TREES TO OFFSET STORMWATER

Case Study 01: Orange County, FL

February 28, 2018

Front cover image: Forest in eastern Orange County
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Project Overview

This project, called *Trees to Offset Stormwater*, is a study of Orange County, Florida's forest canopy and the role that trees play in uptaking, storing and releasing water. This study was undertaken to assist Orange County in evaluating how to better integrate trees into their stormwater management programs. More specifically, the study covers the role that trees play in stormwater management and shows ways in which the county can benefit from tree conservation and replanting. It also evaluated ways for the county to improve forest management as the county develops.

PROJECT FUNDERS AND PARTNERS

This is a pilot project for a new approach to estimate the role of trees in stormwater uptake. Florida is one of six southern states that received funding from the USDA Forest Service to study how trees can be utilized to meet municipal goals for stormwater management. The Florida Forest Service (FFS) is administering the pilot studies in Florida. Orange County applied to be one of the test cases in Florida for the project and was the only county selected to participate. In addition to Orange County, the cities of Miami Beach and Jacksonville are pilot study localities.

The project was developed by the nonprofit Green Infrastructure Center Inc. (GIC) in partnership with the states of Florida, North Carolina, South Carolina, Alabama, Georgia and Virginia. The GIC created the data and analysis for the project. The project was spurred by the on-going decline in forest cover throughout the southern United States. Causes for this decline arise from multiple sources including land conversion for development, storm damages and lack of tree replacement as older trees die. Many localities have not evaluated their current tree canopy, which makes it difficult to track trends, assess losses or set goals to retain or restore canopy. As a result of this project, Orange County now has new tools to track canopy protection progress and to help prioritize restoration of canopy where needed.

Since the project began in January 2017, Orange County staff members have participated in project review, analysis and evaluation. The Technical Review Committee (TRC) consisted of representatives from the following Divisions: Cooperative Extension/IFAS, Development Engineering, Environmental Protection, Facilities Management, Fiscal and Operational Support, Parks and Recreation, Planning, Public Works Engineering and Zoning. In addition, a representative from the Florida Forest Service, Orlando District, also participated on the TRC.

Street trees support downtowns by providing shade and improving real estate values.

The public was asked to add their ideas for tree conservation or planting.

OTHER RELATED STUDIES

Concurrent with the *Trees to Offset Stormwater* project, and as part of its grant match, the county also hired a consultant to conduct its first Urban Forest Ecological Analysis (tree inventory and i-Tree Eco analysis) of the urban service area of unincorporated Orange County, in order to evaluate the urban forest's structure, function and value.

When taken alongside the Urban Forest Ecological Analysis, the tree canopy analysis prepared by the GIC will provide the county with a baseline assessment of its urban tree canopy, which can then serve as the foundation for future urban forest management planning.

The University of South Florida performed a 30-year Tree Canopy Cover Change Analysis from 1986 to 2016 to provide some historical information regarding tree canopy change. Two community meetings were held (one on June 13, 2017 and one on February 22, 2018) to provide information on the study to the public and to gather their input and concerns regarding tree conservation. This report includes those findings and recommendations that are based on tree canopy cover mapping and analysis, the modeling of stormwater uptake by trees, a review of relevant county codes and ordinances, and citizen input and recommendations for the future of Orange County.

More specifically, the following deliverables were included in the pilot study:

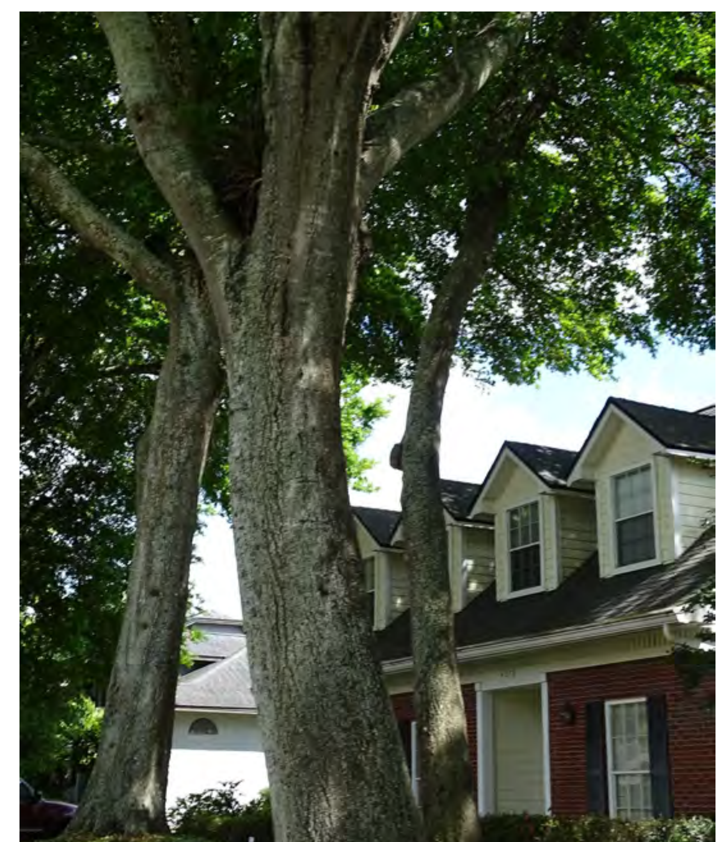
- analysis of the current extent of the urban forest through high resolution tree canopy mapping,
- Possible Planting Area analysis to determine where additional trees could be planted,
- a method to calculate stormwater uptake by the county's tree canopy,
- a review of existing codes, ordinances, guidance documents, programs and staff capabilities related to trees and stormwater management, and recommendations for improvement,
- two community forums to provide outreach and education,
- presentation of the results of the pilot studies as a case study at the National Partners In Community Forestry Conference, and
- a case booklet and PowerPoint presentation detailing the pilot study methodology, as well as lessons learned and best practices.

Orange County can use this report and its associated products to:

- *Set goals and develop a management plan for retaining or expanding its tree canopy by watershed.*
- *Improve management practices so trees will be well-planted and well-managed.*
- *Educate developers about the importance of tree retention and replacement.*
- *Motivate private landowners (residential, commercial, and institutional) to protect their trees.*
- *Justify and support grant applications for tree conservation projects.*

SUMMARY OF FINDINGS

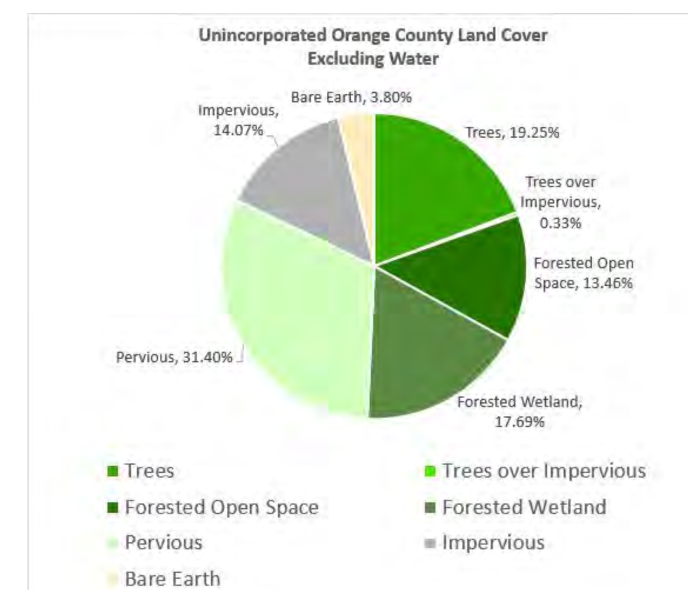
Satellite imagery was used to classify the types of land cover in Orange County (for more on methods see page 15). This shows the county those areas with vegetative cover that allow for the uptake of water and those that are impervious and more likely to have stormwater runoff. High-resolution tree canopy mapping provides a baseline of tree canopy cover that can assess current status and evaluate future progress in tree preservation and enhancement. An ArcGIS geodatabase with all GIS shape files produced during the study was provided to Orange County for its future use.



One mature tree can absorb thousands of gallons of water per year.

The goal of this study was to identify ways in which water entering the county's municipal separate storm sewer system (MS4) could be reduced by using trees. Tree canopy serves as green infrastructure that can provide more capacity to support grey infrastructure (i.e. stormwater drainage systems) in the future. It was also intended to help the county reduce potential pollution of its surface waters, which can have an impact on Total Maximum Daily Load (TMDL) requirements and Basin Management Action Plans (BMAPs).

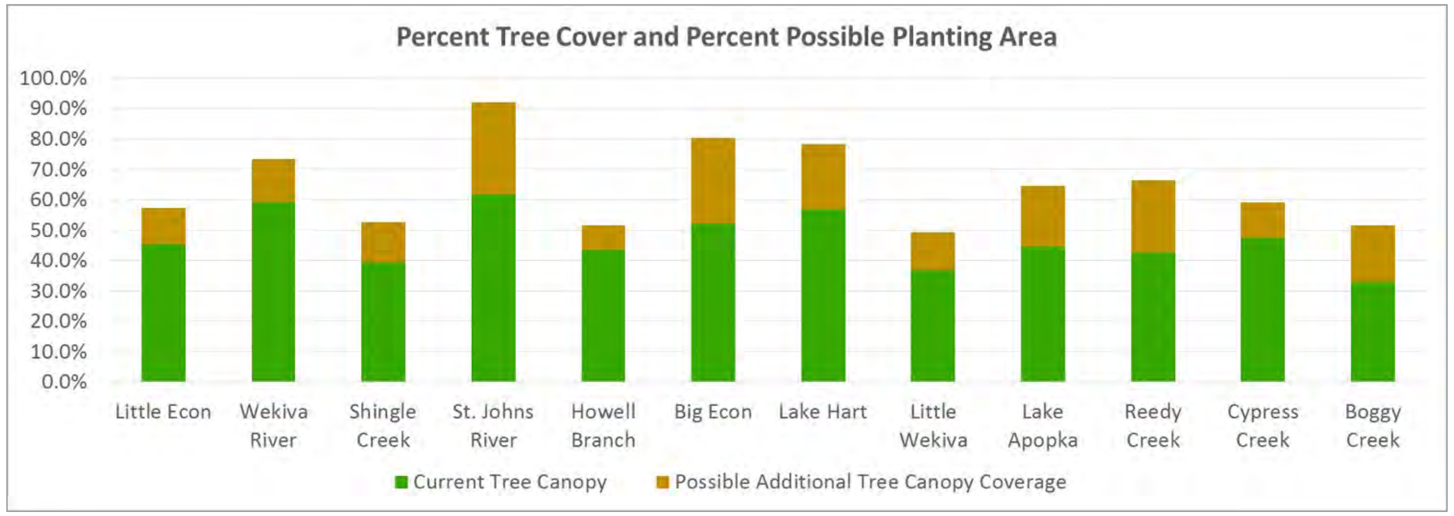
This project created a detailed land cover analysis to evaluate how much water is taken up by the county's trees in various scenarios. This new approach allows for more detailed assessment of stormwater uptake based on the landscape conditions of the county's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks. The amount of open space and the condition of surface soils affect the infiltration of water. In order to determine these conditions, a detailed land cover assessment was performed as described following.



Countywide forest cover is 50.7 percent.

During an average high volume rainfall event in Orange County, over 24 hours the county's trees take up an average of **12.49 billion gallons of water**.

That's 18,911 Olympic swimming pools of water!



Percent Tree Cover and Possible Planting Area by Watershed

Drainage Basin	(no Wetlands) Percent Tree Cover
Little Econ	45 percent
Wekiva River	59 percent
Shingle Creek	39 percent
St. Johns River	62 percent
Howell Branch	44 percent
Big Econ	52 percent
Lake Hart	57 percent
Little Wekiva	37 percent
Lake Apopka	44 percent
Reedy Creek	42 percent
Cypress Creek	48 percent
Boggy Creek	33 percent
County (Overall)	51 percent

Orange County: Fast Facts & Key Stats

2010 Census Population: **1,145,956**

2016 Census Population Estimate: **1,256,055**

County Area
- Total area: 1,003 sq. mi.
- Land: 903 sq. mi
- Water: 100 sq. mi.

12 Major Drainage Basins

Acres of Lakes: **63,300**

Acres of Wetlands: **92,298**

Miles of Stream: **217.8** miles in unincorporated areas

Tree Canopy (unincorporated): **50.7** percent

Why This Study Is Needed

Today, municipalities are losing their trees at an alarming rate, estimated at four million annually (Nowak 2010). This is due in large part to growth. The Orlando area has the second highest rate of population growth in the state. This growth has brought with it pressures for land conversion to accommodate both commercial and residential development. Cumulative impacts of land development, storms, diseases, old age and other factors are reducing the number of older, established trees in cities overall (Nowak and Greenfield 2012). Urbanizing counties, such as Orange County, have lost both natural forest cover as well as the abundant orange groves after which the county is named. This canopy loss is due to the county's success as a growing economy and loss of orange groves due to freezing temperatures and severe storms.

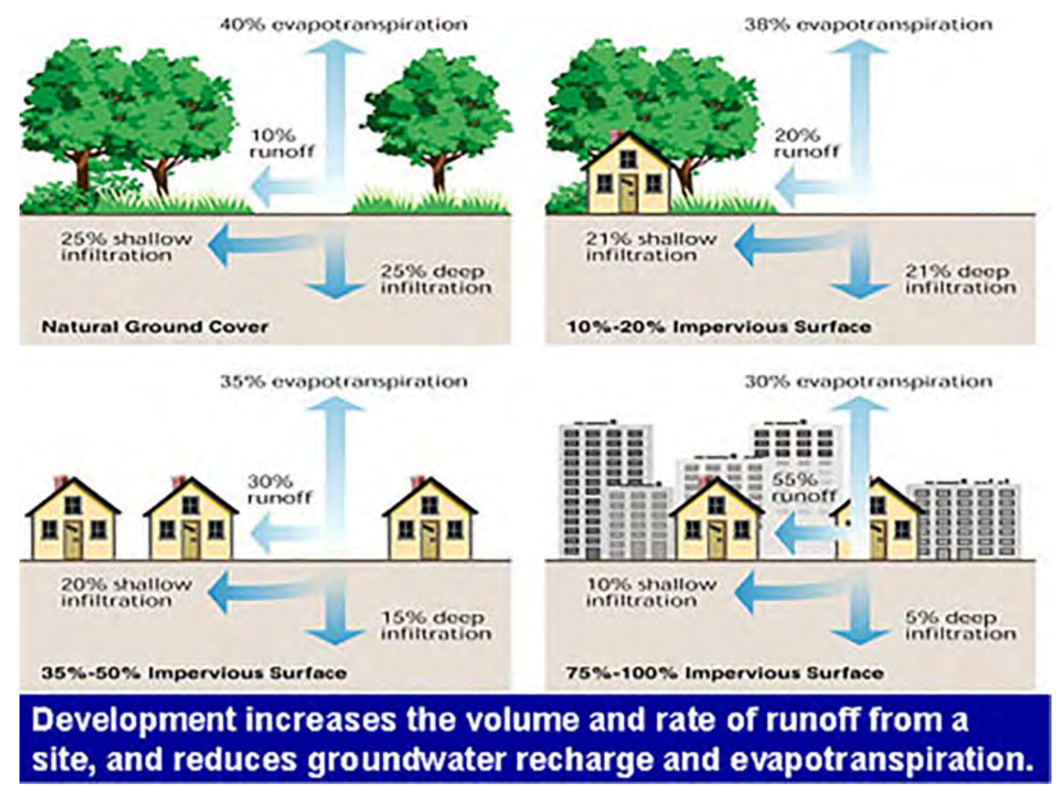
The purpose of this report is not to seek a limit on the county's growth, but to help the county better utilize its tree canopy to manage its stormwater. Ancillary benefits of improved canopy include: fostering a healthful and vibrant community, cleaner air; aesthetic values, reduced heating and cooling costs; decreased urban heat island effects; increased wildlife habitat; fostering walkability and multimodal transportation; and encouraging both tourism and retail sales.

Assessment and inventory of trees is key to ensuring a healthy forest.

As land is converted to impervious surfaces, stormwater runoff increases, causing temperature spikes, increased potential for pollution of surface and ground waters and increased potential for flooding. According to the U.S. Environmental Protection Agency (EPA), excessive stormwater runoff accounts for more than half of the pollution in the U.S.'s surface waters and causes increased flooding and property damages, as well as public safety hazards from standing water. As land becomes more impervious, rates of infiltration decrease, while runoff increases (EPA Watershed Academy). The EPA recommends a number of ways to use trees to manage stormwater in the book *Stormwater to Street Trees.*

Imperviousness is one consideration; another concerns the degree and type of vegetative cover, since it is the vegetation that absorbs stormwater and reduces the harmful effects of runoff. After hurricanes such as Katrina and Irma, many urban trees were lost across the Southeast. Unfortunately, many cities and counties did not have a baseline to assess the damage or *strategies* to replace lost trees.

And it is not just development and storms that contribute to tree loss. Millions of trees are also lost to attrition as they



Runoff increases as land is developed. Credit: U.S. EPA

Limpkin, Orange County, FL.

Alligator, Orange County, FL.

reach the end of their life cycle through natural causes. For every 100 street trees planted, only 50 will survive 13-20 years (Roman et al 2014). Even in older developed areas with a well-established tree canopy, redevelopment projects may remove trees. Trees planted improperly (wrong site), poorly maintained (inadequate care), or planted inappropriately (wrong tree for the site or climate) can also lead to tree canopy losses. It is also important to realize that an older, well-treed neighborhood of today may not have good coverage in the future unless young trees – the next generation – are planted.

Urbanizing counties and cities are beginning to recognize the importance of their urban trees because they provide tremendous dividends. For example, urban canopy can reduce a locality's stormwater runoff anywhere from two to seven percent (Fazio 2010). According to Penn State Extension, during a one-inch rainfall event, one acre of forest will release 750 gallons of runoff, while a parking lot will release 27,000 gallons! That is a 3,500 percent increase in runoff from non-forested lands. This could mean an impact of *millions* of gallons during a *major* precipitation event.

Trees filter stormwater and reduce overall flows. So planting and managing those trees is a natural way to mitigate stormwater. Estimates from Dayton, Ohio surmise a 7 percent reduction in stormwater runoff due to existing tree canopy coverage and a potential increase to 12 percent runoff reduction as a result of a modest increase in tree canopy coverage (Dwyer et al 1992). Conserving forested landscapes, urban forests, and individual trees allows localities to spend less money treating water through the municipal storm systems and reduces flooding.

Each tree plays an important role in stormwater management. For example, based on the GIC's review of multiple studies of canopy interception estimates for the amount of water, a typical street tree can intercept in its crown range from 760 gallons to 3000 gallons per tree per year, depending on the species and age. If a community were to plant an additional 5,000 such trees, the total reduced runoff per year could amount to tens of millions of gallons. This means reduced flooding in neighborhoods and reduced stress on waste water treatment plants or less runoff into the county's rivers and lakes.

Another compelling fiscal reason for planning the conservation of trees and forests as a part of a green infrastructure strategy is minimizing the impacts and costs of natural disasters. By retaining trees and forests, it is possible to reduce the likelihood of extensive flooding.

In urban areas, tree canopy should be assessed and realistic goals established to maintain or expand it. GIS is used to model the extent of the current canopy as well as how many new trees might be fitted into an urban landscape. A Possible Planting Area (PPA) map estimates areas that may be feasible to plant trees. A PPA map helps communities set realistic goals for what they could plant (this is discussed further on page 17).

Buffering surface waters from pollution

Urban forests are also critical to buffering surface waters from pollution. However, at certain levels of urban development and related imperviousness, aquatic life begins to decline. The rate of decline is affected by factors such as land cover, lot sizes and types of land use, as well as the locations of imperviousness within the watershed. Excessive urban runoff results in pollutants such as oil, metals, lawn chemicals (e.g., fertilizer and herbicides), pet waste and other pollutants reaching surface waters. High stormwater flows result in channel and bank scouring, releasing sediments that smother aquatic life and reduce stream depth and clog ditches, leading to yet more bank scouring and flooding, as channel capacity is lost.

Additional Urban Forest Benefits

QUALITY OF LIFE BENEFITS

During Florida's hot summers, more shade is always appreciated. Tree cover shades streets, sidewalks, parking lots, and homes, making southern urban locations cooler, walkable and bikable. An average summer daytime temperature reduction of 6.4 (degrees F) has been documented in association with a typical large tree in Miami (Souch and Souch 1996). In addition, trees absorb volatile organic compounds and particulate matter from the air, improving air quality, and thereby reducing asthma rates. In addition, shaded pavement has a longer lifespan thereby reducing maintenance costs associated with roadways and sidewalks (McPherson and Muchnick 2005).

Children who suffer from Attention Deficit Hyperactivity Disorder (ADHD) benefit from living near forests and other natural areas. One study showed that children who moved closer to green areas have the highest level of improved cognitive function after the move, regardless of level of affluence (Wells 2000). Communities with more green benefit children and reduce ADHD symptoms. Trees also cause people to walk more and walk farther. This is because when trees are not present, distances are perceived to be longer and destinations farther away, making people less inclined to walk than if streets and walkways are well treed (Tilt, Unfried and Roca 2007).

Well treed areas encourage people to walk.

ECONOMIC BENEFITS

Real estate developments that include green space or natural areas to their plans sell homes faster and for higher profits than those that take the more traditional approach of building over an entire area without providing for community green space (Benedict and McMahon 2006).

A study by the National Association of Realtors found that 57 percent of voters surveyed were more likely to purchase a home near green space and 50 percent were more willing to pay 10 percent more for a home located near a park or other protected area. A similar study found that homes adjacent to a greenbelt in Boulder, Colorado were valued 32 percent higher than those 3,200 feet away (Correll et al. 1978).

MEETING REGULATORY REQUIREMENTS

Trees also help meet the requirements of both the Clean Water Act and the Florida Watershed Restoration Act. The Clean Water Act requires Florida to have standards for water quality. When waters are impaired they may require establishment of a Total Maximum Daily Load (TMDL) standard and a clean-up plan (i.e., BMAP) to meet water quality standards. Since a forested landscape produces higher water quality (Booth et al 2002), the more forest that intercepts stormwater runoff, the less pollutants will reach the county's surface and ground waters. Forest cover protects surface water sources and aquifer recharge zones and reduces the cost of drinking water treatment. The American Water Works Association found a 10 percent increase in forest cover reduced chemical and treatment costs for drinking water by 20 percent (Ernst et al. 2004).

Wetlands add to the scenic beauty of Orange County.

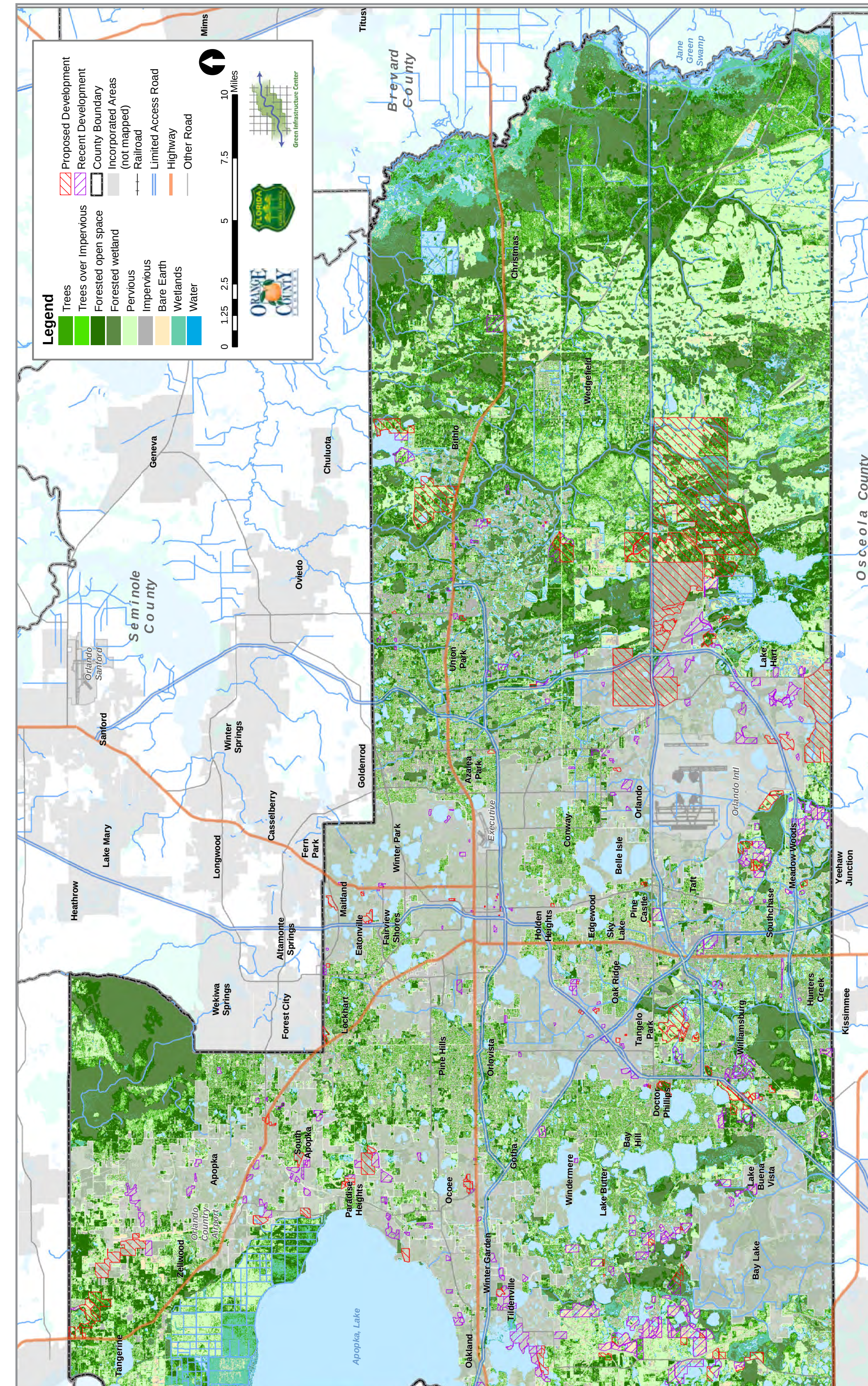
Natural Ecology in Urban Conditions – Changing Landscapes

Natural history, even of an urbanized location, informs planting and other land-management decisions. Prior to conversion from natural or agricultural land cover to urban, it was Orange County's climate and geographic location that determined its flora and fauna such as well-known species including longleaf pine, bald cypress, gopher tortoise or the indigo snake, However, as the county became, first, an agricultural center, and later an urban center, the greatest impacts on the landscape were caused by humans. Indeed, conversion of pine flatwoods to agricultural, residential and commercial land has rendered the Beautiful Pawpaw (*Asimina pulchella*), a low shrub endemic to Florida, and Orange County, endangered.

A challenge for stormwater management and water safety is created by the karst geology that underlies central Florida. In the western part of Orange County, thick carbonate deposits make up the aquifer system. Secondary porosity from dissolution or karst processes causes rapid access to groundwater from surface flows. Notably, these karst features create direct pathways for surface contaminants to reach the ground-water system. Preventing polluted runoff is especially important in these karst landscapes.

Due to hydrologic differences, the land cover on the eastern and western portions of the county are quite dissimilar. The eastern portion of the county contains the majority of the mesic flatwoods and pasture land, whereas the western portion contains the majority of the area used for transportation and medium density residential units. Protecting the mesic flatwoods in the eastern part of the county will ensure protection of surface water quality and stormwater uptake.

Orange County Unincorporated Areas Land Cover



This map shows the coverage of tree and other land cover across the county. The percent tree cover is approximately 51 percent.

HISTORIC LAND COVER

At one time, orange groves dominated much of the county's landscape. This altered the existing hydrology by converting a natural forest to crop land. Unfortunately, multiple winter freezes debilitated the orange groves and landowners sought more stable ventures. As groves ceased production, abundant open land made commercial and residential development in the area possible. Removal of existing native vegetation, alteration of hydrologic regimes, and subsequent urbanization and impervious surface expansion mean that more stormwater runoff is generated today than in the past. Data developed by the Florida Fish and Wildlife Conservation Commission and the Florida Natural Areas Inventory provide land areas of natural ecosystem communities for Orange County.

ORANGE COUNTY GROWTH & DEVELOPMENT CHALLENGES

According to medium estimates from the University of Florida's Bureau of Economic and Business Research, Orange County's population is projected to grow to 2,013,600 by 2045. This increase represents more than twice the current population of the City of Orlando and the City of Apopka combined.

Currently, approximately, two-thirds of the county's population lives in unincorporated areas, while the remainder lives in the 13 municipalities. With its central Florida location, Orange County has one of the fastest rates of growth in the state. This demand for space to meet the needs for housing, commercial, business, industrial uses and transportation puts strains on both the county's grey and green infrastructure.

ORANGE COUNTY'S GREEN FUTURE

Orange County is working to develop in ways that support a quality lifestyle for residents and visitors alike, while also meeting state and federal mandates for protecting air and water. The *Sustainable Orange County Plan* ("Our Home for Life") was completed in May 2014 and includes a strategy to "Promote urban forestry and expand tree canopy." This study represents a significant step forward in accomplishment of that strategy. The sustainability plan also includes several other strategies that relate to this study, including: encouraging low impact development (LID) for new development and retrofitting older stormwater systems with LID; encouraging walkable development; adopting a Complete and Green Streets policy (see

International Drive area tree canopy

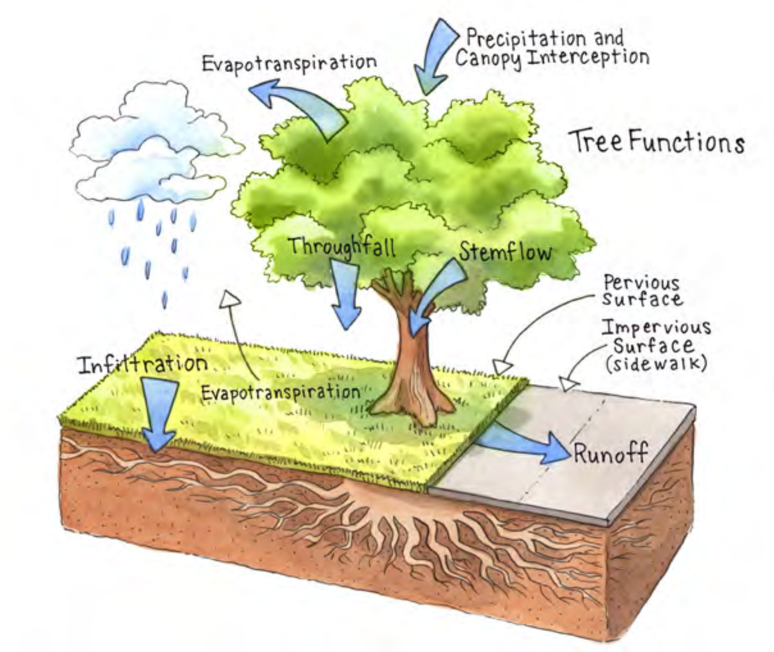
below); implementing bicycle and pedestrian safety strategies; investing in infrastructure that supports economic development; context-sensitive design that incorporates aesthetics and amenities; advancing pedestrian friendly principles in new and existing developments; considering conservation subdivisions in the Rural Service Area; and modifying the land development code to support sustainable development. Progress reports on all the "Our Home for Life" strategies are available at: *www.ochomeforlife.net*.

The county is integrating more green infrastructure into development areas, such as Horizon West, one of the state's fastest growing master-planned communities, which covers some 23,000 acres. To help foster the use of green infrastructure in Horizon West Town Center, Orange County's Planning Division hired a consultant to prepare a number of resources, including an *LID Practices Design & Implementation Guidelines Manual,* which includes seven LID best practices considered suitable for the area; *a Maintenance Cost Projection Evaluation Technical Memorandum; an LID Permitting Criteria Evaluation Technical Memorandum; a Traditional vs. LID Stormwater Management Comparison; and an LID Pilot Program Plan,* each of which were completed in June 2014. Walkability and green space throughout the community are significant factors in its design and future success. The development of a new sustainable land-development code, as noted following, and a new Complete and Green Streets policy are currently underway to help foster those goals.

While the area around International Drive has higher standards for development and community greening, other portions of the county fall under an older development code that does not require street trees, or other amenities called for in newer development areas. Greening these areas, or preventing them from losing green spaces over time, will require new initiatives, incentives and community participation. *Orange Code*, the county's new, simplified and sustainable way to govern how land is developed, is currently being created. While there have been many updates to Orange County's land development code since it was written in 1957, *Orange Code* represents a comprehensive, big picture overhaul that will seek to ensure sustainable land development that preserves the character of existing communities, celebrates Orange County's diversity and creates vibrant places to live, work and relax. The recommendations in this report can help inform the development of the new code and policies that are currently underway.

Orange County's Public Works Department is currently in the process of implementing a multi-million-dollar median street tree planting program that was approved by the Orange County Board of County Commissioners. Recommendations from this study may also inform those planting efforts.

Through its Green PLACE Program, Orange County has preserved approximately 22,700 acres of environmentally sensitive lands (as of February 2018). The county's Environmental Protection Division staff develops plans to manage each of the properties, including restoration activities that can include planting of trees and other plant species. Although often located in rural areas, the proper management of these properties has a number of benefits.



Trees and the Water Cycle

Analysis Performed

METHOD

This project evaluated options for how to best evaluate stormwater runoff and uptake by the county's tree canopy. This project was not intended to be used for site-plan-level stormwater calculations. Its best intended use is for planning at the watershed scale for tree conservation. An example is provided on page 16.

As noted, trees intercept, take up and slow the rate of stormwater runoff. Canopy interception varies from 100 percent at the beginning of a rainfall event to about 3 percent at the maximum rain intensity. Trees take up more water early on during storm events and less water as storm events proceed and the ground becomes saturated (Xiao et al. 2000). Many forestry scientists as well as civil engineers have recognized that trees have important stormwater benefits (Kuehler 2017, 2016). See diagram of tree water flow below.

Currently, the county uses TR55 curve numbers, which are input into a model called ICPR to generate expected runoff amounts. The ICPR model is used to plan for stormwater management as part of the county's MS4 Permit with the State of Florida. The county could choose to use the modified TR55 curve numbers (CN) for this study that include a factor for canopy interception; however, it does not need to. As explained earlier, this project is a tool for setting goals at the watershed scale for planting trees and for evaluating consequences of tree loss as it pertains to stormwater runoff.

This study used curve numbers to calculate stormwater uptake for different land covers, since they are widely recognized and understood by stormwater engineers. Curve numbers produced by this study's methods can be easily utilized in the county's modeling and design reviews. The spreadsheet calculator tool provided makes it very easy for the county to change the curve numbers if they so choose. What is new about the calculator tool is that the curve numbers relate to the real land cover conditions in which the trees are found in order to generate a more realistic curve number. A canopy interception factor is added to account for the role trees play in interception of rainfall.

Tree canopy works to reduce the proportion of precipitation that becomes stream and surface flow, also known as water yield. A study by Hynicka and Divers (2016) modified the water yield equation of the NRCS model by adding a canopy interception term (Ci) to account for the role that canopy plays in capturing stormwater, resulting in:

$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

Where R is runoff, P is precipitation, Ia is the initial abstraction, and S is the potential maximum retention after runoff begins for the subject land cover (S = 1000/CN – 10).

Major factors determining CN are:

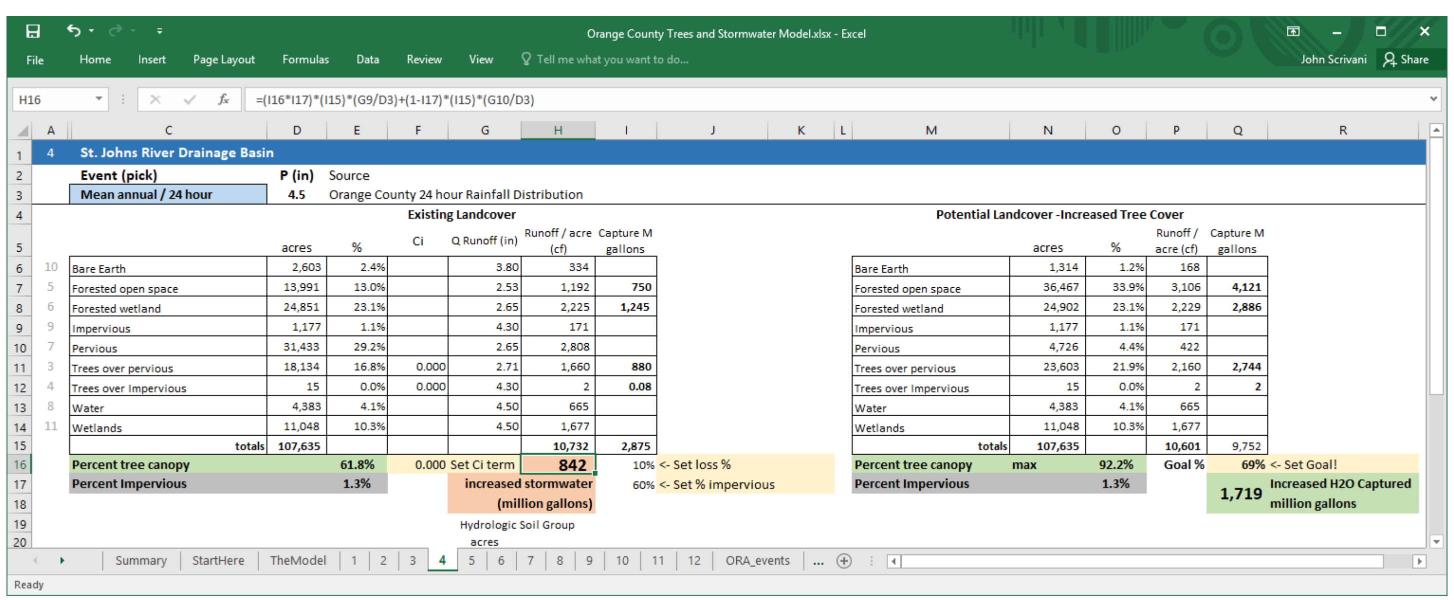
- The hydrologic soil group (defined by surface infiltration rates and transmission rates of water through the soil profile, when thoroughly wetted)
- Land cover types
- Hydrologic condition – density of vegetative cover, surface texture, seasonal variations
- Treatment – design or management practices that affect runoff

In order to use the equation and model scenarios for future tree canopy and water uptake, the project team first had to develop a highly detailed land cover analysis and an estimation of potential future planting areas, as described below. These new land cover analyses can be used for many other projects, such as looking at urban cooling, walkability (see map of street tree coverage on following pages), trail planning and for updating the comprehensive plan.

An example of how this modeling tool can be used for watershed-scale forest planning is indicated below. The actual model spreadsheet was provided to Orange County for their use. It links to the land cover statistics for each type of planting area. It also allows the county to add trees or to reduce trees and to see what the effects are for stormwater capture or runoff. The key finding from this work is that removal of mature trees and existing forests generate the greatest impacts.

The stormwater runoff model provides estimates of the capture of precipitation by tree canopies and the resulting reductions in runoff yield. It takes into account the interaction of land cover and soil hydrologic conditions. It can also be used to run 'what-if' scenarios, specifically losses of tree canopy from development and increases in tree canopy from tree planting programs. In the graphic of the calculator tool, the model is used to estimate a 10 percent loss of tree canopy for one Orange County watershed, resulting an increase of 842 million gallons of stormwater runoff during a mean annual 24-hour storm. The model also estimates a decrease in stormwater runoff (or increase in capture) of 1,719 million gallons, after planting efforts increase the canopy from 61 percent to 69 percent.

This new approach allows for more detailed assessment of stormwater uptake based on the landscape conditions of the county's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks. The amount of open space and the condition of surface soils affect the infiltration of water. In order to determine these conditions, a detailed land cover assessment was performed as described following.



Orange County Trees and Stormwater Model.xlsx - Excel

H16 =(I16*I17)*(I15)*(G9/D3)+(1-I17)*(I15)*(G10/D3)

4 St. Johns River Drainage Basin

Event (pick)	P (in)	Source
Mean annual / 24 hour	4.5	Orange County 24 hour Rainfall Distribution

Existing Landcover

		acres	%	Ci	Q Runoff (in)	Runoff / acre (cf)	Capture M gallons
10	Bare Earth	2,603	2.4%		3.80	334	
5	Forested open space	13,991	13.0%		2.53	1,192	**750**
6	Forested wetland	24,851	23.1%		2.65	2,225	**1,245**
9	Impervious	1,177	1.1%		4.30	171	
7	Pervious	31,433	29.2%		2.65	2,808	
3	Trees over pervious	18,134	16.8%	0.000	2.71	1,660	**880**
4	Trees over Impervious	15	0.0%	0.000	4.30	2	**0.08**
8	Water	4,383	4.1%		4.50	665	
11	Wetlands	11,048	10.3%		4.50	1,677	
	totals	**107,635**				**10,732**	**2,875**
	Percent tree canopy		**61.8%**	0.000	Set Ci term	**842**	10% <- Set loss %
	Percent Impervious		**1.3%**			**increased stormwater (million gallons)**	60% <- Set % impervious

Hydrologic Soil Group acres

Potential Landcover -Increased Tree Cover

	acres	%	Runoff / acre (cf)	Capture M gallons
Bare Earth	1,314	1.2%	168	
Forested open space	36,467	33.9%	3,106	**4,121**
Forested wetland	24,902	23.1%	2,229	**2,886**
Impervious	1,177	1.1%	171	
Pervious	4,726	4.4%	422	
Trees over pervious	23,603	21.9%	2,160	**2,744**
Trees over Impervious	15	0.0%	2	**2**
Water	4,383	4.1%	665	
Wetlands	11,048	10.3%	1,677	
totals	**107,635**		**10,601**	9,752
Percent tree canopy max		**92.2%**	**Goal %**	**69%** <- Set Goal!
Percent Impervious		**1.3%**		**1,719** Increased H2O Captured million gallons

Summary | StartHere | TheModel | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | ORA_events

The calculator tool developed for this project allows the county to see the water uptake by existing canopy and model impacts from changes, whether positive (adding trees) or negative (removing trees).

LAND COVER, POSSIBLE PLANTING AREA, POSSIBLE CANOPY AREA ANALYSIS

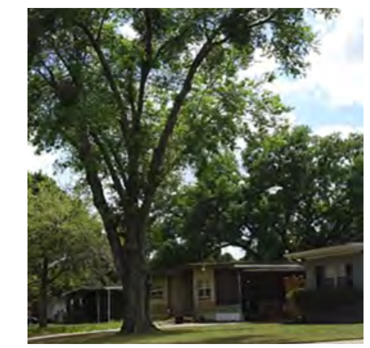
The land cover data was created using 2015 leaf-on imagery from the National Agriculture Imagery Program (NAIP) distributed by the USDA Farm Service Agency. Ancillary data for roads (from Orange County Government), the Cooperative Land Cover (CLC) Map (Florida Natural Areas Inventory), and hydrology (from National Wetlands Database) were used to incorporate: 1) Tree Cover Over Impervious Surfaces class, which otherwise could not be seen due to these features being covered by tree canopy; and 2) Wetland classes not distinguishable using spectral/feature-based image classification tools. Forested open space was identified as areas of compact, continuous tree canopy greater than one acre, not intersected by buildings or paved surfaces.

The final classification consists of nine classes. The Potential Planting Area (PPA) is created by selecting the land cover features that have space available for planting trees. Of the nine land cover classes, only pervious, turf, and bare earth are considered for PPA.

Next, these eligible planting areas are limited based on their proximity to features that might either interfere with a tree's natural growth (such as buildings) or places a tree might affect the feature itself such as power lines, sidewalks or roads. Playing fields, cemeteries and other known land uses that would not be appropriate for tree cover are also avoided. However, there may be some existing land uses (e.g., golf courses, agricultural lands that are expected to remain in agricultural use, etc.) that are unlikely to be used for tree planting areas that were not excluded from the PPA. In addition, the analysis did not take into account proposed future developments (e.g., planned developments) that would not likely be fully planted with trees. Therefore, the resulting PPAs represent the *maximum* potential places trees can be planted and grow to full size.

Tree over street

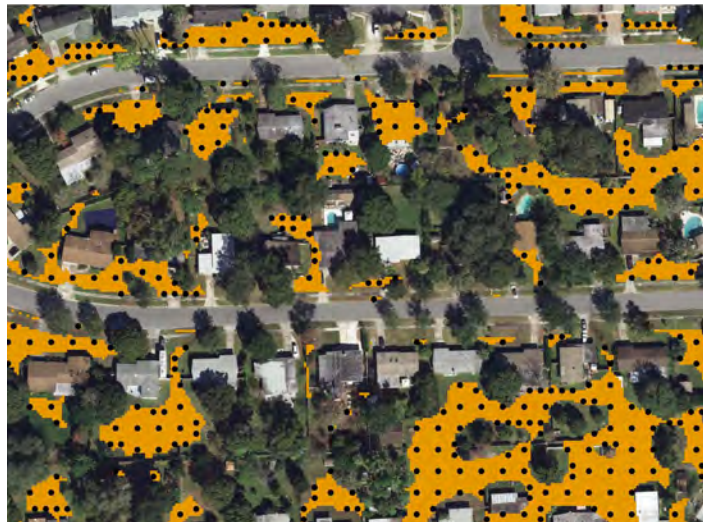
Tree over parking lot



Tree over lawn

Trees in forest

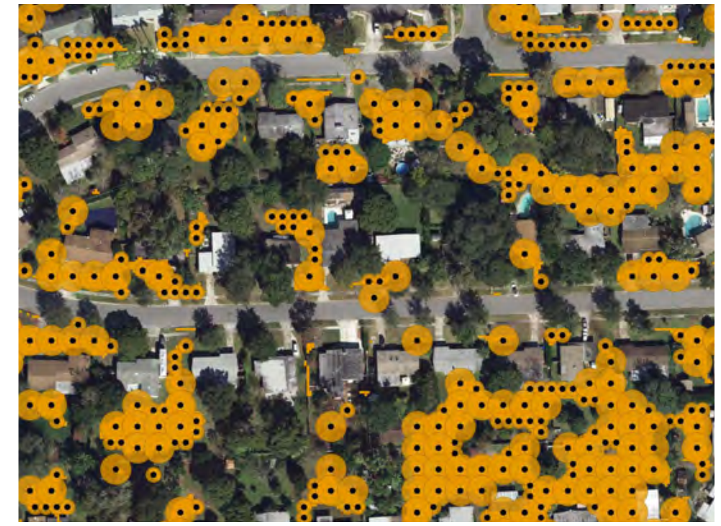
Potential Planting Area



Potential Planting Spots (PPS)

The Potential Planting Spots (PPS) are created from the PPA. The PPA is run through a GIS model that selects those spots a tree can be planted depending on the size of trees desired. For this analysis, expected sizes of both 20 ft. and 40 ft. diameter of individual mature tree canopy was used with priority given to 40 ft. diameter trees (larger trees have more benefits). It is expected that 30 percent overlap will occur as these trees reach maturity. The result demonstrates a scenario where, if planted today, once the trees are mature, their full canopy will cover the potential planting area and overlap adjacent features, such as roads and sidewalks.

The Potential Canopy Area (PCA) is created from the PPS. Once the possible planting spots are selected, a buffer around each point that represents a tree's mature canopy is created. For this analysis, that buffer radius is either 10 ft. or 20 ft., which result in either a 20 ft. or 40 ft. diameter canopy for each tree. These



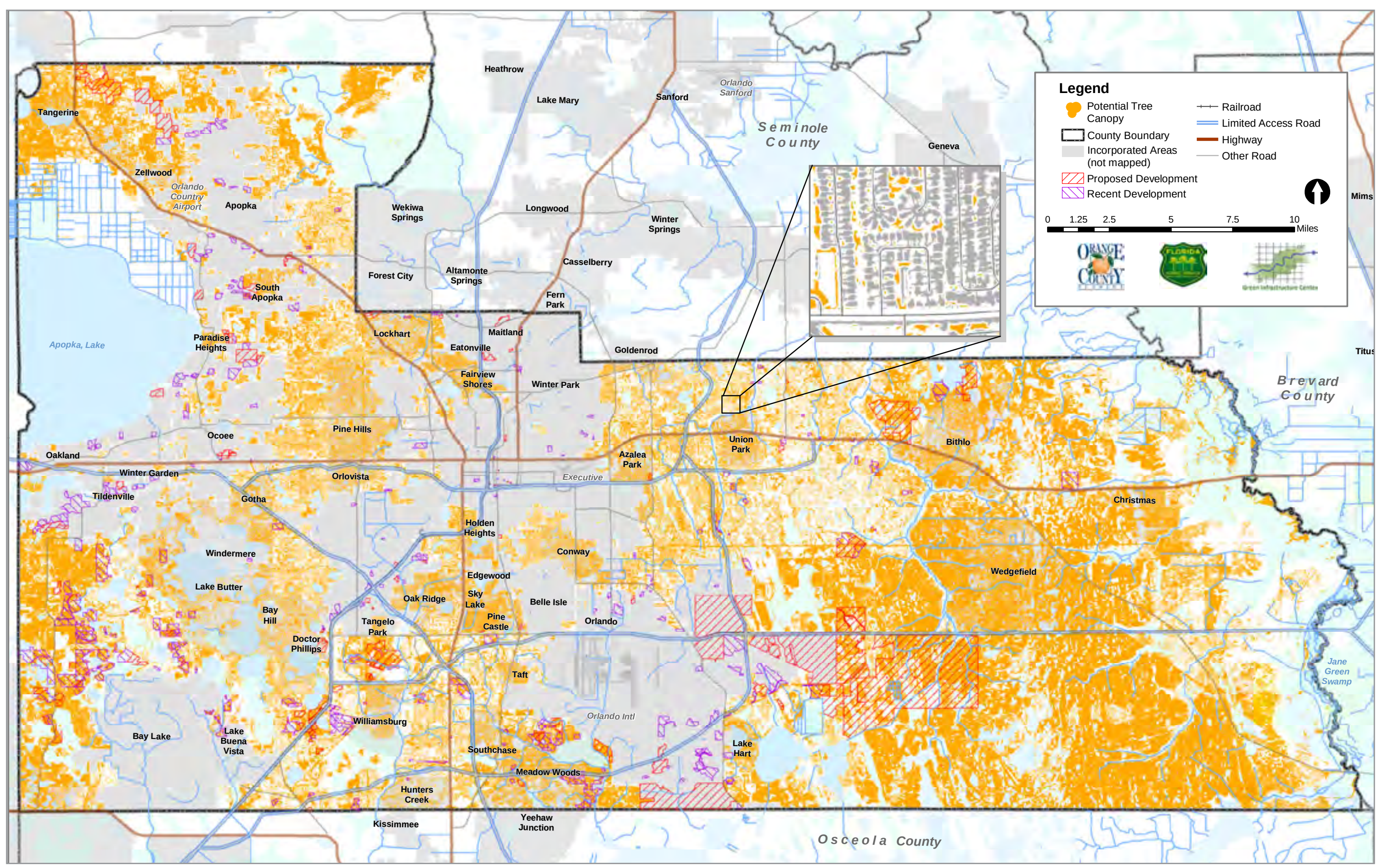
Potential Canopy Area (PCA)

individual tree canopies are then dissolved together to form the potential overall canopy area.

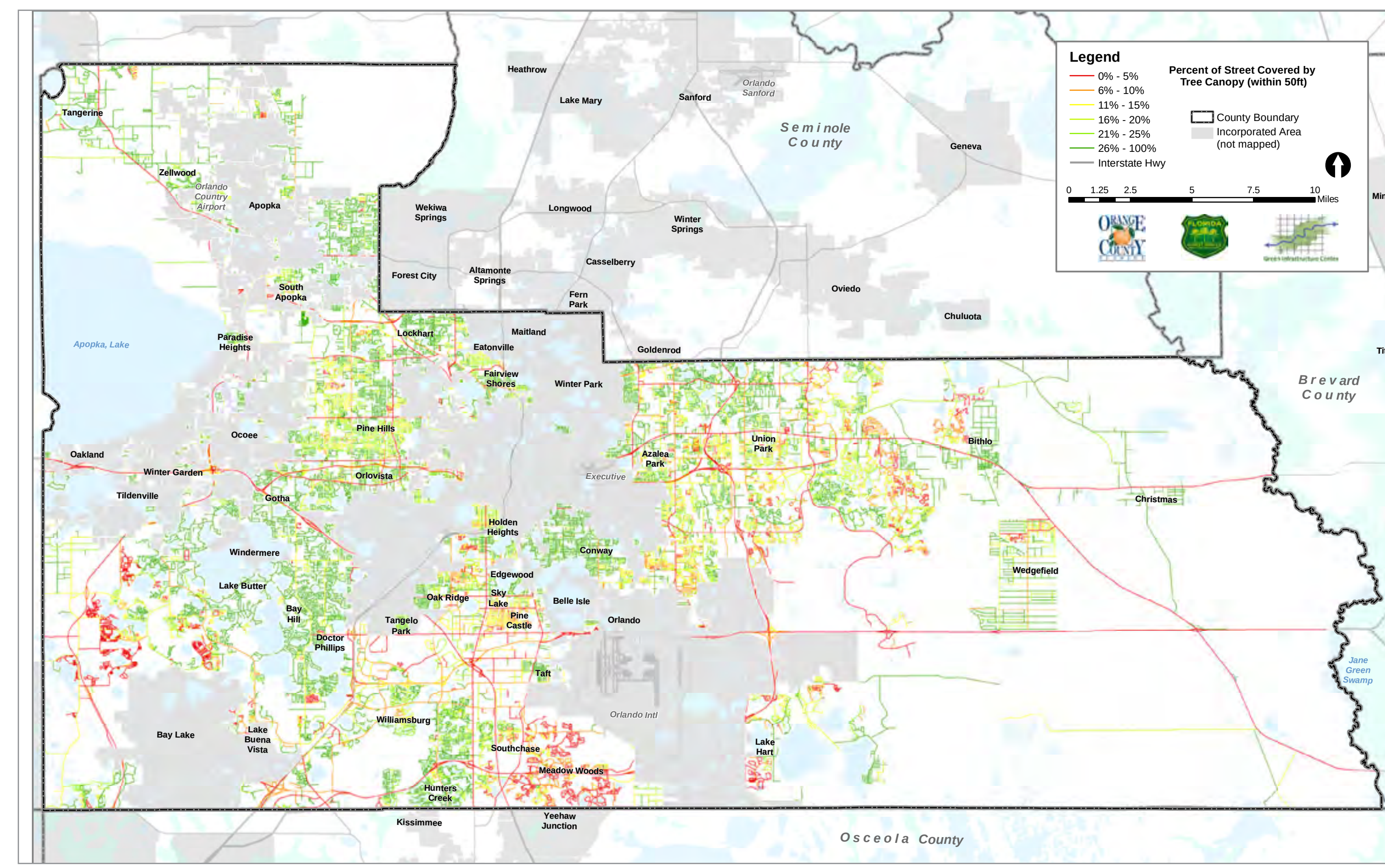
Percent Street Trees is calculated using the Land Cover Tree Canopy and road centerlines, which are buffered to 50 ft. from each road segment's centerline. The percent value represented is the percentage of tree cover within that 50 ft. buffer.

See Methods Appendix for more details on mapping methodology.

Map of Possible Canopy Area



Map of Street Tree Coverage



Codes, Ordinances and Practice Review

Documents reviewed during the codes, ordinances and practices analysis portion of the project include relevant sections of the county's current code, relevant sections of the forthcoming *Orange Code* (versions available as of early 2017), the Adopted Fiscal Year 2016-2017 Budget, the *Orange County Local Mitigation Strategy, Orange County Citizen Participation Guide*, the *Low Impact Development Practices Design*, the *Implementation Guidelines Manual for Horizon West Town Center* and the *Sustainable Orange County Plan*. Data were gathered through analysis of county codes and policies, as well as interviews with county staff, whose input was incorporated directly on the spreadsheet summary prepared by the GIC. The spreadsheet provided to the county lists all the codes reviewed, interviews held and relevant findings. A more detailed memo submitted to the county by GIC, also provides more ideas for improvements.

Points were assigned to indicate what percentage of urban forestry and planning best practices have been adopted to date by the county. The spreadsheet can also serve as a tracking tool and to determine other practices or policies the county may want to adopt in the future to strengthen the urban forestry program or to reduce impervious land cover.

The percentage scores for these categories are listed below. Average and mean scores can only be determined when a large enough sample size has been provided. A future report will compare the county to other localities in the south. For Orange County, scoring was applied to the following seven urban forestry categories. The achievement score for each category is as follows:

Best Practice	Percentage
Tree Care & Protection	50 percent
Plans & Goals	20 percent
Implementation Capacity	37 percent
Monitoring Progress	43 percent
Emergency Response	0 percent
Integration	32 percent
Reducing Impervious Surfaces	49 percent

It is important to note that these percentages are not a grade. They simply represent what percent of a possible maximum is done currently. For example, it could be the case that of 100 percent of potential practices, only 70 percent are appropriate for Orange County. A final report comparing all localities progress across the south will be issued in 2019.

Orange County invests a great deal of staff time and energy into protecting trees and caring for the local environment. In fact, the county just celebrated ten years of being recognized as a 'Tree City USA' by the Arbor Day Foundation, which means that it spends adequate funds per capita on tree care, that it has a tree ordinance, and practices tree management. It is clear that this level of effort will continue.

The recommendations provided in this report are a way to increase the protections for, and size of, the forest in Orange County. In a perfect world, a county or city would score 100 percent by utilizing all the various practices suggested. However, each locality is unique and not all practices or policies are needed or appropriate.[1]

Orange County staff read a proclamation of support for Arbor Day from County Mayor Teresa Jacobs, February 22, 2018.

[1] *Orange County is the first of 12 localities in a six-state area of the Southeastern U.S. to be studied and the first to be completed. As other places are studied, they will be compared to the county, and vice versa.*

Recommendations to Improve Forest Care in Orange County Include the Following:

1) *Expand the tree inventory requirements to include all trees.*
2) *Require the use of sturdy chain link metal fencing to protect trees, rather than plastic fencing.*
3) *Use root matting to minimize compaction and ensure survivability of a tree post construction, if the root protection zone must be breached.*
4) *Implement the Right-Of-Way tree ordinance across the entire unincorporated area.*
5) *Use Silva Cells to improve the chance of tree survival and growth to maturity in constricted spaces.*
6) *Create a UFMP with a structured and organized plan for the implementation and maintenance of an urban tree program.*
7) *Use the cores and corridors schema to identify, rank and protect existing corridors using the data provided by the GIC.*
8) *Utilize various methods to involve the public in setting and meeting urban forest management goals.*
9) *Orange County should prioritize forestry activities and develop a budget of essential items, with dedicated funding. This guarantees support of urban forest management even during economic slowdowns.*
10) *Orange County should use urban forestry management software to create and maintain detailed records of the urban forest.*
11) *Request TRAQ-certified arborists to help the county develop a risk management plan for its trees.*
12) *Orange County should develop a plan for funding and carrying out replacement tree plantings following hurricanes. This plan should include processes for data collection about lost resources, funding application procedures, and staff management during replanting.*
13) *Increase the stormwater utility fee to cover the costs of the urban tree program.*
14) *Introduce a system of best management practices (BMPs) that give credit to homeowners, factories and developers.*
15) *Use trees to enhance stormwater management in the county.*
16) *Coordinate and cooperate with developers to improve their understanding of the county's tree program and enforce all tree ordinances.*
17) *Develop a Complete and Green Streets policy that encourages and enforces the installation of Complete and Green Streets at development and re-development sites.*
18) *To combat the over-provision of parking spaces, set parking requirements as minimums and maximums (as opposed to only minimums) to prevent excessive parking lot size.*
19) *Provide developers with information on pervious parking surfaces and provide specifications.*

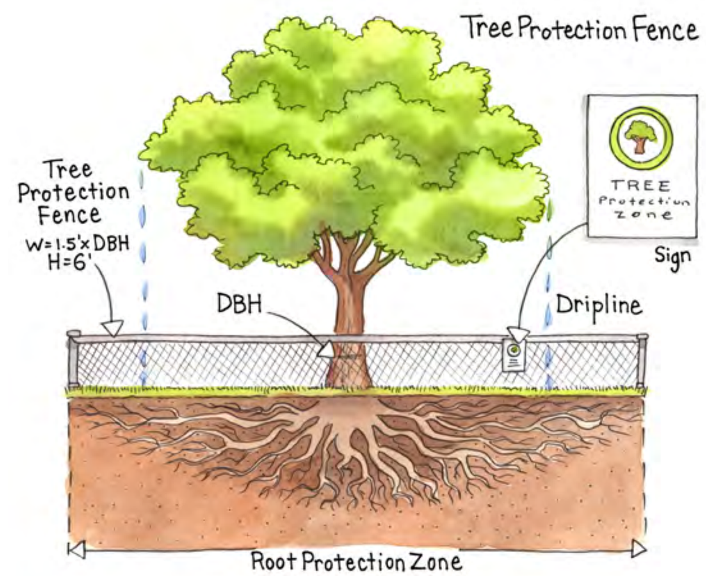
TREE PROTECTION MECHANISMS

TREE INVENTORY REQUIREMENTS

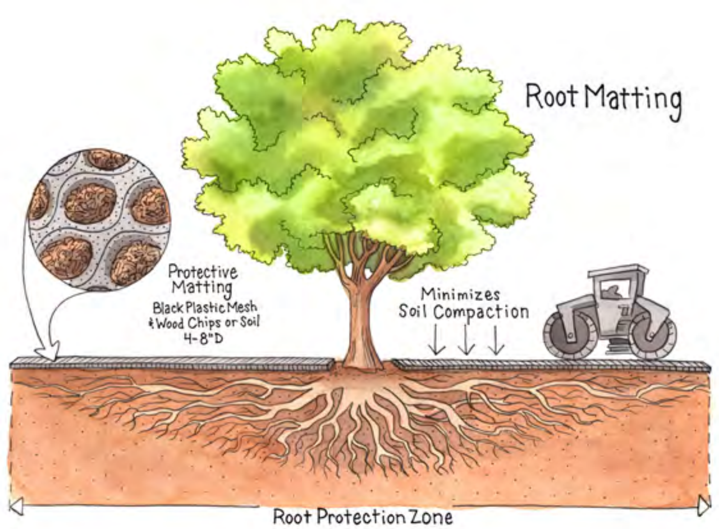
Often, large numbers of trees are removed during development and construction activities. Although Chapter 15, Article VIII (Tree Protection and Removal) of Orange County's Code requires tree replacement, the maximum replacement required is 90 caliper inches per acre. In order to further discourage clear cutting of large volumes of mature trees during the development process, the county may want to consider removing this cap or increasing the required tree replacement and mitigation fees to better account for the stormwater and other benefits provided by mature trees. In many situations, developers may try to save one tree here or there, but do so without proper tree protection, so sometimes their efforts are in vain.

Tree protection begins with tree inventory. A tree inventory contains information about the type, age, and caliper of existing trees on a site. Orange County currently inventories only those trees on the recommended stock list.

Recommendation 1: Expand the tree inventory requirements to include all trees.



Tree protection fencing helps protect roots and increases tree survival post-development.



Root mats can be placed to reduce compaction in active construction zones.

STEEL ROOT FENCING

It is critical to protect the root zone of trees to be saved on a development site. Plastic or metal fencing which is placed a set distance from the tree is the most commonly used form of tree protection. This discourages equipment or foot traffic from entering the protected space, which should be the entire *root protection zone* – a wide area around each tree. Unfortunately, the entirety of the root zone is rarely protected fully, meaning that much of a tree's root system is compacted by heavy machinery, or even severed to lay pipes, foundations and utility lines.

Orange County currently uses plastic mesh as its tree protection fencing. While this can be effective in low-risk construction areas (without heavy machinery), it does not protect trees from damage by large machinery. The county should use sturdy chain link metal fencing and place the tree protection fence 1-to-1.5 times (100-150 percent) the DBH (diameter at breast height) in inches from the tree.

Recommendation 2: Require the use of sturdy chain link metal fencing to protect trees, rather than plastic fencing.

ROOT MATTING

Sometimes, a tree protection zone must be breached in order to complete the planned construction. For example, if directional boring is to take place near a tree, it can only be saved if precautions are taken to minimize compaction of the soil and subsequent damage to its roots.

Compaction related to construction activity reduces infiltration rates on sandy soils in North Central Florida by 70 to 99 percent (Gregory et al. 2006). Because of this, it is necessary to install root matting. Root matting is a 4"-8" plastic mesh laid on the ground surface around the tree to cover the full extent of the root protection zone. It is filled with wood chips or soil, which absorb the impact of construction traffic

Recommendation 3: Use root matting to minimize compaction and ensure survivability of a tree post construction, if the root protection zone must be breached.

TREE PLANTING & TREE CARE

Managing and caring for an urban forest includes the responsibility to plant trees. Trees planted along roadways and walkways minimize the urban heat island effect and make a southern municipality such as Orange County a cooler place to live, walk, and bike. Orange County has the draft Orange Code, which specifies Right-Of-Way (ROW) tree plantings. The GIC supports its adoption throughout the entire unincorporated area of Orange County.

Recommendation 4: Implement the Right-Of-Way tree ordinance across the entire unincorporated area.

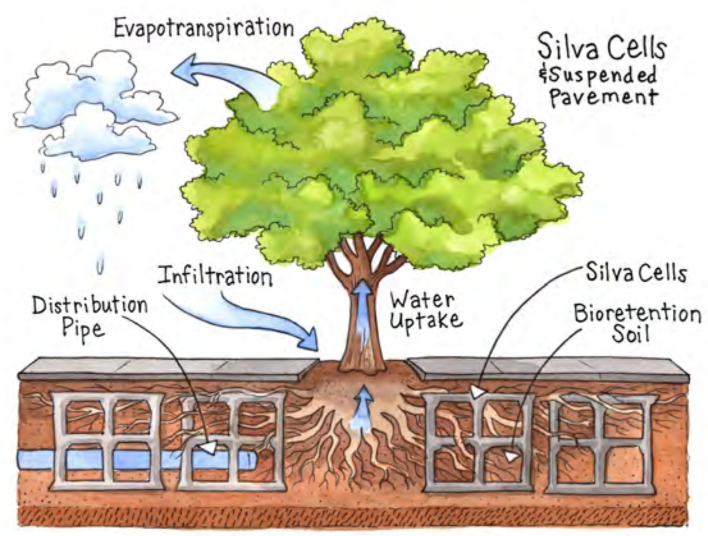
IMPROVING SURVIVABILITY

An urban tree strategy must address the challenge of planting trees in urban locations. To give a tree a significant chance of surviving and reaching maturity, some modification of the planting site may be necessary. Technologies such as Silva Cells can provide significantly more space for roots to grow and so allow trees to grow bigger in constricted urban locations, such as sidewalk cut-outs. Plan for the use of Silva Cells and structural soils when planting space is limited but the reward of a healthy tree canopy is great. For example, a heavily trafficked downtown commercial space is a rewarding place to implement this technology. See image of Silva Cells.

Recommendation 5: Use Silva Cells to improve the chance of tree survival and growth to maturity in constricted spaces.

URBAN FOREST MANAGEMENT PLAN

An Urban Forest Management Plan (UFMP) details a vision for an urban tree canopy. It meshes local government and community interests, outlining a way to proactively manage the urban canopy and render long-term benefits to the community. Examples of good plans are found in New York City, Charlottesville, and Vancouver. Orange County does not currently have a UFMP, but its codes and ordinances do contain typical UFMP components. These components could be reorganized into several sections to include documentation of the community values of trees, an outline of specific urban forestry goals, and an itemized maintenance schedule. With the completion of this study and the Urban Forest Assessment, Orange County now has baseline data that can serve as an appropriate jumping off point for development of goals and strategies to promote urban forestry and expand its tree canopy.



Silva or other plastic cells can help reinforce tree roots, allowing trees to grow in smaller spaces.

Recommendation 6: Create a UFMP with a structured and organized plan for the implementation and maintenance of an urban tree program.

GREEN INFRASTRUCTURE PLANNING

This project evaluated and mapped Orange County's treed landscape. Forested open space, forested wetlands, trees over pervious surfaces and trees over impervious surfaces are mapped at one-meter resolution. Understanding where these treed resources are, allows planning to take place at the county level that will protect forested cores and corridors that preserve its natural resources. To learn more about green infrastructure planning visit the Center for Landscape Conservation Planning at the University of Florida.

Recommendation 7: Use the cores and corridors schema to identify, rank and protect existing corridors using the data provided by the GIC.

Econlockhatchee River, Orange County, FL

ADVISORY BOARDS / GROUPS

Only a minority of land in any locality is owned by the public. The majority is in private hands. Given this fact of life, it is vital to involve affected stakeholders – citizens and citizen groups – in urban forestry campaigns and decision making. One tool to achieve this involvement is to encourage citizen representation to serve on an Orange County Tree Committee. Rather than establishing a completely new committee, Orange County may want to investigate the possibility of having the existing Sustainability Advisory Board fill that role. This involvement should be as representative of the many interest groups in the county. Citizens can engage in an urban forestry plan in multiple other ways as well, from establishing a web site that provides information and asks for public comments, to holding public meetings, using the media to spread the message, and conducting questionnaires. During the course of this study, Orange County developed an Urban Forestry webpage to disseminate information to the public at ***http://www.orangecountyfl.net/Environment/UrbanForestry.aspx***. Orange County may also want to consider using the technical review committee structure that was developed for this study as a way to coordinate tree management related activities internally in the future.

Recommendation 8: Utilize various methods to involve the public in setting and meeting urban forest management goals.

FUNDING

During economic slowdowns, prioritization of tree maintenance activities is essential. It allows critical tree care activities, such as watering and risk management, to be carried out, while less critical items can be completed at a later date. Listing these maintenance activities for staff in other departments allows greater understanding of urban forestry and how it should best be funded.

Recommendation 9: Orange County should prioritize forestry activities and develop a budget of essential items, with dedicated funding. This guarantees support of urban forest management even during economic slowdowns.

RECORDKEEPING

Data are required for efficient management of the urban forest. Software packages are available that collect tree data, such as the planting date, field observation date, location (GPS coordinates), species, DBH, condition and any management actions taken. These records help monitor the spread and treatment of pests and diseases, create an understanding of the urban forest composition and establish data on successful versus unsuccessful tree species for planting in Orange County.

Recommendation 10: Orange County should use urban forestry management software to create and maintain detailed records of the urban forest.

RISK MANAGEMENT

Trees provide myriad benefits, but they also pose risks, especially in urban areas. For example, the canopy can interfere with overhead utility lines, tree roots can push up sidewalks, and rotted branches can fall onto pedestrians and traffic. Efforts must be taken to mitigate these risks as much as possible. The International Society of Arboriculture has developed a program and certification called the Tree Risk Assessment Qualification (TRAQ). TRAQ-certified arborists work with municipalities or homeowners to estimate risk and develop a plan of action for mitigation. Orange County should require tree risk assessments in highly urbanized areas yearly, and less frequently in lower-risk areas. Currently, the county has TRAQ qualified staff who can assist with this task.

Recommendation 11: Request TRAQ-certified arborists to help the county develop a risk management plan for its trees.

FORESTRY EMERGENCY RESPONSE

When natural disasters such as hurricanes occur, most of the effort in a municipality is directed toward clean up and repair. However, after debris from disasters is removed, there is little effort directed toward replacing lost natural resources, such as trees. This is despite the fact that trees increase groundwater infiltration, maintain soil stability and reduce flooding. By not replacing lost or damaged trees, any future disaster will be even more catastrophic.

Recommendation 12: Orange County should develop a plan for funding and carrying out replacement tree plantings following hurricanes. This plan should include processes for data collection about lost resources, funding application procedures, and staff management during replanting.

STORMWATER MANAGEMENT

Taking into account the proven links between trees and stormwater, the implementation of an effective stormwater fee is an important aspect of an urban forestry program. Currently, Orange County's stormwater utility fee is set at $0. Orange County should determine a reasonable stormwater utility fee amount by analyzing stormwater maintenance costs and desired urban forestry program elements.

Recommendation 13: Increase the stormwater utility fee to cover the costs of the urban tree program.

Develop a clear procedure to reducing the stormwater utility fee through BMPs, in order to reward those who are treating their stormwater effectively on-site. Charlottesville Virginia has a particularly helpful program to show citizens which practices can be used. The BMPs to which credit should be given include both tree canopy and tree plantings. The county should also provide documentation on how to apply for the credit, as well as technical construction standards where applicable (e.g. how to build a raingarden). Although guidance for seven LID practices has been provided for the Horizon West Town Center, it would likely be beneficial to expand such guidance documents to include eastern parts of the county where soil types and water table depths are considerably different and can impact appropriate practices. As the trees will need to be maintained, a tree maintenance section will need to be added to any stormwater management plan incorporating trees.

Recommendation 14: Introduce a system of best management practices (BMPs) that give credit to homeowners, factories and developers.

Trees are a valuable asset for taking up more stormwater in constructed stormwater systems. Roots increase soil infiltration rates by tunneling through the soil, making the ground less compact and more able to absorb stormwater. When placed properly, trees safely increase stormwater uptake when utilized as part of BMPs that are designed to incorporate vegetation, such as rain gardens, vegetated swales, stormwater wetlands and stormwater ponds. Incorporate trees in stormwater management systems in Orange County, especially the installed stormwater ponds, which currently do not incorporate any vegetation. Orange County has a tree replacement trust fund that receives funds from tree replacement and mitigation fees. However, a stormwater utility fee would help supplement tree planting efforts that are tied to stormwater management.

Recommendation 15: Use trees to enhance stormwater management in the county.

COLLABORATION WITH DEVELOPERS

A great deal can be achieved through constructive collaboration with developers. For example, holding a pre-development conference allows all parties to explore ideas for tree conservation before extensive funds are spent on land planning. For example, Alpharetta Georgia (one of the pilot cities for this study) holds regular meetings prior to development plans which involve a representative from each department (e.g. planning, engineering, forestry) for their projects and has found many opportunities. This includes training them in the city's tree ordinances and providing guidance on how to protect the city's trees. Many developers are willing to cooperate in such ventures, as houses often sell for a premium on a well-treed development. However, it will also be necessary to enforce the implementation of development designs that minimize the loss of urban forest canopy and habitat. Often, developers have not explored other site layout options to find the one that removes the least amount of natural resources. Arrange conversations with staff across departments to ensure all competing land use interests are represented when meetings with developers are held.

Recommendation 16: Coordinate and cooperate with developers to improve their understanding of the county's tree program and enforce all tree ordinances.

COMPLETE & GREEN STREETS

Complete Streets is a program launched by the National Complete Streets Coalition. These streets facilitate the integration of stormwater management and aesthetic goals. By incorporating vegetation as an integral part of the design, they create and connect habitat, reduce urban heat island effect and promote walking and biking. Orange County's *"Our Home for Life" Sustainable Orange County Plan*, includes a strategy to, "Adopt a complete streets policy and manual." This goal should be modified to "Adopt a complete green streets policy and manual." Smart Growth America has a useful policy guide to complete green streets as does U.S. EPA.

Recommendation 17: Develop a Complete and Green Streets policy that encourages and enforces the installation of Complete and Green Streets at development and re-development sites.

PARKING STANDARDS

Excessive impervious surfaces from overly sized parking lots are needless generators of stormwater runoff. Orange County currently sets parking minimums at reasonable levels consistent with both national regulations and local studies. However, parking requirements are only set as minimum standards, allowing developers to design and install unlimited parking. Conversations held with county staff revealed that developers have installed as much as four times the amount of parking spaces required for a development.

Recommendation 18: To combat the over-provision of parking spaces, set parking requirements as minimums and maximums (as opposed to only minimums) to prevent excessive parking lot size.

PERVIOUS PAVEMENTS

Pervious pavements require maintenance (annual or bi- annual vacuuming with a special vacuum truck) and they should not be used in areas with high sand content or drift that may clog spaces. Pervious pavers can work well in multiple locations throughout the county.

Recommendation 19: Provide developers with information on pervious parking surfaces and provide specifications.

Great Egret, Orange County, FL

Conclusion

Adapting codes, ordinances and municipality practices to use native vegetation for greener stormwater management will allow Orange County to effectively treat stormwater in a more cost-effective manner. Implementation of these recommendations will significantly reduce the impact of the sources of stormwater (impervious cover) and use better ecologically sound methods (trees and vegetation) to uptake and clean stormwater. It will also lower costs of cleanup and damages caused by trees during storms since at risk trees can be dealt with ahead of time with proper pruning or removal.

Orange County can use the canopy data, analysis and recommendations to continue to create a safer, cleaner, cost-effective and more attractive environment for all.

Appendix

METHODS APPENDIX: TECHNICAL DOCUMENTATION

This section provides technical documentation for the methodology and results of the land cover classification used to produce both the Land Cover Map and Potential Planting Scenarios for Orange County.

Land cover classifications are an affordable method for using aerial or satellite images to obtain information about large geographic areas. Algorithms are trained to recognize various types of land cover based on color and shape. In this process, the pixels in the raw image are converted to one of several types of pre-selected land cover types. In this way, the raw data (i.e. the images) are turned into information about land cover types of interest, e.g. what is pavement, what is vegetation. This land cover information can be used to gain knowledge about certain issues; for example: What is the tree canopy percentage in a specific neighborhood?

Land cover classification

NAIP 2015 Leaf-on imagery (4 band, 1-meter resolution) was used for the Land cover classification. The full set of NAIP data were acquired through the Earth Resources Observation and Science (EROS) Center of the U.S. Geological Survey.

Pre-processing

The NAIP image tiles were first re-projected into the coordinate system used by:

Projection: Transverse_Mercator
False_Easting: 656166.6666666665
False_Northing: 0.0
Central_Meridian: -81.0
Scale_Factor: 0.9999411764705882
Latitude_Of_Origin: 24.33333333333333
Linear Unit: Foot_US (0.3048006096012192)

Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
Spheroid: GRS_1980
Semimajor Axis: 6378137.0
Semiminor Axis: 6356752.314140356
Inverse Flattening: 298.257222101

The imagery was then clipped to the area of interest (Orange County – Including Incorporated Areas). A 100 ft. buffer was used to avoid errors along the city boundary. Thus, the total area of interest was all land within the boundaries of Orange County plus the 100 feet of land or water surrounding it.

Supervised classification

The imagery was classified using an object-based supervised classification approach. The ArcGIS extension Feature Analyst was used to perform the primary classification with a "bulls eye" object recognition configuration, which was used to identify features based on their surrounding features. Feature Analyst software is an automated feature extraction extension that enables a GIS analyst to rapidly and accurately collect vector feature data from high-resolution satellite and aerial imagery. Feature Analyst uses a model-based approach to extract features based on their shape and spectral signature.

For better distinction between classes, an NDVI image was created using Raster Calculator instead of ArcGIS' Imagery Analyst menu for consistency. The NDVI image, along with the source NAIP bands (primarily 4,1 and 2), identified various features where they visually matched the imagery most accurately.

Post-processing

The raw classifications from Feature Analyst then went through a series of post-processing operations. Planimetric data were also used at this point to improve the classification. Roads, sidewalks and trails were 'burned in' to the raw classification (this converted vector data to raster data, which then replaced the values in the raw classification). The 'tree canopy' class was not affected by the burn-in process, however, because tree canopy can overhang streets.

These data layers were also used to make logic-based assumptions to improve the accuracy of the classification. For example, if a pixel was classified as 'Turf,' but that pixel overlapped the Roads layer, then it was converted to Tree Cover over Impervious.

The final step was a manual check of the classification. Several ArcGIS tools were built to automate this process. For example, the ability to draw a circle on the map and have all pixels reclassified from "tree canopy" to "non-tree vegetation," which is a process usually requiring several steps, is now only a single step.

Potential Planting Area dataset

The Potential Planting Area dataset has three component data layers. They are created using the land cover layer and relevant data, in order to exclude unsuitable tree planting locations, especially where trees would interfere with existing infrastructure.

1. Potential Planting Area (PPA)
2. Potential Planting Spots (PPS)
3. Potential Canopy Area (PCA)

Initial Inclusion selected from GIC created land cover:

- Pervious surfaces
- Bare Earth

Exclusion Features (buffer distance):

- Excluded Land cover features
  - Existing tree cover
  - Water
  - Wetlands
  - Imperious surfaces
- Ball Fields (i.e.: Baseball, Soccer, Football) where visually identifiable from NAIP imagery. (Digitized by GIC)
- Roads (based on road width estimate from centerlines) (5ft)
- Sidewalks (5ft)
- Park trails (5ft)
- Railroads (10ft)
- Buildings (15ft)
- Wetlands (10ft)
- Hydrological Features (10ft)
- Active Airport Area (near and around runways)
- Stormwater Canals (5ft)
- Stormwater pipes (5ft)
- The following features from the CLC Dataset* (some features might not occur in an area of interest) (5ft)
  - Cemeteries
  - Rock quarries
  - Industrial cooling ponds
  - Ball fields
  - Golf courses
  - Vineyards
  - Canals
  - Marshes
  - Floating/emergent aquatic vegetation
  - Sawgrass
  - Sandhill Lake
  - Sinkhole Lake

Potential Planting Spots

The Potential Planting Spots (PPS) are created from the potential planting areas (PPA). The PPA is run through a GIS model that selects those spots a tree can be planted, depending on the size of trees that are desired.

The tree planting scenario was based on a 20 ft. and 40 ft. mature tree canopy with a 30 percent overlap.

Potential Canopy Area

The Potential Canopy Area (PCA) is created from the PPS. Once the possible planting spots are identified, they are given a buffer around each point that represents a tree's mature canopy. For this analysis, they are given a buffer radius of 10 or 20 ft., which results in 20 and 40 ft. canopy for each tree.

Process to create the PPA

*CLC: The Florida Cooperative Land Cover Map (CLC) **http://www.fnai.org/LandCover.cfm.** All other data was provided by the county government, unless otherwise listed.*

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