both public and private trees, in conjunction with preservation and maintenance of existing tree canopy.

The Town of Easton's current tree canopy within the central business district is 21%.

Townwide Planting Strategy

This planting strategy is based on achieving a range of 35% to 40% tree canopy cover within 40 years. Growing the existing tree canopy to 40% cover will require planting, preservation, and maintenance of both public and private trees.

The UTC assessment identified 2,899 acres of potential plantable areas. To reach 40% canopy cover in 40 years, approximately 950 acres of canopy need to be added over the next 10 years. Growth of the existing urban forest is included in this projection and is based on the Town's existing tree canopy increasing by approximately 250 acres over the next 40 years. The remaining 700 acres of canopy needed equates to a total of 30,360 trees, or 3,036 trees per year for 10 years. The number of trees needed was calculated based on an approximate crown diameter of 35 feet or 1,000 square feet. This assumes a net annual growth percentage of 0.30%. The Townwide UTC targets, acres of canopy, and trees needed are presented in Table 10.

Table 10. Townwide UTC Targets with Required Canopy and Trees

UTC Target	Acres of Canopy	Number of Trees
35%	582	14,460
40%	947	30,360

Planting 30,360 trees over the next 10 years will require trees to be planted on both public and private property. This assumes that a mix of large, medium, and small statured trees that appropriately correlate with the planting space size available will be planted.

Seventy percent of the 30,360 new trees will have to be planted on private property including residential areas, repurposed agriculture lands, or other commercial and industrial areas. Planting public street trees along highway corridors, in parks, and adjacent to parking lots currently under Town control accounts for 30% of the trees needed for planting.

Private Tree Canopy Increase

Estimated UTC targets for residential, commercial, and repurposed agricultural land over a 40-year time horizon are provided in Table 11. The acres of canopy and number of trees required to reach the Townwide UTC Targets of 35% and 40% is provided as is the number of trees that must be planted within the next 10 years to reach the Townwide UTC targets.

Reaching these targets will require the Town to bolster programs and policies implemented by the Town that encourage the planting of new trees by homeowners and discourage the removal of existing trees by homeowners. Increases in canopy in agricultural areas will occur on lands already within the Town of Easton that are planned for development under current zoning. It is reasonable to expect that these areas will be developed over the next 40 years. When developed, trees will be planted in these areas through the application of the *Forest Conservation Ordinance* and *Zoning Ordinance–Landscaping and Buffering*. Trees are expected to be planted in commercial areas as development or building projects occur as a requirement of the Town's Landscaping Regulations. Additional plantings may also occur on commercial sites per the application of the Town's Forest Conservation Ordinance.

Table 11. Public Trees Needed to Reach Townwide UTC Targets.

Assumed Source of Canopy Increase	Existing UTC	UTC Target	Required Increase in Acres of Tree Canopy	Trees Required	
				Townwide UTC Target of 35%	Townwide UTC Target of 40%
Residential Property	34%	50%	356	7,376	15,507
Commercial Property	22%	25%	55	1,140	2,396
Developed Agricultural Property	34%	40%	66	1,367	2,875

Public Tree Canopy Increase

The remaining 10,000 trees needed to reach 40% tree canopy cover Townwide in 40 years will need to come from planting public trees. Public areas identified for planting include vacant planting sites within Town rights-of-way, highway corridors, parks, and public parking lots. The number of public trees needed to reach the Townwide UTC targets of 35% and 40% canopy in 40 years is provided in Table 12. All trees will need to be planted within the next 10 years to reach the UTC target.

Table 12. Public Trees Needed to Reach Townwide UTC Targets.

Townwide UTC Target	Public Trees Planted by the Town
35%	4,579
40%	9,582

Further analysis of public areas was conducted to estimate the number of planting spaces available within Town rights-of-way, along highway corridors, parks, and adjacent to public parking lots. The approximate tree count for each area was calculated assuming a mix of large, medium, and small statured trees that appropriately correlate with the planting space size available.

Street Trees

Of the 1,186 vacant planting sites collected during the street tree inventory, 447 are located in areas rated as High or Very High risk for stormwater runoff (Table 13). Planting in these prioritized areas will provide the greatest stormwater benefits.

Because the May 2013 street tree inventory was only a partial inventory, additional vacant planting sites may be located in other areas of the town. While tree planting is needed to increase canopy, the maintenance of existing and future street trees is also needed to grow Easton's tree canopy (Figure 14).

Table 13. Prioritized Vacant Planting Sites

Runoff Risk	Large and Small Vacant Planting Sites
Very High	50
High	397
Moderate	415
Low	292
Very Low	32
Total	1,186

Figure 14. There are many areas within the Town of Easton where additional street trees could be planted.

Highway Corridors

Six highway corridors were identified as areas that could benefit from planting trees (Table 14). Assuming trees can be planted on both sides of the highway and planted 40 feet on center, approximately 2,345 large trees could be planted (Figure 15).

Table 14. Planting Sites Along Highway Corridors

Highway	Large Planting Sites
Maryland 33	81
Maryland 322	956
Maryland 328	124
Maryland 331	94
Maryland 333	124
US 50	966
Total	2,345

Figure 15. Six highways were identified for tree planting.

Parks

At the Town's direction, 10 parks were selected as areas where trees could be planted. Some parks contain recreational fields and other areas not conducive for planting trees (Figure 16). Setting a goal of 30% tree canopy coverage throughout all 10 parks would require planting approximately 150 large trees. This would provide flexibility to plant the trees in appropriate areas and still reach a desirable canopy coverage. When possible, trees should be planted along trails and adjacent to parking lots and riparian areas to protect the watershed from sedimentation.

Figure 16. Recreational fields and some open areas within parks may not be appropriate for planting trees.

Public Parking Lots

Plantings immediately adjacent (within 30 feet) to parking areas should be considered to expand existing UTC. Parking lots are great places to add additional canopy to reduce runoff and add shade to decrease urban heat island temperatures (Figure 17).

Within the Town of Easton, there are 21 potential public parking lots that contain very little to no tree canopy. The number of trees that could be planted adjacent to each parking lot was estimated based on three categories: less than 5 trees, 5–10 trees, and more than 10 trees. If planting a mix of small, medium, and large trees, it was estimated that approximately 100–150 trees could be planted throughout these 21 parking lots.

Installation of green infrastructure devices, such as suspended pavement or structural cells, structural soil, tree pits, permeable pavements, and vegetative swales, should be considered prior to redevelopment or when repairing existing parking areas.

Figure 17. Planting trees adjacent to parking lots will reduce runoff and add shade.

Tree Canopy Prediction

Table 15 illustrates the projected canopy growth in 10-year increments over 40 years based on planting 3,036 trees a year. A total of 30,360 trees or approximately 10,000 public trees and 20,000 private trees will need to be planted. This analysis assumes that the existing canopy will increase by 250 acres over 40 years.

This projected UTC does not include the growth of trees planted by the Town and in private areas from 2009 to 2013. Over 5,000 trees have been planted in the Town in the last 8 years. Adding the growth of these trees to the projected canopy will compensate for the additional canopy needed to reach 40% in 40 years.

This is an ambitious goal and will require not only planting but proper care and preservation of the existing tree canopy.

Table 15. Projected Tree Canopy Growth in 10-Year Increments Over 40 Years

Planting Scenario	Existing	Projected			
	2010	Year 10	Year 20	Year 30	Year 40
3,036 small, medium, and large trees every year for 10 years.	27.00%	28.14%	29.88%	32.82%	38.02%

Recommendations

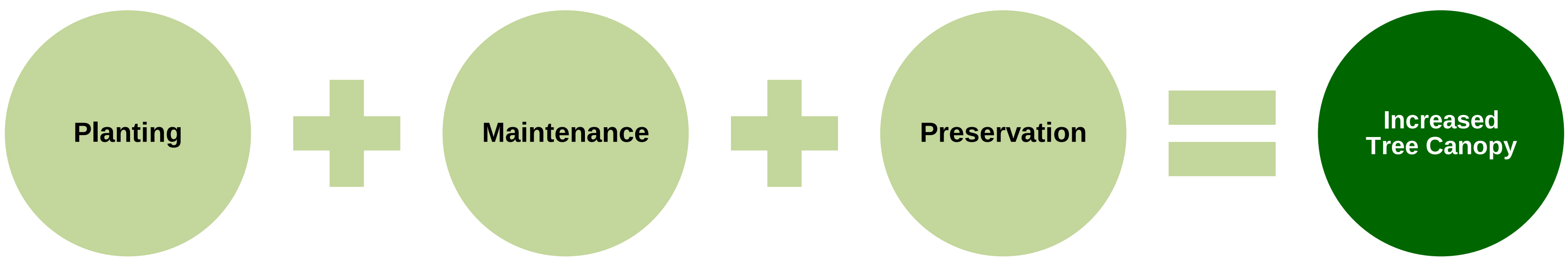
Set a tree canopy goal of 40% to be attained in 40 years. The goal should be townwide and include both public and private trees.

Use the results of the UTC assessment and the prioritized plantable area analysis to schedule tree planting throughout the Town. Prioritize tree planting initiatives in areas with low tree canopy and/or areas that have Very High or High runoff potential.

Having a diverse population of trees will ensure that Easton's urban forest is sustainable at the street, neighborhood, and park level, as well as townwide. Easton should consider adopting a species diversity policy that limits a single species to no more than 10% and genus to no more than 20% of the population.

Maintain existing healthy public trees and strive to preserve public and private tree canopy. Tree maintenance and preservation creates a sustainable urban forest.

Increase public outreach efforts about the urban forest and the benefits it provides to the community. This bolsters public support for trees and helps the community understand the importance of trees and the need for tree planting, maintenance, and preservation.



Glossary

bare soil land cover: The land cover areas mapped as bare soil typically include vacant lots, construction areas, and baseball fields.

canopy: Branches and foliage which make up a tree's crown.

canopy cover: As seen from above, it is the area of land surface that is covered by tree canopy.

canopy spread: A data field that estimates the width of a tree's canopy in five-foot increments.

existing UTC: The amount of UTC present within the town boundary.

geographic information systems (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a piece of an organization's overall information system framework. GIS links location to information (such as people to addresses, buildings to parcels, or streets within a network) and layers that information to give you a better understanding of how it all interrelates.

greenspace: A land use planning and conservation term used to describe protected areas of undeveloped landscapes.

impervious land cover: The area that does not allow rainfall to infiltrate the soil and typically includes buildings, parking lots, and roads.

land cover: Physical features on the earth mapped from satellite or aerial imagery such as bare soils, canopy, impervious, pervious, or water.

open water land cover: The land cover areas mapped as water typically include lakes, oceans, rivers, and streams.

pervious land cover: The vegetative area that allows rainfall to infiltrate the soil and typically includes parks, golf courses, and residential areas.

possible UTC: The amount of land that is theoretically available for the establishment of tree canopy within the town boundary. This includes all pervious and bare soil surfaces.

potential plantable area: The amount of land that is realistically available for the establishment of tree canopy within the town boundary. This includes all pervious and bare soil surfaces with specified land uses.

right-of-way (ROW): A strip of land generally owned by a public entity over which facilities, such as highways, railroads, or power lines, are built.

street tree: A street tree is defined as a tree within the right-of-way.

species: Fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. Characteristically, it has one main stem, although many species may grow as multi-stemmed forms.

tree benefit: An economic, environmental, or social improvement that benefited the community and resulted mainly from the presence of a tree. The benefit received has real or intrinsic value associated with it.

tree canopy land cover: The area of land surface that is covered by the tree's leaf covered branches as seen from above the ground surface.

urban forest: All of the trees within a municipality or a community. This can include the trees along streets or rights-of-way, parks and greenspaces, and forests.

urban tree canopy assessment: A study performed of land cover classes to gain an understanding of the tree canopy coverage, particularly as it relates to the amount of tree canopy that currently exists and the amount of tree canopy that could exist. Typically performed using aerial photographs, GIS data, or LIDAR.

References

American Forests. 2002. *CITYGreen.* (Version 5.0) [Computer software] Available at http://americanforests.org/productsandpubs/citygreen.

Coder, K. D. 1996. “Identified Benefits of Community Trees and Forests.” University of Georgia Cooperative Extension Service, Forest Resources Publication FOR96-39.

Ellis, A., M. Binkley, and D. J. Nowak. 2011. *i-Tree Vue* (Version 4.0) [Computer software] Available at http://www.itreetools.org. Accessed September 2013.

Faber Taylor, A., F.E. Kuo, and W.C Sullivan. 2001. “Coping with ADD: The surprising connection to green play settings.” *Environment and Behavior*. 33(1), 54–77.

Heisler, G. M. 1986. “Energy Savings with Trees.” *Journal of Arboriculture* 12(5):113–125. Prepared by Ryan Bell and Jennie Wheeler.

Karnosky, D. F. 1979. Dutch Elm Disease: A Review of the History, Environmental Implications, Control, and Research Needs. Environmental Conservation 6(04): 311–322.

Kuo, F. E. and A. Faber Taylor. 2004. “A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a National Study.” *Am. J. of Public Health*. 94(9):1580–1586.

Kuo, F., and W. Sullivan. 2001a. “Environment and Crime in the Inner City: Does Vegetation Reduce Crime?” *Envir. and Behavior* 33(3): 343–367.

———. 2001b. “Aggression and Violence in the Inner City - Effects of Environment via Mental Fatigue.” *Envir. and Behavior* 33(4): 543–571.

Lovasi, G. S., J. W. Quinn, K. M. Neckerman, M. S. Perzanowski, and A. Rundle. 2008. “Children living in areas with more street trees have lower prevalence of asthma.” *J. Epidemiol Community Health* 62:647–9.

Maryland Natural Resources–Forest Preservation Act of 2013 (passed May 2, 2013).

McPherson, E. G., J. R. Simpson, P. J. Peper, S. L. Gardner, K. E. Vargas, S. E. Maco, Q. Xiao, and S. K. Cozad. 2006. *Midwest Community Tree Guide: Benefits, Costs and Strategic Planting*. USDA Forest Service, Pacific Southwest Research Station. PSW-GTR-199. Albany, NY: USDA FS. 98

McPherson, E. G., R.A. Rowntree. 1989. “Using structural measures to compare twenty-two US street tree populations.” *Landscape J.* 8(1):13–23.

Miller, R. W., and W. A. Sylvester. 1981. “An Economic Evaluation of the Pruning Cycle.” *J. Arbor* 7(4):109–112.

North Carolina State University. 2012. *Americans are Planting Trees of Strength*. http://www.treesofstrength.org/benefits.htm. Accessed May 12, 2012.

Ohio Department of Natural Resources. 2012. *Position Statement: Master Street Tree Planting Plans*. http://ohiodnr.com/LinkClick.aspx?fileticket=uq3ki%2FMX51w%3D&tabid=5443. Accessed April 3, 2012.

Pokorny, J. D. 1992. *Urban Tree Risk Management: A Community Guide to Program Design and Implementation*. U.S. Forest Service, Northeastern Area State and Private Forestry. NA-TP-03-03. St. Paul, MN: USDA Forest Service.

Richards, N. A. 1983. "Diversity and Stability in a Street Tree Population." *Urban Ecology* 7(2):159–171.

Stamen, Randal. S. "Understanding and Preventing Arboriculture Lawsuits." Presented at the Georgia Urban Forest Council Annual Meeting, Madison, Georgia, November 2–3, 2011.

Ulrich, R. 1984. "View through Window May Influence Recovery from Surgery." *Science* 224(4647): 420–421.

———. 1986. "Human Responses to Vegetation and Landscapes." *Landscape and Urban Planning* 13:29–44.

USDA Forest Service. 2003a. "Benefits of Urban Trees. Urban and Community Forestry: Improving Our Quality of Life." *Forestry Report* R8-FR 71.

———. 2003b. *Is All Your Rain Going Down the Drain? Look to Bioretainment—Trees are a Solution.* Davis, CA: Center for Urban Forest Research, Pacific Southwest Research Station.

USDA. 2010. *National Agricultural Imagery Program*. [Ditigal Imagery] Available at: http://datagateway.nrcs.usda.gov. (Accessed July 2013.)

Wolf, K. L. 1998a. "Urban Nature Benefits: Psycho-Social Dimensions of People and Plants." *University of Washington, College of Forest Resources Fact Sheet*. 1(November).

———. 1998b. "Trees in Business Districts: Comparing Values of Consumers and Business. *University of Washington College of Forest Resources Fact Sheet.* 4(November).

———. 1998c"Trees in Business Districts: Positive Effects on Consumer Behavior!" *University of Washington College of Forest Resources Fact Sheet.* 5(November).

———. 1999. "Grow for the Gold." *TreeLink Washington DNR Community Forestry Program.* 14(spring).

———. 2000. "Community Image: Roadside Settings and Public Perceptions." *University of Washington College of Forest Resources Fact Sheet.* 10(August).

———. 2003. "Public Response to the Urban Forest in Inner-City Business Districts." *Journal of Arboriculture* 29(3):117–126.

Wolf, K.L., and K. Flora. 2010. "Mental Health and Function. Review of Literature." *Green Cities: Good Health.* College of the Environment, University of Washington. Last modified October 31, 2013. www.greenhealth.washington.edu.

Appendix A
Methodology and Accuracy Assessment

Land Cover Classification

An object-based image analysis (OBIA), semi-automated feature extraction method was used to process and analyze current high-resolution, color infrared (CIR) aerial imagery and remotely sensed data to identify tree canopy cover and land cover classifications including pervious, impervious, bare soil, and open water. Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery.

The semi-automated extraction process was completed using Feature Analyst®, an extension of ArcGIS®. Feature Analyst® uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual characteristics (e.g., texture, size, shape, pattern, and spatial association). The results of the extraction process were post-processed and clipped to each project boundary prior to the manual editing process to create smaller and more efficient file sizes. Secondary source data, high-resolution aerial imagery, and custom ArcGIS® tools were used to aid in the final manual editing, quality assurance, and quality checking (QA/QC) processes.

Workflow

The following manual QA/QC process was implemented to identify, define, and correct any misclassifications or omission errors in the final land cover layer.

1. Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2. Gather training set data for all desired land cover classes—tree canopy, pervious, impervious, bare soil, and open water (if needed)—and shadows. Training data for open water are not always needed since hydrologic data are usually available.
3. Extract only the tree canopy layer. This decreases the amount of shadow removal needed from large shadows created by tree canopy. Fill small holes and smooth to remove rigid edges.
4. Edit and finalize the tree canopy layer at a 1:1,500 scale. Create a point to digitize smaller individual trees that may be missed during the extraction process. These points are buffered to represent the tree canopy. This process is done to speed up editing time and improve accuracy by including smaller individual trees.
5. Extract remaining land cover classes using the tree canopy layer as a mask. This decreases the amount of shadow along edges.
6. Edit the impervious layer to reflect actual impervious features such as roads, buildings, parking lots, etc. to update features.
7. Using canopy and actual impervious as a mask, input the bare soil training data, and extract it from the imagery. Edit the layer to remove or add any features. Try to delete dry vegetation areas that are associated with lawns, grass/meadows, and agricultural fields.

8. Assemble hydrological datasets, if provided. Add or remove any water features to create the hydrology class. Perform a feature extraction if no water feature datasets exist.
9. Use geoprocessing tools to clean, repair, and clip all edited land cover layers to remove any self-intersections or topology errors that sometimes occur during editing.
10. Input canopy, impervious, bare soil, and open water layers into our 5 Class Land Cover Model to complete the classification. Davey Resource Group's model generates the pervious land cover class (grass & low-lying vegetation) by combining all other areas not previously classified.
11. Thoroughly inspect the final land cover dataset for any classification errors and correct as needed.
12. Perform accuracy assessment. Repeat Step 11 as needed.

Automated Feature Extraction Files

The automated feature extraction (AFE) files allow other users to run the extraction process by replicating the methodology. Since Feature Analyst does not contain all geoprocessing operations that Davey Resource Group utilizes, the AFE files only account for part of the extraction process. Using Feature Analyst, we created the training set data, ran the extraction, and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, we used additional geoprocessing tools within ArcGIS.

Workflow

From the AFE file results, the following steps were taken to prepare the extracted data for manual editing.

1. Fill all holes in the canopy less than 30 square meters. This eliminates small gaps that are created during the extraction process while still allowing for natural canopy gaps.
2. Delete all features that are less than 9 square meters for canopy and 50 square meters for impervious surfaces. This process reduces the amount of small features that could result in incorrect classifications and improves computer performance.
3. Run the Repair Geometry, Dissolve, and Multipart to Singlepart (in that order) geoprocessing tools to complete the extraction process.
4. Manually edit the Multipart to Singlepart shapefile to add, remove, or reshape features.

Accuracy Assessment Protocol

Determining the accuracy of spatial data is important. To achieve the best possible result, we manually edit and conduct thorough QA/QC on all tree canopy and land cover layers. The QA/QC process is completed using ArcGIS® to identify, clean, and correct any misclassification or topology errors in the final land cover dataset. The initial land cover layer extractions are edited at a 1:500 scale in the urban areas and at a 1:2,500 scale in rural areas; the most current high-resolution aerial imagery is used.

To test for accuracy, random plots are generated throughout the study area and then verified using QA/QC methods. To determine the accuracy of the final land cover layer, we compare a 3x3 grouping of pixels, rather than just a single pixel, to the most current NAIP high-resolution imagery (reference image). During the comparison, a GIS analyst views the individual pixels and assesses them for likeness between the imagery and results. Their findings are recorded in a classification matrix as correct, if the point matches the imagery, or incorrect if they do not match it. Accuracy is assessed using four metrics: overall accuracy, kappa, quantity disagreement, and allocation disagreement. These accuracy metrics are calculated using Excel™.

Land Cover Classification Code Values

Land Cover Classification	Code Value
Tree Canopy	1
Impervious	2
Pervious	3
Bare Soil	4
Open Water	5

Land Cover Accuracy

The following describes Davey Resource Group's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

1. *Random Point Generation*—Using ArcGIS, 1,000 random assessment points are generated. These points are utilized as "center points" of 3x3 pixel groupings. A box is drawn around the 9-pixel grouping. The 1,000 randomly generated groupings are used for the accuracy assessment. Using a 3x3 grouping of pixels provides more information for the accuracy assessment since adjacent pixels are also looked at. It also increases the number of pixels assessed since 9 pixels are assessed instead of just a single pixel. This method reduces the weight of the center pixel from 1 to 1/9 since the 3x3 grouping is assessed as a whole.

2. *Point Determination*—Each individual pixel of the 3x3 grouping is carefully assessed by the GIS analyst for likeness with the aerial photography. The number of pixels for each land cover type is recorded. The land cover class with the most pixels represented in the pixel grouping is determined to be the correct land cover class, unless visually disputed on high-resolution sub-meter imagery. To record findings, two new fields, CODE and TRUTH, are added to the accuracy assessment point shapefile. CODE is a numeric value (1–5) assigned to each land cover class (Table 1) and TRUTH is the actual land cover class as identified according to the reference image. If CODE and TRUTH are the same for all nine pixels assessed, then the point is counted as a correct classification. Likewise, if none of the pixels assessed match, then the point is classified as incorrect. If the location has been 100% egregiously misclassified (all nine pixels incorrect), then the results have the same outcome as using just a single pixel. The same is true for a correct classification.

In most cases, distinguishing if a point is correct or incorrect is straightforward. Points will rarely be misclassified by an egregious classification or editing error. Often incorrect points occur where one feature stops and the other begins. Using 9 pixels for the accuracy assessment instead of only 1 pixel allows for better identification of transitional pixels and assignment of varying degrees of correctness. For example, if the center pixel of the 9-pixel box is considered incorrect, the other 8 pixels surrounding it may still be classified correctly. Thus, instead of the accuracy of this location being completely correct or completely incorrect, it can be classified as mostly correct as opposed to being classified completely incorrect.

3. *Classification Matrix*—During the accuracy assessment, if a point is considered incorrect, it is given the correct classification in the TRUTH column. Points are first assessed on the NAIP imagery for their correctness using a “blind” assessment—meaning that the analyst does not know the actual classification (the GIS analyst is strictly going off the NAIP imagery to determine cover class). Any incorrect classifications found during the “blind” assessment are scrutinized further using sub-meter imagery provided by the client to determine if the point was incorrectly classified due to the fuzziness of the NAIP imagery or an actual misclassification. After all random points are assessed and recorded; a classification (or confusion) matrix is created. The classification matrix for this project is presented in Table 2. The table allows for assessment of user’s/producer’s accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals (Omission/Commission Error Figure and Table below)

Classification Matrix

Land Cover Class	Tree Canopy	Impervious	Pervious	Bare Soil	Open Water	**Row Total**	Producer's Accuracy	Errors of Omission
Tree Canopy	2330	42	144	0	0	**2516**	92.61%	7.39%
Impervious	28	1737	196	0	0	**1961**	88.58%	11.42%
Pervious	55	90	4042	8	1	**4195**	96.35%	3.65%
Bare Soil	0	0	0	116	0	**116**	100.00%	0.00%
Open Water	0	0	12	0	188	**200**	94.00%	6.00%
Column Total	**2413**	**1869**	**4394**	**124**	**188**	**8988**		
User's Accuracy	96.56%	92.94%	91.99%	93.55%	100.00%		Overall Accuracy	93.60%
Errors of Commission	3.44%	7.06%	8.01%	6.45%	0.00%		Kappa Coefficient	0.9017

4. Following are descriptions of each statistic as well as the results from some of the accuracy assessment tests.

   Overall Accuracy – Percentage of correctly classified pixels; for example, the sum of the diagonals divided by the total points ((2,330+1,737+4,042+116+188)/8,988 = 93.60%).

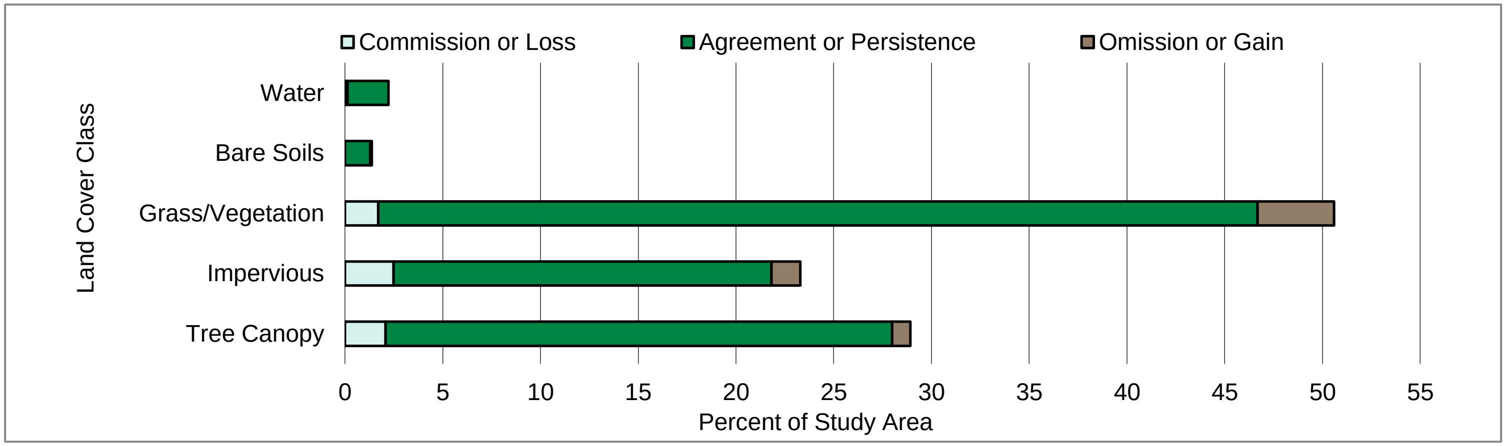
   User's Accuracy – Probability that a pixel classified on the map actually represents that category on the ground (correct land cover classifications divided by the column total [2,330/2,413 = 96.56% for tree canopy]).

   Producer's Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [2,330/2,516= 92.61% for tree canopy]).

   Kappa Coefficient – A statistical metric used to assess the accuracy of classification data. It has been generally accepted as a better determinant of accuracy partly because it accounts for random chance agreement. A value of 0.80 or greater is regarded as "very good" agreement between the land cover classification and reference image.

   Errors of Commission – A pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actually present). This is termed as a false positive. In Table 2, we can determine that 3.44% of the area classified as tree canopy is most likely not tree canopy.

   Errors of Omission – A pixel reports the absence of a feature (such as trees) when, in reality, they are actually there. In Table 2, we can conclude that 7.39% of all tree canopy classified is actually present in the land cover data.



Omission/Commission Errors

Allocation Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than optimal match in the spatial allocation (or position) of the classes.

Quantity Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than perfect match in the proportions (or area) of the classes.

Confidence Intervals – A confidence interval is a type of interval estimate of a population parameter and is used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter based on the observed probability of successes and failures. Since all assessments have innate error, defining a lower and upper bound estimate is essential.

95% Confidence Intervals, Accuracy Assessment, and Statistical Metrics Summary

Land Cover Assessment

Land Cover Class	Acreage	Percentage	Lower Bound	Upper Bound
Tree Canopy	1,967.6	27.0%	26.5%	27.5%
Impervious	1,588.4	21.8%	21.4%	22.3%
Pervious	3,469.1	47.6%	47.0%	48.2%
Bare Soil	104.8	1.4%	1.3%	1.6%
Open Water	156.9	2.2%	2.0%	2.3%
Total	7,286.7	100.00%		

Accuracy Assessment

Land Cover Class	User's Accuracy	Lower Bound	Upper Bound	Producer's Accuracy	Lower Bound	Upper Bound
Tree Canopy	96.6%	96.2%	96.9%	92.6%	92.1%	93.1%
Impervious	92.9%	92.3%	93.5%	88.6%	87.9%	89.3%
Pervious	92.0%	91.6%	92.4%	96.4%	96.1%	96.6%
Bare Soil	93.5%	91.3%	95.8%	100.0%	100.0%	100.0%
Open Water	100.0%	100.0%	100.0%	94.0%	92.3%	95.7%

Statistical Metrics Summary

Overall Accuracy =	93.60%
Kappa Coefficient =	0.9017
Allocation Disagreement =	4%
Quantity Disagreement =	2%

Ecosystem Benefits Estimator

i-Tree Vue

Davey Resource Group used i-Tree Vue (Version 4.0: USDA Forest Service et al., 2012) to calculate the environmental benefits tree canopy cover provides. Studies have shown National Land Cover Data (NLCD) to underestimate both tree canopy and impervious cover to varying degrees. Within i-Tree Vue, a user-defined adjustment factor applies uniformly across the entire area of interest and allows the user to reset the overall tree canopy and impervious cover percentages. By adjusting the tree canopy values to the existing tree canopy values derived from the 2011 land cover extractions, ecosystem services such as: carbon storage, carbon sequestration, and pollution removal values can be more accurately. By default, i-Tree Vue uses state average data for the analysis; however, additional adjustments can be made if local information is available. Further analyses utilize the adjusted imperious cover values to calculate estimated available Green Space and model tree canopy percent change. The following is an explanation of each analysis.

Air Quality: i-Tree Vue uses NLCD satellite-based imagery to assess a project area's land cover and quantifis the monetary and unit values of pollution reduction.

Carbon: i-Tree Vue models the urban forests' carbon benefits demostrating the amount of UTC directly correlated to current and future increases in carbon reduction.

Stormwater Modeling and Prioritized Plantable Area

CITYGreen®

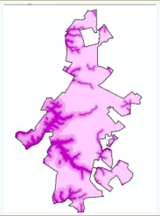
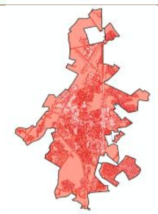
Stormwater: Stormwater assessment was completed using the TR-55 hydrologic equations created by the USDA for modeling stormwater runoff. These equations are commonly used to assess stormwater runoff in urban watersheds by generating a curve number. This number is correlated with hydrologic soil groups which identify a soil's permeability. In addition, the curve number also uses current land cover as an input. To calculate runoff, the equation uses rainfall data, potential maximum retention, and initial abstraction. CITYGreen® for ArcView® 3.x software was utilized to quantify the monetary and unit values of pollution reduction and stormwater.

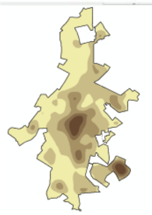
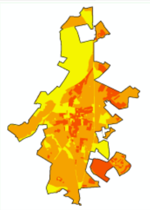
Prioritized Plantable Area

To identify and prioritize risk of stormwater runoff potential, Davey Resource Group looked at a number of environmental features via GIS, including location within a floodplain, hydrologic soil group, slope, proximity to hardscape and tree canopy, and road and population densities (see table on following page). For modeling, individual grids of each of the above-mentioned environmental features were created. Values between zero and four, with zero being the least potential for runoff and four the greatest, were assigned to areas of the grids to represent runoff risk potential. The grids were superimposed and the values assigned averaged at any given point. Using the numeric scale, the areas were ranked and classified from very high to low risk of stormwater runoff.

Tree planting was recommended based on the priority assigned and, thus, directed at reducing stormwater runoff. Prioritized plantable areas were identified using the grid analysis results and the assumption that the planting area was a regular polygon shape greater than 100 square feet. Irregular planting area polygons less than 100 square feet were eliminated from the analysis.

Environmental Features Assessed During Stormwater Runoff Modeling

Factor	Justification
	Floodplain: A floodplain is an area of land adjacent to a stream or riverthat stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. Floodplains can support particularly rich ecosystems, both in quantity and diversity. Protecting them is ecologically important.
	Hydrologic Soil Group: Soils are assigned groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils have four groups (A, B, C, and D). Soil designated as A have a high infiltration rate (low runoff potential) while D soils have slow infiltration rates (high runoff).
	Slope: Slope is a measure of change in elevation. It is a crucial parameter in several well-known predictive models used for environmental management. A higher degree of slope increases the velocity of stormwater runoff causing a greater risk of erosion due to sheeting, especially if slopes are bare.
	Hardscape Proximity: Impervious surfaces vastly increase the amount of runoff during storm events. By identifying these locations and their surroundings, measures can be taken to reduce the amount of runoff by planting trees close to hardscapes.

Factor	Justification
	<u>Canopy Proximity:</u> Canopy fragmentation has many ecological downsides by degrading the overall health of the trees and wildlife. It is essential to close as many gaps and create more connectivity to increase biodiversity and health of the canopy.
	<u>Road Density:</u> The amount of road density signifies how much noise and air pollution is being released in the atmosphere. Controlling these factors helps maintain quieter neighborhoods as well as reduced levels of air pollution emissions such as carbon dioxide, ozone, particulate matter.
	<u>Population Density:</u> Population density represents the number of people within a given area. Having greater amounts of people within an area attracts the need for more trees to aesthetically improve the urban landscape. By planting in areas with higher population density, there is more return on investment because more people receive this benefit.

Appendix B
Urban Tree Canopy Assessment Summaries

A full account of summary data for townwide, watersheds, and land use results are presented below. Parcel data were not included in the summary due to the length of the file. All data were provided on CD-ROM.

Townwide Urban Tree Canopy Assessment Results

AREA	ACRES	CANOPY (ACRES)	CANOPY (%)	IMPERVIOUS (ACRES)	IMPERVIOUS (%)	PERVIOUS (ACRES)	PERVIOUS (%)	BARE SOIL (ACRES)	BARE SOIL (%)	WATER (ACRES)	WATER (%)	POSSIBLE (ACRES)	POSSIBLE (%)	POTENTIAL (ACRES)	POTENTIAL (%)
Townwide	7,286.73	1,967.57	27.00	1,588.37	21.80	3,469.09	47.61	104.82	1.44	156.88	2.15	3,573.91	49.05	2,898.57	39.78
Business District	118.61	24.54	20.69	65.95	55.60	25.42	21.43	2.10	1.77	0.60	0.51	27.52	23.20	27.62	23.28

Watershed Urban Tree Canopy Assessment Results

WATERSHED	ACRES	CANOPY (ACRES)	CANOPY (%)	IMPERVIOUS (ACRES)	IMPERVIOUS (%)	PERVIOUS (ACRES)	PERVIOUS (%)	BARE SOIL (ACRES)	BARE SOIL (%)	WATER (ACRES)	WATER (%)	POSSIBLE (ACRES)	POSSIBLE (%)	POTENTIAL (ACRES)	POTENTIAL (%)
Miles River	1,825.08	385.44	21.12	281.78	15.44	1,124.74	61.63	29.14	1.60	3.99	0.22	1,153.88	63.22	746.70	40.91
Lower Choptank	5,042.09	1,485.32	29.46	1,223.40	24.26	2,117.04	41.99	66.77	1.32	149.57	2.97	236.23	56.30	234.70	55.94
Upper Choptank	419.55	96.81	23.08	83.20	19.83	227.31	54.18	8.91	2.12	3.32	0.79	2,183.81	43.31	1,917.18	38.02

Land Use Urban Tree Canopy Assessment Results

LAND USE	ACRES	CANOPY (ACRES)	CANOPY (%)	IMPERVIOUS (ACRES)	IMPERVIOUS (%)	PERVIOUS (ACRES)	PERVIOUS (%)	BARE SOIL (ACRES)	BARE SOIL (%)	WATER (ACRES)	WATER (%)	POSSIBLE (ACRES)	POSSIBLE (%)	POTENTIAL (ACRES)	POTENTIAL (%)
Agriculture	1,026.08	344.65	33.59	7.47	0.73	652.90	63.63	7.47	0.73	13.60	1.32	660.37	64.36	653.52	63.69
Commercial	1,643.95	355.51	21.63	482.87	29.37	729.84	44.40	58.37	3.55	17.35	1.06	788.22	47.95	485.84	29.55
Exempt	898.17	214.28	23.86	167.39	18.64	501.03	55.78	14.02	1.56	1.44	0.16	515.05	57.34	283.87	31.61
Industrial	257.92	67.93	26.34	43.75	16.96	141.94	55.03	3.87	1.50	0.43	0.17	145.81	56.53	145.85	56.55
Mixed Use	13.84	4.72	34.14	2.29	16.59	5.71	41.31	0.73	5.28	0.37	2.69	6.44	46.58	6.47	46.76
Residential	2,239.70	764.36	34.13	346.63	15.48	1,104.00	49.29	11.83	0.53	12.88	0.58	1,115.83	49.82	1,039.34	46.41
Unknown	260.12	81.73	31.42	32.74	12.59	136.94	52.64	3.26	1.25	5.46	2.10	140.20	53.90	96.43	37.07

Appendix C
Vacant Planting Sites Specifications

Vacant Planting Sites

Specifications

- Space size of 4 feet x 8 feet or larger for a large vacant planting site.
- Space size of 3 feet x 4 feet for a small vacant planting site.
- Professional judgment and the existing streetscape will be used to determine vacant planting sites and, in some cases, vacant planting site size may be less than 3 feet x 4 feet.
- Trees are planted 35 feet on center; however, professional judgment may decrease this distance.
- Planting sites will be located no closer than 5 feet from known underground utilities. The location of underground utilities will be based on GIS data provided by the Town.
- Based on Town-provided GIS data, vacant planting sites will not be placed over underground utilities that are directly beneath the sidewalk.
- If underground utilities are present on one side of the street, then using professional judgment, vacant planting sites may be collected more frequently and closer than 35 feet on center on the other side of the street in an effort to compensate for the unplantable side of the street.

Overhead Utilities

- All are distribution lines per Town direction. Use professional judgment when assessing sites under overhead utility lines for tree planting.

Cut-outs

- Using professional judgment, areas of full or partial cement will be recommended for tree planting if:
  - No underground utilities are present within 5 feet.
  - No underground utilities are directly beneath the sidewalk.
  - Overhead utilities are not in conflict.
- Cut-outs may be consistent with existing streetscape, recommended in areas considered stark, or where professional judgment warrants it.

Data Fields

- Cut-outs. This data field will be added to the data collection program and will be used for vacant planting sites only. It will be a *yes* or *no* data field utilized when a cut-out is needed to allow for a vacant planting site.
- Notes. The notes data field will be used for concerns deemed significant and worthy of notation by the Davey Resource Group arborist and for threats to trees from ivy deemed very severe by the Davey Resource Group arborist.

Appendix D
Tree Planting Tips

To ensure a successful tree planting effort:

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift it by the trunk.
- If trees are stored prior to planting, keep the roots moist.
- Dig the planting hole according to the climate. Generally, the planting hole is two to three times wider than and not quite as deep as the root ball. The root flair is at or just above ground level.
- Fill the hole with native soil unless it is undesirable; in which case, add soil amendments as appropriate for local conditions. Gently tamp and add water during filling to reduce large air pockets to ensure a consistent medium of soil, oxygen, and water.
- Stake the tree as necessary to prevent it from shifting too much in the wind.
- Add a thin layer (1 to 2 inches) of mulch to help prevent weeds and keep the soil around the tree moist. Do not allow mulch to touch the trunk.

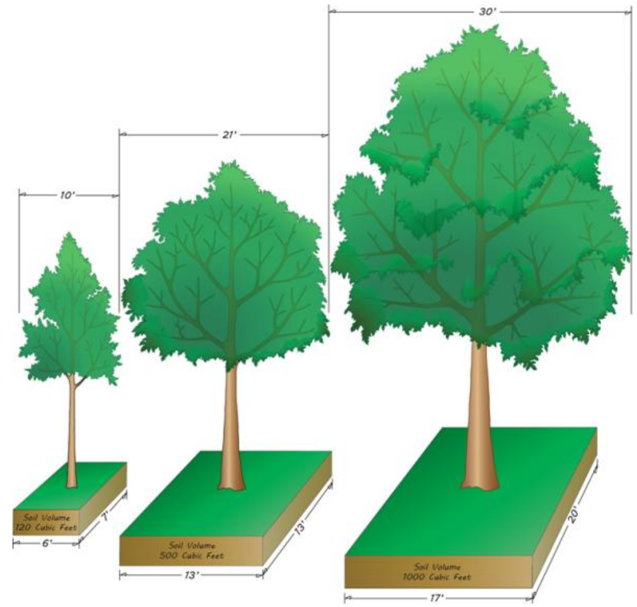


Illustration based on the work of Casey Trees, 2008.

Newly Planted and Young Tree Maintenance

Equal in importance to planting trees is caring for them after they are planted. After planting a tree, it must receive maintenance for several years.

Initially, watering is the key to survival; new trees typically require at least 60 days of watering to establish. Determine how often to irrigate trees based on time of planting, drought status, species selection, and site condition.

Mulch can be applied to the growspace around a newly planted tree (or even a more mature tree) to ensure that no weeds grow, the tree is protected from mechanical damage, and the growspace is moist. Mulch should be applied in a thin layer, generally one to two inches, and the growing area covered. Mulch should not touch the tree trunk or be piled up around the tree.

Life-Long Tree Care

After the tree is established, it will require routine tree care, which includes inspections, routine pruning, and watering, plant health care, and integrated pest management as needed.

The Town should employ qualified arborists to provide most of the routine tree care. An arborist can determine the type of pruning necessary to maintain or improve the health, appearance, and safety of trees. These techniques may include eliminating branches that rub each other; removing limbs that interfere with wires and buildings; or that obstruct streets, sidewalks or signage; removing dead, damaged, or weak limbs that pose a hazard or may lead to decay; removing diseased or insect-infested limbs; creating better structure to lessen wind resistance and reduce the potential for storm damage; and removing branches, or thinning, to increase light penetration.

An arborist can help decide whether a tree should be removed and if so how urgent the removal is. Additionally, an arborist can provide advice about and perform tree maintenance when disasters such as storms or droughts occur. Storm-damaged trees can often be dangerous to remove or trim. An arborist can assist in advising or performing the job in a safe manner, while reducing further risk of damage to property.

Plant Health Care, a concept of preventive maintenance to keep trees in good health, will help a tree better defend itself against insects, disease, and site problems. Arborists can help determine proper plant health so the Town's tree population will remain healthy, providing benefits to the community for as long as possible.

Integrated Pest Management is a process involving common sense and sound solutions for treating and controlling pests. These solutions incorporate basic steps: identifying the problem, understanding pest biology, monitoring trees, and determining action thresholds. The practice of Integrated Pest Management can differ dramatically site by site, individual tree by individual tree; a qualified arborist will be able to make sure that the Town's trees are properly diagnosed and that a beneficial and realistic action plan is developed.

Cabling or bracing for added support to branches with weak attachment, aeration to improve root growth, installation of lightning protection systems are also practices the arborist can help with.

Educating the community in basic tree care is a good way to promote the Town's urban forestry program and encourage tree planting on private property. The Town should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the Town if they notice any changes in the trees such as: signs or symptoms of pests, early fall foliage, or new mechanical or vehicle damage.

Appendix E
Suggested Tree Species

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant Town personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate (USDA Hardiness Map Zone 7) conditions found throughout the state of Maryland.

This suggested species list was compiled through the use of the references *Dirr's Hardy Trees and Shrub's* (Dirr 1997), *Dirr's Trees and Shrubs for Warm Climates* (Dirr, 2002), and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1998). This list is not inclusive, and the listed species are offered only as recommendations based on Davey Resource Group's experience. Note that tree availability in the nursery trade varies considerably.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar/Notes
Acer rubrum	red maple	'Autumn Flame'; 'Red Sunset'
Acer saccharum	sugar maple	'Green Mountain'
Carya illinoinensis	pecan	
Celtis laevigata	sugarberry	'All Seasons'; 'Magnifica'
Cercidiphyllum	katsuratree	
*Eucommia ulmoides**	hardy rubbertree	
Ginkgo biloba	ginkgo	use male trees only
Gymnocladus dioica	Kentucky coffeetree	
Nyssa sylvatica	black gum	
Platanus × acerifolia	London planetree	'Bloodgood'
Quercus imbricaria	shingle oak	
Quercus rubra	northern red oak	
Quercus shumardii	Shumard oak	
Tilia cordata	littleleaf linden	
Tilia tomentosa	silver linden	
Ulmus parvifolia	Chinese elm	'Dynasty'
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees: 31 to 45 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar/Notes
Acer truncatum	Shantung maple	
Carpinus betulus	European hornbeam	'Fastigiata'
Cladrastis kentukea	American yellowwood	
Corylus colurna	Turkish filbert	
Gleditsia triacanthos	honeylocust	inermis
Koelreuteria paniculata	goldenraintree	
Maackia amurensis	Amur maackii	
Ostrya virginiana	eastern hophornbeam	
Phellodendron amurense	Amur corktree	
Pistacia chinensis	Chinese pistache	
Prunus maackii	Amur chokecherry	
Prunus sargentii	Sargent cherry	
Prunus × yedoensis	Yoshino cherry	
Quercus acutissima	sawtooth oak	

Small Trees: 15 to 30 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar/Notes
Acer buergerianum	trident maple	
Acer campestre	hedge maple	
Acer griseum	paperbark maple	
Acer tataricum	Tatarian maple	
Acer tataricum ginnala	Amur maple	
Acer triflorum	three-flower maple	
Aesculus × carnea	red horsechestnut	
Amelanchier × grandiflora	apple serviceberry	'Autumn Brilliance'
Carpinus caroliniana	American hornbeam	
Cercis canadensis	eastern redbud	
*Chionanthus retusus**	Chinese fringetree	use tree form only

Small Trees: 15 to 30 Feet in Height at Maturity (Continued)

Botanical Name	Common Name	Cultivar/Notes
*Chionanthus virginicus**	white fringetree	use tree form only
Cornus florida	flowering dogwood	
Cornus kousa	kousa dogwood	
*Cornus mas**	Corneliancherry dogwood	
*Cornus officianalis**	Japanese Cornel dogwood	
*Cotinus obovatus**	American smoketree	use tree form only
Crataegus crusgalli	cockspur hawthorn	inermis
Crataegus laevigata	English hawthorn	'Superba'
*Crataegus phaenopyrum**	Washington hawthorn	
Crataegus viridis	green hawthorn	'Winter King'
Crataegus × *lavallei*	Lavalle hawthorn	
Magnolia ×*	Galaxy hybrid magnolia	'Galaxy'
Malus spp.	flowering crabapple	use disease-free only
Oxydendrum arboreum	sourwood	
Parrotia persica	Persian parrotia	use single-stem form only
Prunus serrulata	Japanese flowering cherry	'Shirotae'
Prunus subhirtella	Higan cherry	'Autumnalis'; 'Rosy Cloud'
Prunus virginiana	common chokecherry	'Schubert'
Prunus × *incamp*	Okame cherry	'Okame'
Stewartia koreana	Korean stewartia	
Stewartia monadelpha	tall stewartia	
Syringa reticulata	Japanese tree lilac	'Ivory Silk'; 'Summer Snow'

Trees for Narrow Streets

Botanical Name	Common Name	Cultivar
Acer rubrum	red maple	'Armstrong'
Acer saccharum	sugar maple	'Goldspire'
Carpinus betulus	European hornbeam	'Columnaris'
Ginkgo biloba	ginkgo	'Princeton Sentry'; 'Magyar'
Prunus sargentii	Sargent cherry	'Spire'
Quercus palustris	pin oak	'Pringreen'
Quercus robur	English oak	'Fastigiata'
Sorbus aucuparia	European mountainash	'Fastigiata'

Large Grow Spaces: Along Streets, Adjacent to Parking Lots, or Park Trees

Botanical Name	Common Name	Cultivar
Betula nigra	river birch	Heritage®
*Carya glabra**	pignut hickory	
Carya illinoinensis	pecan	
*Carya ovata**	shagbark hickory	
*Liquidambar styraciflua**	American sweetgum	
*Liriodendron tulipifera**	tuliptree	
*Metasequoia glyptostroboides**	dawn redwood	
Nyssa sylvatica	black gum	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus macrocarpa	bur oak	
Quercus phellos	willow oak	
Quercus prinus	chestnut oak	
*Taxodium ascendens**	pondcypress	
*Taxodium distichum**	common baldcypress	
Ulmus americana	American elm	'Delaware'

Note: * denotes species that are **not** recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Cedrus deodora	deodar cedar	
Cryptomeria japonica	Japanese cryptomeria	'Yoshino'
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus echinata	shortleaf pine	
Pinus heldreichii	Bosnian pine	
Pinus koraiensis	Korean pine	
Pinus ponderosa	ponderosa pine	
Pinus rigida	pitch pine	
Pinus serotina	pond pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Psedotsuga menziesii	Douglas-fir	
Thuja plicata	western arborvitae	numerous exist
Tsuga canadensis	eastern hemlock	
Xanthocyparis nootkatensis	Nootka false cypress	'Pendula'

Medium Trees: 31 to 45 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	numerous exist
Juniperus virginiana	eastern redcedar	‘Princeton Sentry’
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Thuja occidentalis	eastern arborvitae	numerous exist

Small Trees: 15 to 30 Feet in Height at Maturity

Botanical Name	Common Name	Cultivar
Ilex × *attenuata*	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo	mugo pine	