TITLE: **Springfield Township Tree Canopy Study**

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ABSTRACT:

Urban forests provide environmental, economic, and aesthetic value to society. Reduction in stormwater runoff, energy savings, improvements in air quality, as well as their visual aesthetic are among the benefits of including trees as a part of the urban and suburban fabric. To safeguard tree resources into the future, municipalities can determine the percentage of their canopy cover and establish appropriate goals.

The Urban Forestry team's mission is to connect people and plants through outreach, education, and consulting both locally and regionally. With that mission in mind, the goal of this project was to help Springfield Township better understand its tree resources by conducting a tree canopy study using GIS (Geographic Information Systems) and LiDAR (*Light Detection and Ranging*) mapping technology.

Our planet's geography was poorly defined until the dawn of aerial photography following WWI. In today's modern age, maps are a precise and powerful tool used for presenting and analyzing spatial information. More advanced data are now being collected by aerial flyover. Montgomery County, Pennsylvania acquired a LiDAR dataset in 2008. These data can dramatically improve the ability of municipalities to make tree-related decisions because of more detailed and accurate measurements of their tree canopy.

Using LiDAR data, Springfield Township was found to have a 32.4% tree canopy cover. The resulting canopy cover map will be used in Springfield Township's Natural Resources section of their decennial Comprehensive Plan. The Township can now consider and set an appropriate canopy goal and next determine which areas to be targeted for future tree plantings.

To supplement the study, a proposal was developed to conduct a more in-depth analysis of Springfield Township's tree resources by inventorying and assessing trees under its jurisdiction. Additionally a marketing brochure was designed to promote the study to other municipalities and has evolved into a campaign to help additional townships understand their urban forest in its current form and plan feasible approaches to increasing tree canopy cover to benefit their citizens.

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BACKGROUND

Benefits of Urban Trees

Beyond their visual beauty, trees sequester carbon, reduce stormwater runoff, moderate the urban heat island effect, save energy, improve air quality, and increase property values illustrated in Figure 1 (Staley, 2004). Much of the literature on the benefits of urban trees comes from the United States Department of Agriculture Forest Service. From the Northern and Western Research Stations, David Nowak and other research foresters have quantified urban and suburban tree canopy cover and the benefits they offer.

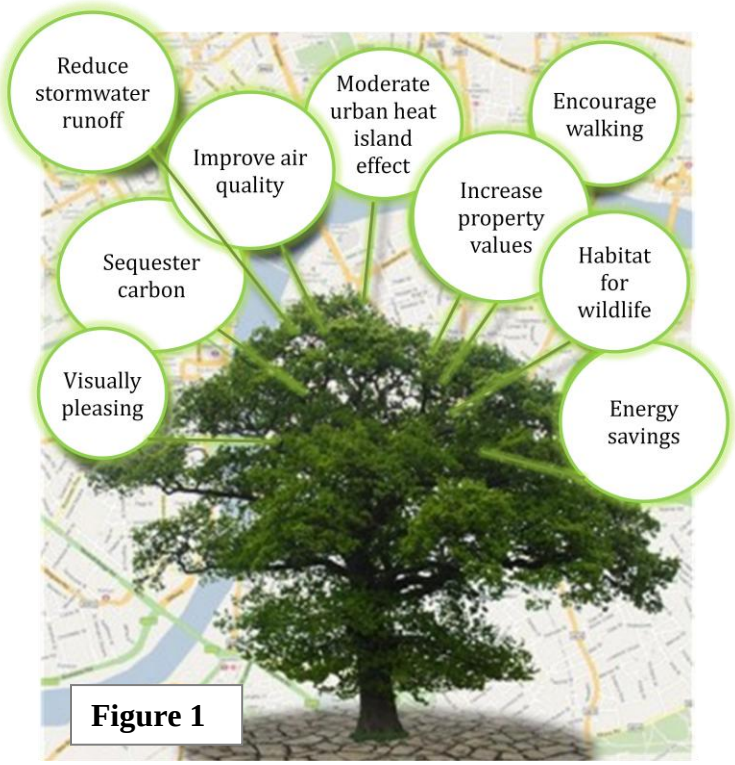


Figure 1

In March of 2003, American Forests, Inc. and the U.S. Forest Service presented a report titled "Urban Ecosystem Analysis: Delaware Valley Region." The report's findings indicated that the 2.4 million acres that make up the Delaware Valley had suffered a loss of 8% of heavy tree cover (-34,000 acres) in 15 years, translating into a reduction in benefits offered by those trees (Urban Ecosystem Analysis, 2003). The analysis looked at changes in land use over time and calculated the monetary value of the environmental impact trees have on the region.

Stormwater Runoff

Trees are particularly beneficial to watersheds. Springfield Township's Wissahickon Creek Watershed and its receiving streams are negatively affected by a rise in impervious surfaces resulting from development where trees once stood. During a rain event water runs off hard surfaces and travels towards streams gaining speed, collecting pollutants, and increasing the volume of water that flows into streams. This process is exacerbated with a diminished forested landscape. Stormwater runoff peak and total flows are increased by this process and cause flooding, erosion, widening of stream banks, sedimentation, and a loss in water quality (Cotrone, 2008).

Most of the benefits derived from the urban forest come from the trees' leafy canopy. The canopy intercepts rain water, slows stormwater runoff, and reduces runoff volume. Interception is a way to calculate runoff mitigation by trees, and accounts for stormwater that fails to reach the ground surface. Studies have found that interception can reduce runoff from an average of 10-40% depending on species, season, and the precipitation rate. A deciduous tree in an urban or suburban setting can intercept 500 to 760 gallons of water per year. The volume is greater for evergreen trees, intercepting over 4,000 gallons per year, due to their foliage enduring over colder seasons (Cotrone, 2008). A Forest Service study found that a small nine-year-old Callary pear (*Pyrus callaryana*), intercepted 67% of the rain that fell within its canopy (58

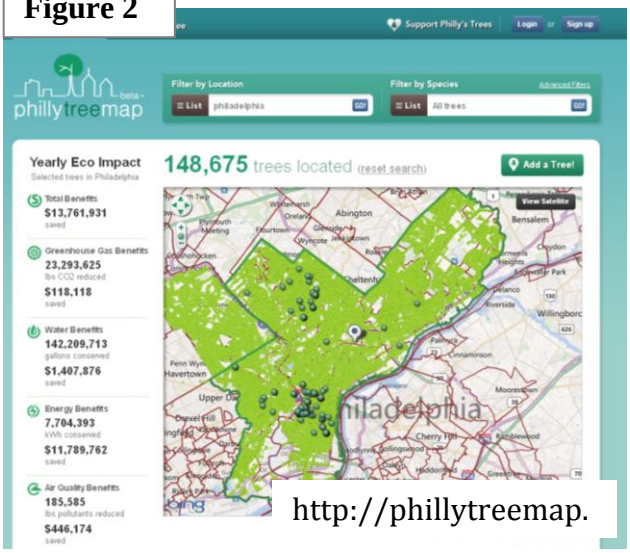
gallons of stormwater from a ½-inch rainfall). However, large canopy trees planted over urban impervious surfaces are up to eight times more effective at intercepting stormwater (Cotrone, 2008).

Regional Urban and Suburban Foresting Efforts

Reacting to a declining urban forest, TreeVitalize was introduced by the Department of Conservation and Natural Resources (PADCNR), with a campaign to "Plant One Million" trees in three states, (Pennsylvania, New Jersey, and Delaware) and is currently run by the Pennsylvania Horticultural Society (PHS). Moreover, they have a goal to train 10,000 volunteers in tree biology and tree care to serve as community stewards in establishing and maintaining new plantings. Ultimately the goal of TreeVitalize is to establish strong urban forestry partnerships in the region, and to build local capacity for sustaining the urban forest resource (www.treevitalize.net).

A number of collaborative initiatives by other organizations have since been introduced. Philadelphia Parks and Recreation recently launched TreePhilly, a tree giveaway program for private property home owners. All regional planting efforts count towards the "Plant One Million" goal. To track and analyze urban trees a number of inventory and analysis software programs are available including iTree and CityGreen. Additionally, to encourage public engagement and ease the data collection loads, a local mapping consulting company, Azavea, has developed Philly Tree Map represented in Figure 2. This open source website allows anyone to enter data for species, location, and size and see the calculated benefits of the urban forest.

Figure 2



Springfield Township and the Morris Arboretum

Springfield Township, located in Montgomery County, Pennsylvania, recognizes the benefits of their urban forest. The updated decennial Comprehensive Plan will include a new subsection on Tree Canopy Cover within its chapter on Natural & Historic Resources, demonstrating that the township values trees as an important part of their green infrastructure. The township stretches across over 16 square miles of mostly suburban community with a population of about 19,500 (www.springfieldmontco.org). To ensure a sustainable healthy urban forest, the township can benefit from further analysis of their canopy cover.

Springfield Township is home to the Morris Arboretum's Bloomfield Farm, where the Horticultural Center accommodates about a quarter of the Arboretum staff. Figure 3, represents Springfield Township and the Morris Arboretum, which is represented by a star. The Arboretum's Director of Public Programs, Robert Gutowski, serves as Chairman of the Springfield Township Planning Commission, and has established a close and active relationship between the township and the Arboretum. Former Arboretum projects included updating Springfield Township's approved plant materials list.

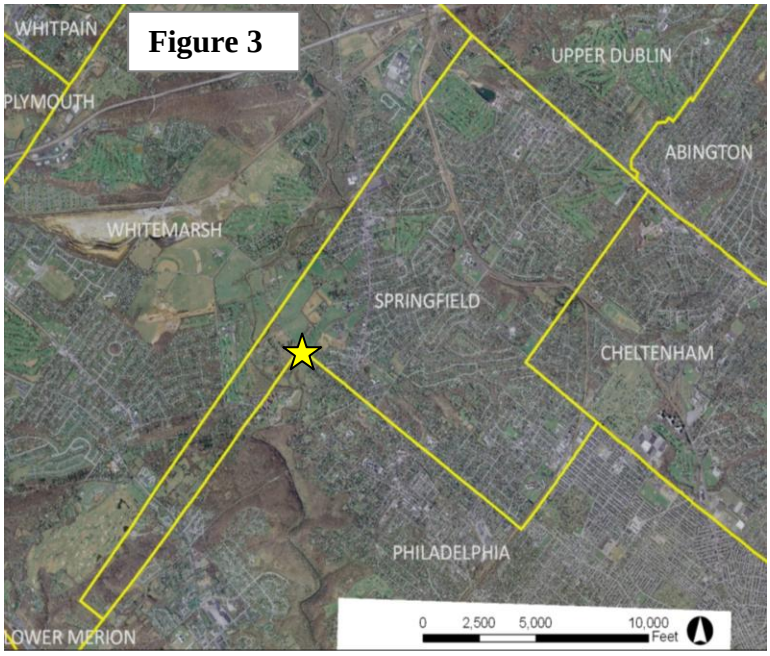


Figure 3

METHODOLOGY

Tree canopy studies are a necessary part of natural resource planning and management. Recognizing the importance of the urban forest, researchers have explored ways to more accurately and efficiently determine canopy cover. While conducting an inventory and assessments of individual trees is useful for assessing the health and potential hazard of urban trees, it can be timely and costly. For large scale sites tree canopy mapping can be determined using aerial data.

The Spatial Analysis Laboratory (SAL) at the University of Vermont's (UVM) Rubenstein School of the Environment and Natural Resources developed a methodology for determining tree canopy cover using Light Detection and Ranging (LiDAR) data. The methodology has been used for determining canopy cover for a number of American cities. Based on 2008 data and the USDA Forest Service's tree canopy protocol, the UVM analyzed Philadelphia's tree canopy. This project was made possible by an America Recovery and Reinvestment Act (ARRA) grant through the USDA Forest Service's Northern Research Station, in collaboration with Philadelphia Parks & Recreation (O'Neil-Dunne, 2011).

In 2008, Montgomery County also acquired LiDAR data through the PAMAP program by the Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. The data are made available for free through the Pennsylvania Spatial Data Access (PASDA) website, a hub for spatial information. To determine canopy cover, these data were extracted for Springfield Township, and processed using a methodology similar to that of UVM and documentation from the Environmental Sciences Research Institute (ESRI). The geographic information system used for processing was ArcGIS.

Prior to the availability of LiDAR data, the only comprehensive remotely-sensed estimates of tree canopy for the region were from the 2001 National Land Cover Database (NLCD 2001). NLCD 2001 is derived from relatively coarse, 30-meter resolution satellite imagery. Using LiDAR acquired in 2008, land cover can be mapped with greater accuracy than NLCD 2001, due to closer intervals of data points and the absence of shadows. Figure 4 from the UVM protocol illustrates this difference between LiDAR over NLCD.

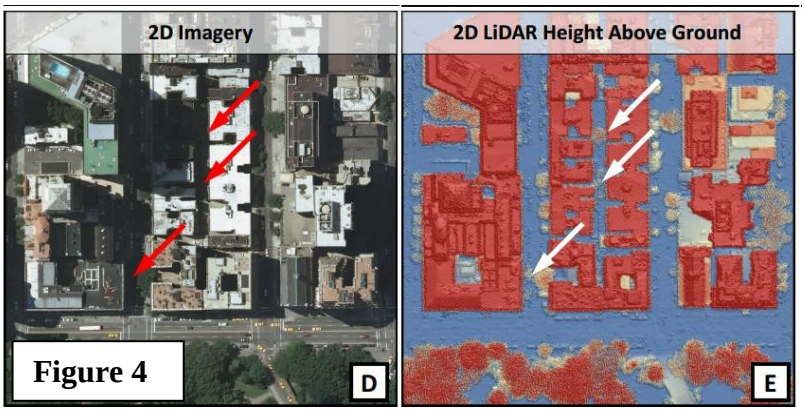


Figure 4

http://nrs.fs.fed.us/urban/utc

LiDAR is captured by flyover in which the plane illuminates the target with light using laser pulses. Capturing the distance it takes for each pulse to bounce back, a corresponding x, y, and z coordinate point is created. All the captured points form a point cloud that illustrates the volumetric shape of the given site. Figure 5 represents the point cloud for an amusement park in section view.

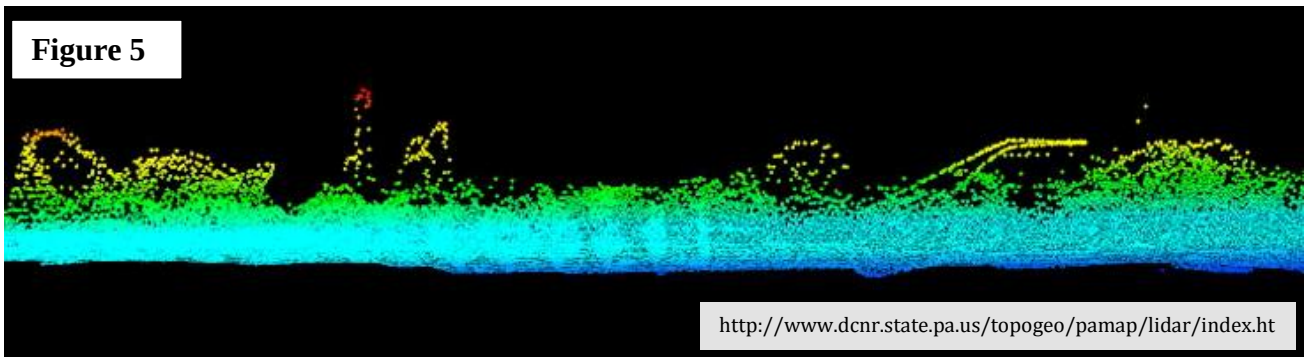
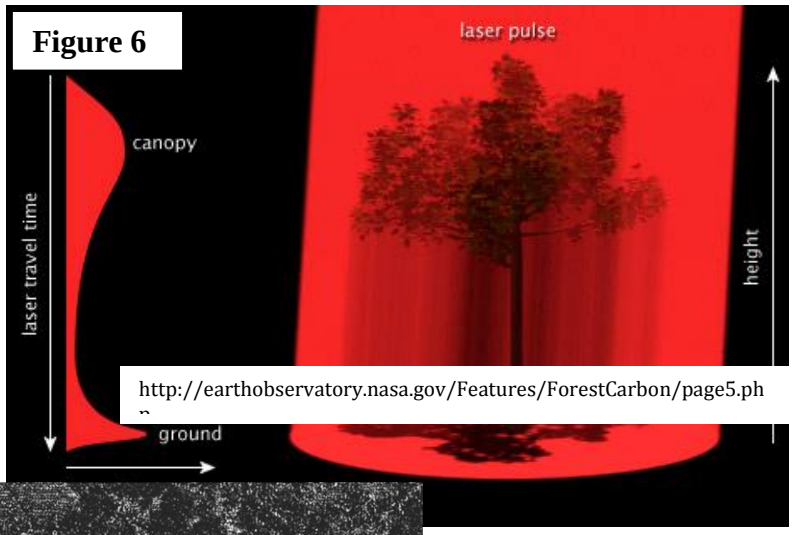


Figure 5

http://www.dcnr.state.pa.us/topogeo/pamap/lidar/index.ht

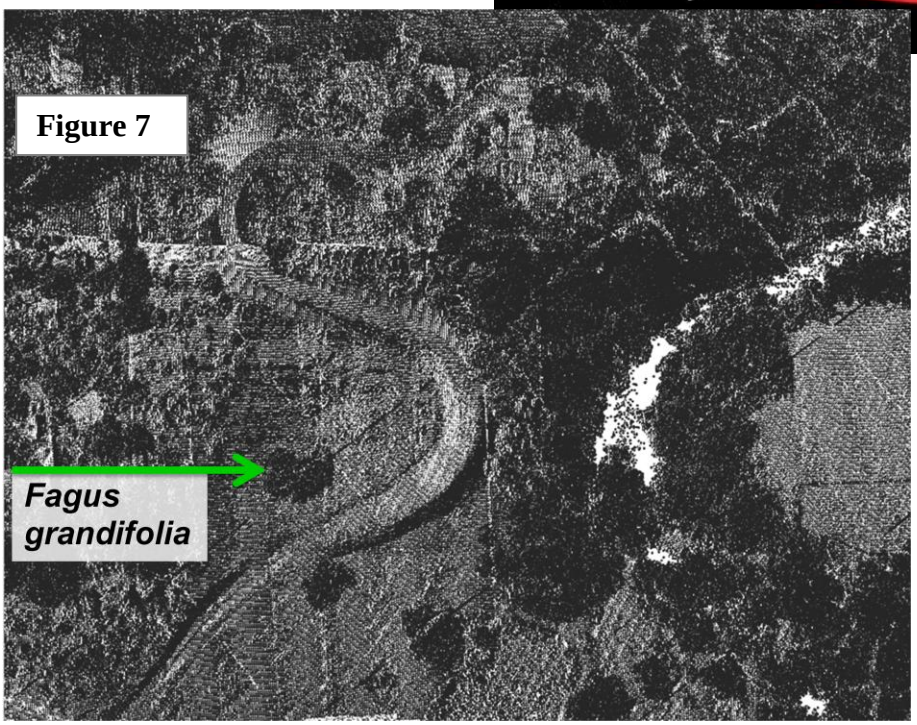
Tree canopy is the layer of leaves, branches, and stems that cover the ground when viewed from above. Trees have a unique spatial characteristic due to the height variation associated with each trees shape. LiDAR points are determined for the ground as gaps between leaves and branches allow for ground penetration. Figure 6 illustrates how light contacts trees and captures height values. Moreover, maximum height is captured as light contacts the top of the crown. Similarly, values are captured for light contacting branches, foliage, and trunk between the ground and the crown. Figure 7 shows a LiDAR point cloud representation for the Morris Arboretum's "S" shaped driveway up the Magnolia Slope with the big *Fagus grandiflora* marked for scale. This section of the Morris Arboretum will be used to illustrate the following steps for creating a tree canopy map.

Figure 6



http://earthobservatory.nasa.gov/Features/ForestCarbon/page5.ph

Figure 7



The data points were interpolated to create a smooth surface presenting minimum and maximum surface points. Where data points were not captured, the values were estimated through extrapolation. The absolute height, adjusted for variations in ground elevation is attained by subtracting the minimum value from the maximum. The resulting map of the difference represents canopy cover. Most groundcover and infrastructure that has the same maximum as minimum will cancel each other out since their difference is zero. Minor adjustments, selecting the minimum height to display, can then be made to determine tree canopy. Maps for interpolations of minimum, maximum, and difference are represented below by Figures 8, 9, and 10.

Figure 8

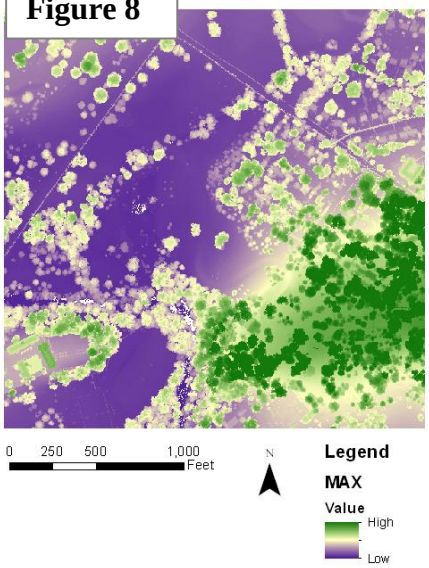


Figure 9

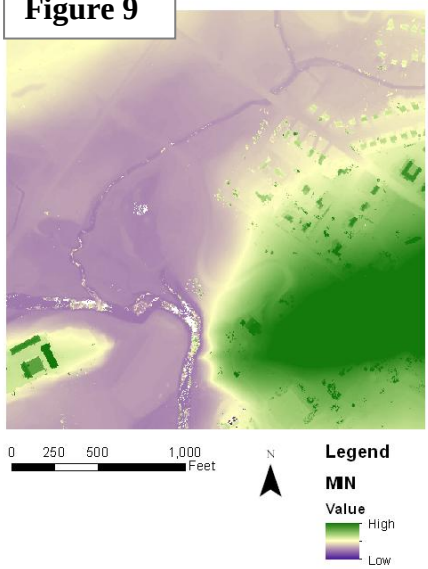
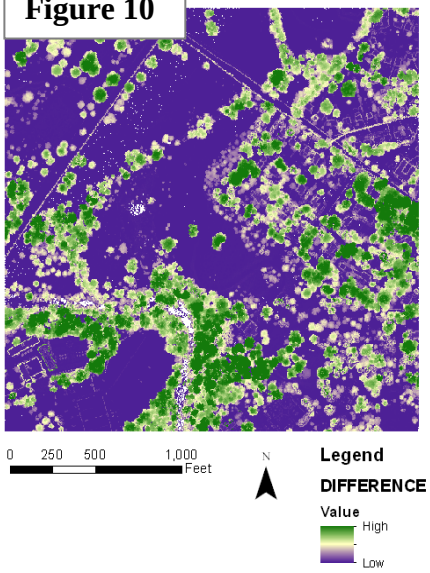
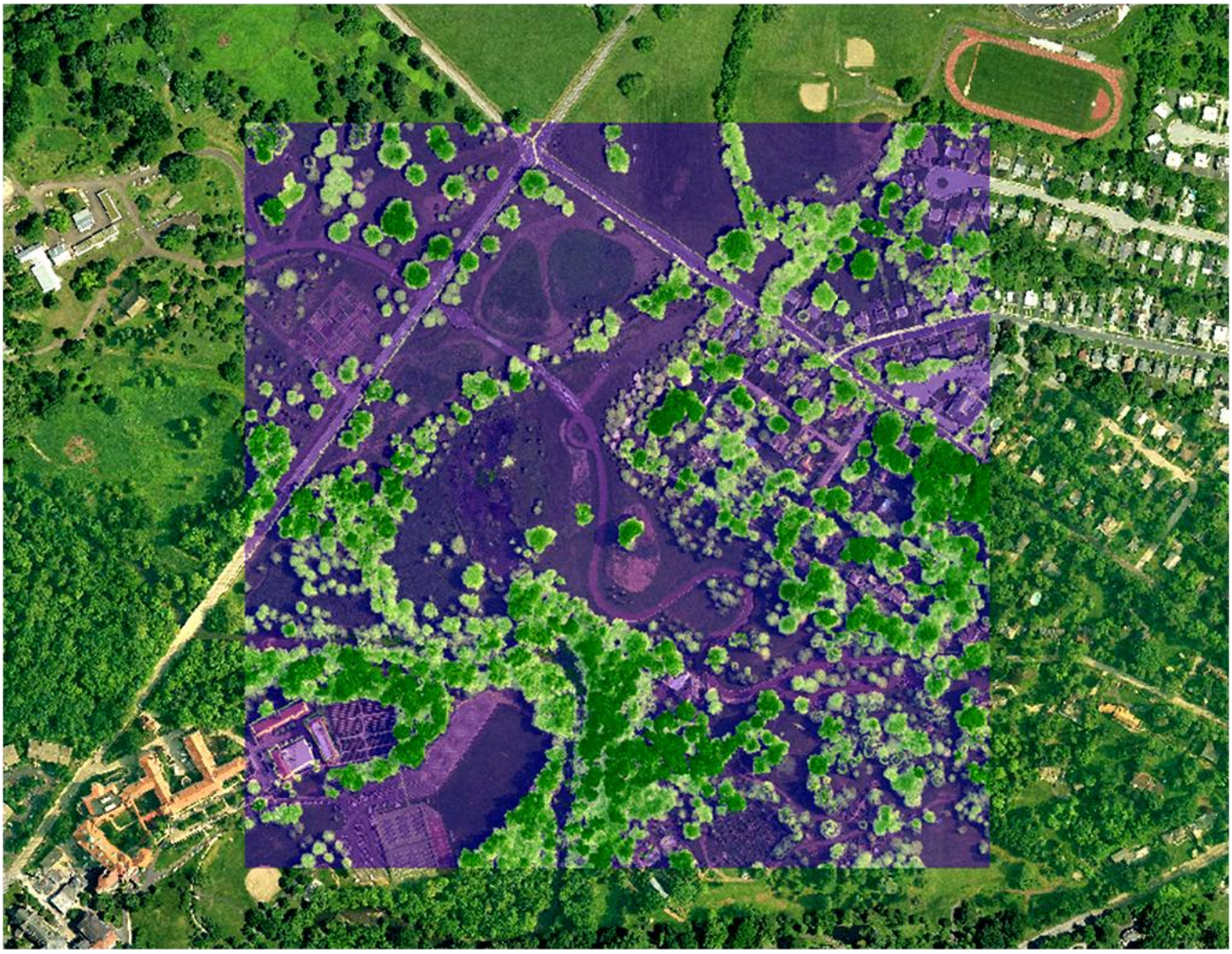


Figure 10



The difference map was next overlaid on aerial imagery and is illustrated in Figure 11 to roughly show that the canopy cover map does fit the site very well.

Figure 11: Morris Arboretum Sample Site Canopy



RESULTS

Comparison to other Municipalities

The preceding steps from the described methodology were followed for Springfield Township and revealed a total canopy cover of 32.4%. Springfield Township's canopy cover is below American Forests' recommendations: of 40% for overall canopy; 50% in suburban residential; 25% in urban residential; and 15% in central business districts (Urban Ecosystem Analysis Delaware Valley Region). Across the country, many municipalities are determining their canopy cover and are setting tree canopy goals for the future. Philadelphia, learning it had a canopy of 20% in 2008, is planning to expand their urban forest to 30% by 2015 (O'Neil-Dunne, 2011). Similarly, Washington D.C. has a goal of 40% by year 2035, from a 2002 canopy cover of 34% (www.caseytrees.org/programs/policyadvocacy/utc). Figure 12 represents other municipalities and their corresponding canopy cover and goals.

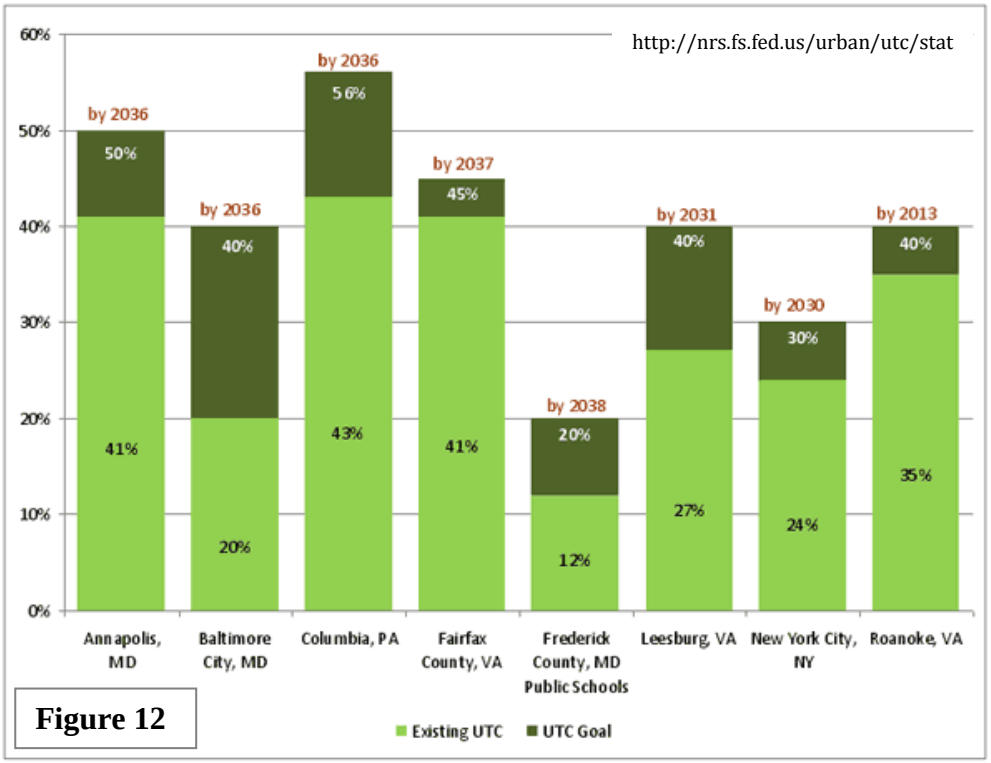


Figure 12

Springfield Township Stormwater Runoff Implications

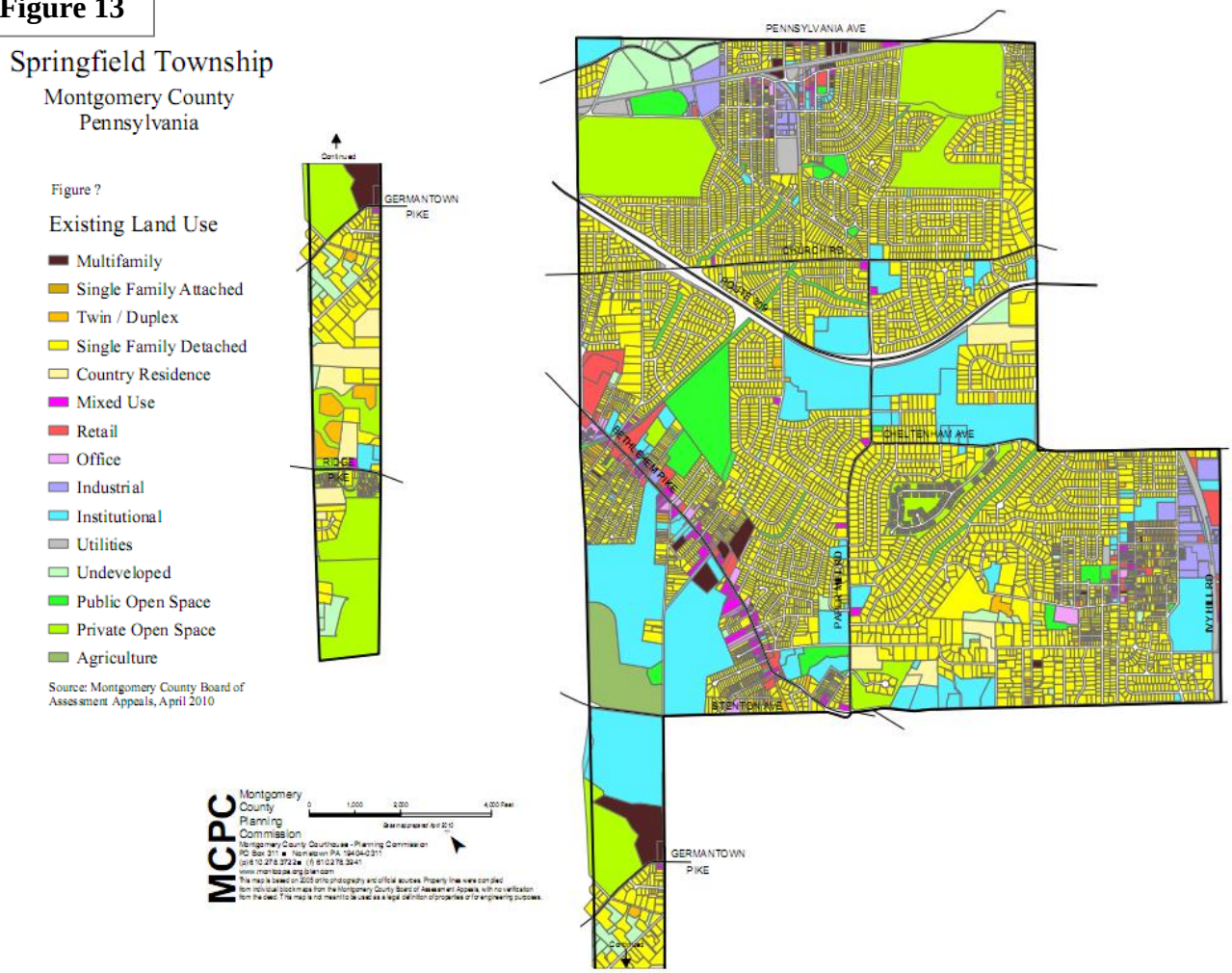
Canopy cover offers many benefits, some of which can be quantified financially. Springfield Township's planners are especially concerned with stormwater management. Infrastructure used to manage stormwater is costly. Using values determined by the Urban Ecosystem Analysis for the Delaware Valley Region in 2003 stormwater mitigation benefits by canopy cover were extrapolated for Springfield Township. Given an average 2-year, 24-hour rainfall of 3.25 inches, with a 32.4% canopy cover (1,395 acres of total canopy) the construction cost of building additional stormwater infrastructure at $2 per cubic foot would be $4,356 per acre. Canopy cover for Springfield Township provides a benefit of about $6,000,000 in

infrastructure cost savings from runoff. The estimated cost savings is for stormwater runoff alone, and neglects all the other benefits offered by trees.

Potential for Tree Planting

To ensure future generations of trees, it is important to maintain existing trees and plant new trees. Taking a closer look at land use can reveal opportunities for tree plantings. The resulting canopy cover map was overlaid on a Land Use category map, shown in Figure 13, provided by Montgomery County to determine the percentage of canopy cover for each land use category.

Figure 13



Among land use categories there is room for improvement for "Single Family Attached" areas, which has a calculated canopy cover of 26%. Not surprisingly, the "Wooded" category has the highest percentage (71%) of canopy cover. Amongst residential areas, "Single Family Detached Low Density" has the highest canopy cover with 43%. All categories and their corresponding canopy cover are represented in Figures 14, 15 and 16 in map, tabular, and graph formats.

Figure 14

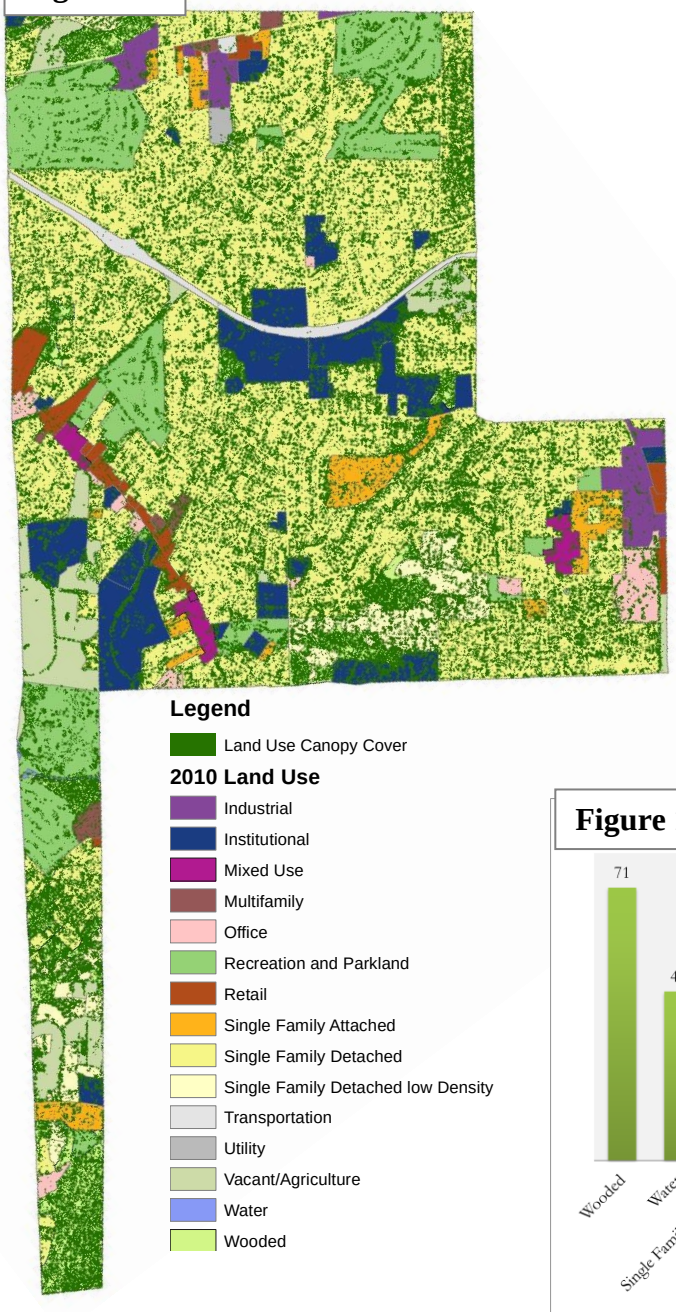
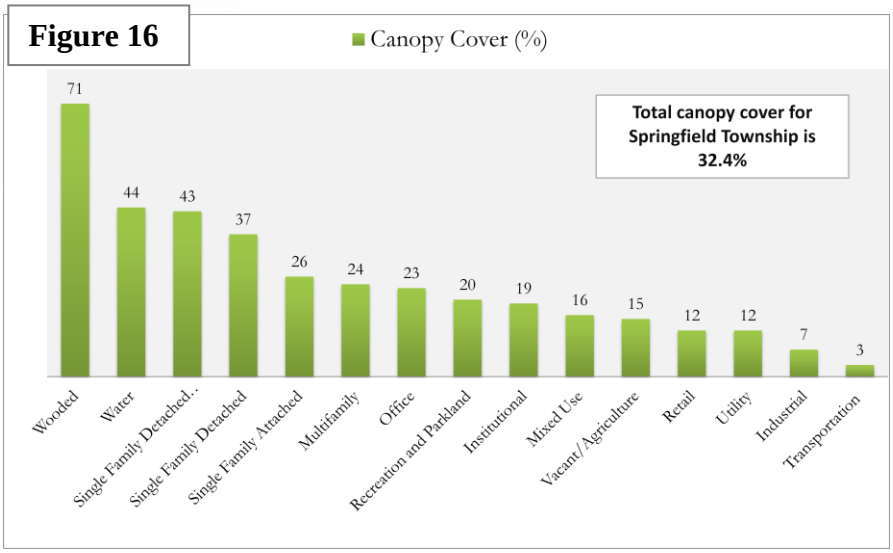


Figure 15

Land Use	Land Use #	Area (acres)	Canopy Cover (%)
Wooded	14	266	71
Water	16	3	44
Single Family Detached Low Density	2	179	43
Single Family Detached	1	2355	37
Single Family Attached	4	116	26
Multifamily	3	25	24
Office	10	66	23
Recreation and Parkland	13	493	20
Institutional	11	361	19
Mixed Use	9	39	16
Vacant/Agriculture	15	190	15
Utility	7	9	12
Retail	8	76	12
Industrial	12	83	7
Transportation	6	46	3

Figure 16



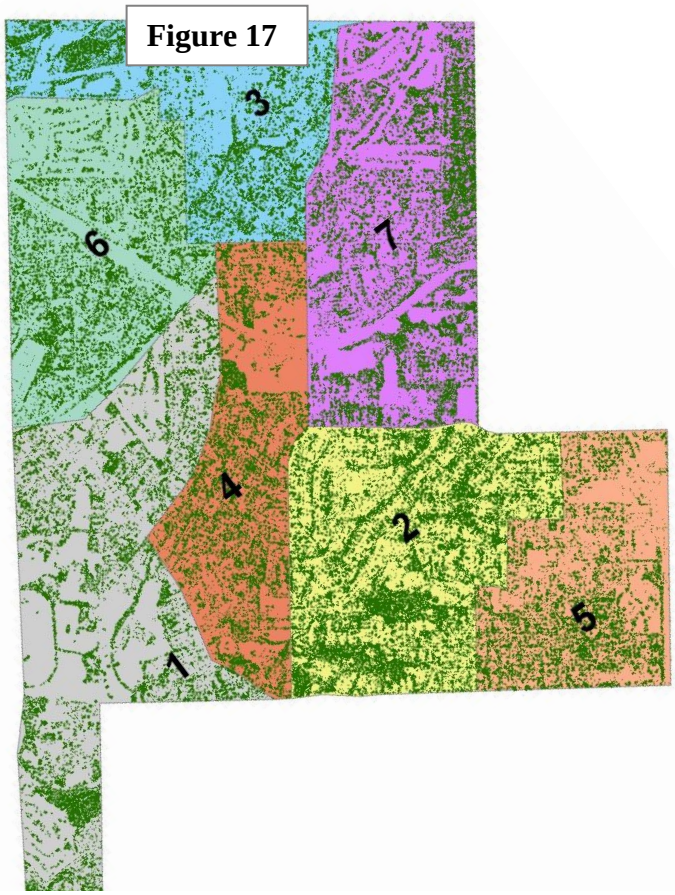


Figure 17

Additionally, canopy cover was broken down by Voting Wards, shown in Figure 17. Ward 2, accounting for the general Wyndmoor area, had over 10% more canopy cover than the others, with a total of 44%. Given this condition, potential for improvement lies in the top left corner of the yellow area. Ward 6 had the least cover with 27%. Ward 1, Flourtown, with 32%, has the second most coverage, but it too but could be improved since much of the canopy is designated in the protected natural panhandle area of the ward.

LIMITATIONS TO THE STUDY

There are a number of limitations to this study. First, related to the data, the tree canopy map represents conditions at the time the LiDAR data was collected (2008). It is unlikely that the canopy has changed significantly since then and the more meaningful question is when can this data be collected again? The PAMAP program has flyovers planned for every three years. However, budgetary constraints have restricted abiding to the schedule. It can be anticipated that LiDAR flyover will resume in the future as this type of data continues to become more precise and popular. Ultimately Springfield Township can expect to have the data capacity to reassess its tree canopy in the future for comparison to 2008.

Furthermore, the data was captured at intervals of 3.2 feet. For areas between points that were not collected, canopy cover was determined by extrapolation algorithms. Since 2008, LiDAR has become even more precise. The city of Philadelphia is expecting to acquire a 4 inch interval dataset.

Finally, knowing that tree canopy encompasses 32.4% of Springfield Township is helpful, but does not provide any information about the health and longevity, like a tree inventory and assessment would provide. Moreover, the canopy cover map layer can be more beneficial for determining planting locations if supplemented with other map layers such as impervious surface, slope, sidewalk planting pits, etc.

DISCUSSION

Springfield Township now has baseline information allowing planners to understand and quantify their canopy cover. They can use the tree canopy map as a planning tool for determining planting locations. To supplement this study Springfield Township would benefit from a planting targeting study to detail specific potential planting locations and a tree inventory and assessment. While these services fall outside of the scope of this study, a proposal addressing these issues is in Appendix I.

The general mindset of Springfield Township residents is that development has reached its peak, and no further investment in green infrastructure planning is needed. Residents may be uncompromising when it comes to the use of their tax dollars on canopy planning efforts as well as being advised on what to do on their private property. For instance, after paying a few thousand dollars to remove a hazardous tree in their yard, it is understandable that someone may not want to plant a new one. Educating people about the benefits of trees can start to shift residents' thinking.

Finally, while this study is restricted by the geographic boundaries of Springfield Township, nature knows no boundaries. Stormwater runoff and retention is not confined within municipal borders. A larger campaign aimed to help other municipalities understand their canopy cover and set appropriate goals is necessary for larger scale benefits. Whitemarsh Township has already expressed a strong interest in the study and is reviewing a proposal submitted by the Urban Forestry Consultants. To promote canopy cover studies region-wide, a marketing brochure was developed and is included in Appendix II.

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Additional Resources:
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City of Philadelphia, Enterprise GIS

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