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FOR231

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Southern Escambia County, Florida's Urban Forests[1]

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Introduction

The urban forest provides a community numerous benefits and is composed of a mix of native and non-native species. The mix of tree sizes and conditions, as well as the distribution of trees is determined by climate, urbanization patterns, and human preferences. To better understand southern Escambia County's urban forest and its social, economic, and environmental benefits, we developed this publication to help assess: 1) composition and structure, 2) canopy cover, 3) carbon sequestration and storage, 4) air pollution removal, and 5) energy effects on residential buildings. We then compare southern Escambia County's urban forest with forests in other cities in the state of Florida. The information in this publication can provide useful benchmarks and information to urban foresters, residents, and planners so they can better manage this resource (Escobedo et al. 2007).

Methodology

Data was collected by sampling 79, random, 0.04-ha (0.10-acre) plots during 2008 over an area of 2,289 hectares (ha) (5,654 acres) in southern Escambia County, Florida (Figure 1). In these plots we measured tree diameter at breast height (DBH) (e.g. woody species with DBH greater than 2.5 cm regardless of growth habit), species, height, crown characteristics, location, as well as distance and direction relative to residential buildings. We also collected information on tree canopy cover, land use conditions, and shrub and surface cover. The data were analyzed using USDA Forest Service's Urban Forest Effects (UFORE) model (http://www.ufore.org). Key parameters estimated by the model include *leaf area*, which is the sum of all tree leaf surfaces; *carbon storage*, which in our model is the proportion of woody biomass held in the tree's stem and branches over its lifetime; and *carbon sequestration,* which is the estimated amount of annual carbon removed by trees through their growth.

To estimate carbon storage, the model uses the relationship between a tree's size and its dry weight biomass (Escobedo et al 2009c). Approximately 50% of a tree's dry weight biomass is carbon. The average

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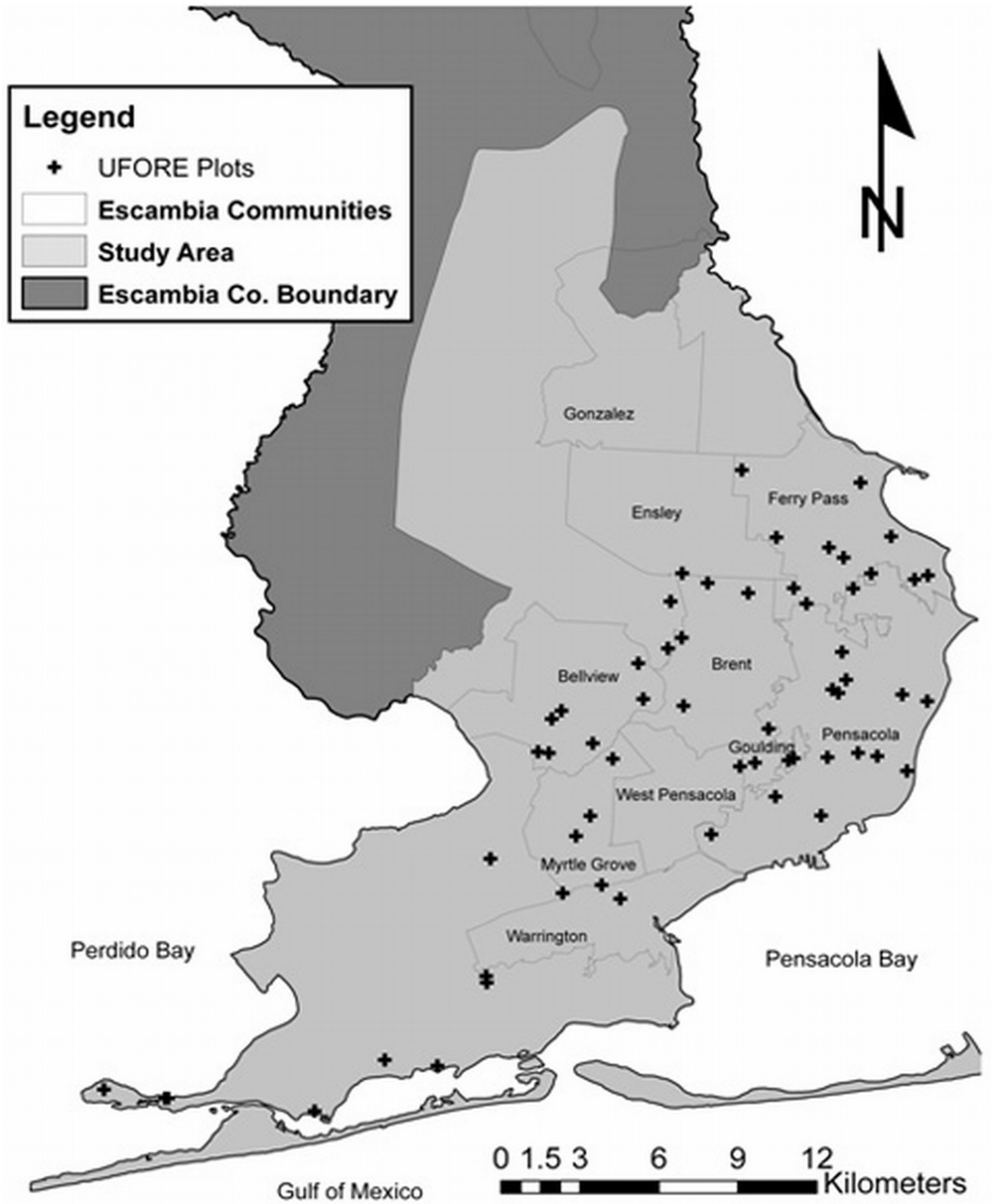

Figure 1. Urban forest effects (UFORE) analysis in the southern Escambia County area.

annual growth for specific types of trees, as well as their size, and condition were accounted for in estimating carbon sequestration rates (Nowak and Crane 2002). Since carbon sequestered by trees is often exchanged in markets in units of carbon dioxide, carbon estimates were converted to carbon dioxide (CO2) equivalents by multiplying by 3.67. Values were multiplied by $4 per metric ton of CO_2 equivalents ($4/mtCO2) based on the current market value (August 2008) on the Chicago Climate Exchange (2008).

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The amount of air pollution removal by trees in southern Escambia County was estimated using tree cover and leaf area data as well as available hourly pollution and weather data for 2000. The amount of pollution removal was calculated for ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than ten microns (PM_{10}). Finally, estimates of urban tree effects on residential buildings energy use (e.g. heating and cooling) were based on field measurements of the distance and direction of trees greater than 20 feet tall relative to space-conditioned residential buildings less than 2 stories high. The UFORE model also incorporated tree type (e.g. evergreen or deciduous), building type and age, regional climate characteristics, and common carbon dioxide emissions from the generation of electricity in the southeastern United States (McPherson and Simpson 1999, Nowak and others 2006).

Urban forest structure and composition

Southern Escambia County's urban forest was composed of a relatively diverse number of species (Escobedo et al. 2009a). A total of 616 trees were measured and 65 different species were identified. Approximately 13 percent of all trees sampled were non-native to the state of Florida. Increased tree diversity can minimize the overall impacts by a species-specific insect or disease. An increase in the number of exotic-invasive plants can pose a risk to native plants if these out-compete and displace native plants.

The 10 most common species accounted for 82 percent of all trees. The three most common species in the city were laurel oak (*Quercus laurifolia*), swamp cyrilla (*Cyrilla racemiflora*), and loblolly pine (*Pinus taeda*), at 38, 10, and 8 percent of the total tree population, respectively (Figure 2). Tree composition varied by land use. Chinese tallow tree (*Triadica sebifera*; 71 percent) dominated commercial lands, crape myrtle (50 percent) dominated industrial lands, and laurel oaks dominated residential areas (22 percent) as well as forest and vacant lands (46 and 33 percent, respectively).

The study area had an estimated 720,720 trees. Trees with diameters at breast height between 2.5 and 13 cm (1 and 6 inches) account for 80 percent of southern Escambia County's total tree population. This is not uncommon for urban forests (Escobedo et al 2009a). The highest tree density occurs on forest lands with 1,705 trees per hectare (690 trees/acre) followed by vacant lands with an average of 890 trees per ha (360 trees/acre), followed by residential areas with 141 trees/ha (57 trees/acre) and then by commercial and industrial lands both with 49 trees/ha (20 trees/acre) (Figure 3). The average tree density in southern Escambia County, taking into account all of its land uses, is 315 trees/ha (127 trees/acre), which is greater than many other cities in the United States, which average 14 to 119 trees/acre (Nowak and others 2006). The high average number of trees per acre in southern Escambia County might be due to the abundance of remnant, naturally forested areas with high regeneration rates in the understory and an abundance of smaller sized trees.

Tree crown condition also varies by land use. Overall, 78 percent of the trees were classified as being in good and excellent condition, and 14 percent were classified as being in poor condition, declining, or dead. Industrial land use had the greatest percentage of excellent and good trees, whereas forest land use had the highest percentage of trees with poor or worse condition most likely due to lack of active tree maintenance, past hurricanes impacts and removals.

In summary, a large percentage of southern Escambia County's trees are smaller, which, in most cases, indicates a younger urban forest. Many different native trees can be found throughout the city. More than a half of all trees are found on forested lands. Land use change and hurricane impacts could have affected the urban forest structure assessed in this publication.

Canopy cover, ground cover and leaf area

Most ecosystem services from trees are linked directly to the amount of healthy urban forest canopy cover (Escobedo et al 2008b). Urban forest cover is

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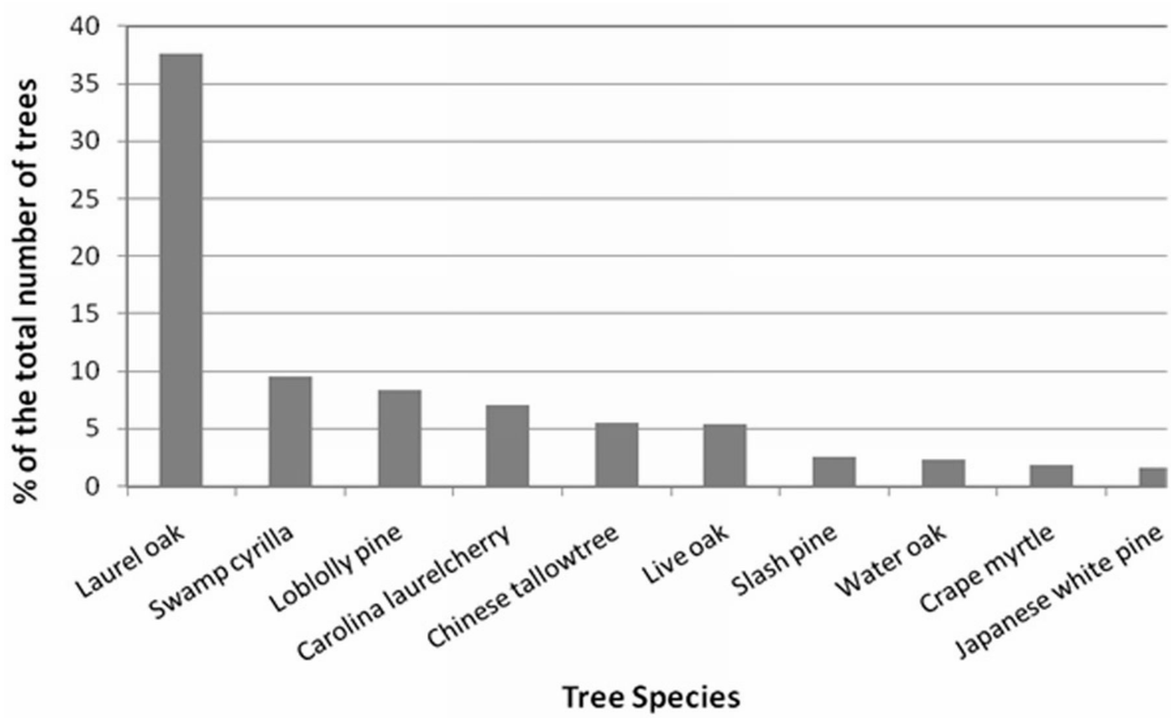

Figure 2. Top 10 most common trees sampled in southern Escambia County's urban forest in 2008.

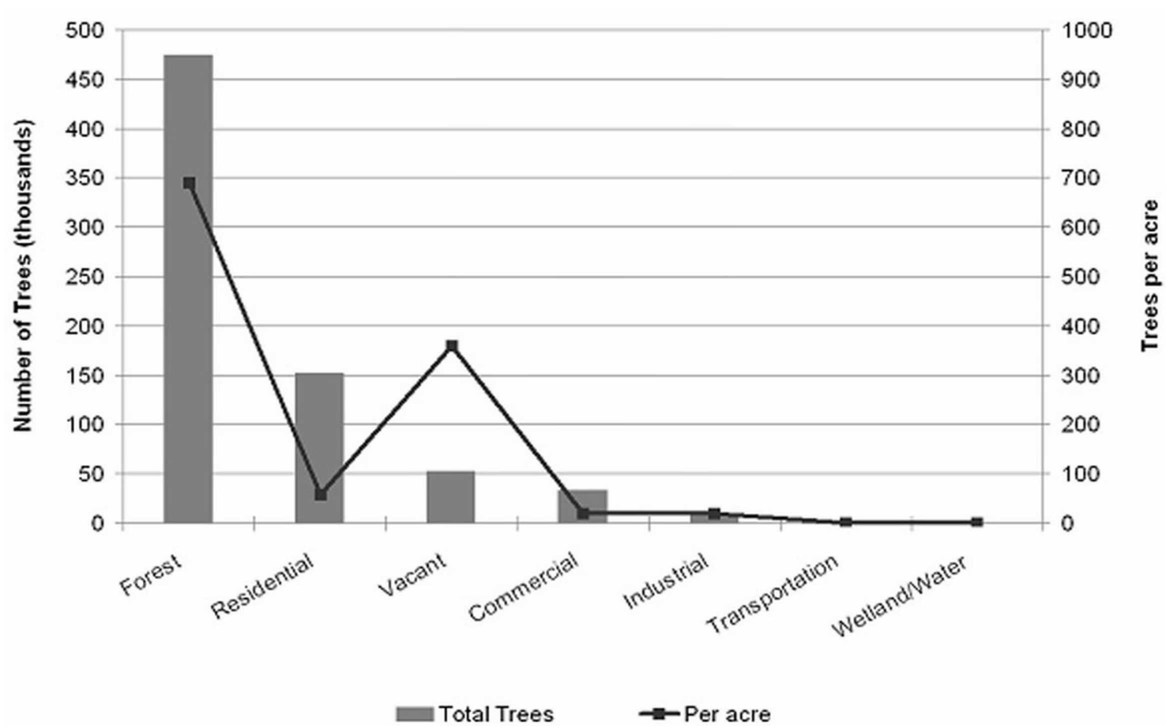

Figure 3. Tree distribution by land use of southern Escambia County's urban forest.

dynamic and changes over time due to factors such as urban development, hurricanes, removals, and growth. The amount of a city's canopy cover depends on its land use, climate, and people's preferences. This section examines how tree composition and location influence urban forest canopy and leaf area, and how tree and ground surface covers vary across southern Escambia County.

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Results obtained from the UFORE model and field data indicate *tree cover* in southern Escambia County was 14 percent while *shrub cover*, often present under trees, was 24 percent. Herbaceous surface cover (e.g. lawns, gardens, pastures) was 41 percent, impervious surface cover (e.g. concrete, roads, tar) was 22 percent, and buildings covered 11 percent of southern Escambia County (Figure 4). The amount of urban forest and impervious cover is often used as an indicator or standard by planners to establish future goals and targets. Over half of all trees were found in residential, industrial and vacant areas. Impervious and building surfaces are predominantly found in transportation and commercial areas.

While all tree species contribute to the community's overall urban forest cover, some species contribute more than others because of their size (e.g., crape myrtle versus a live oak). Approximately 57 percent of southern Escambia County's tree cover is evergreen (evergreen trees maintain their leaves year round and provide year-round functions). In southern Escambia County, trees that dominate in terms of leaf area are laurel oak (*Quercus laurifolia*), live oak (*Quercus virginiana*), and swamp cyrilla (*Cyrilla racemiflora*). Tree species that dominate in terms of actual numbers are laurel oak, swamp cypress, and loblolly pine (*Pinus taeda*).

Figure 5 shows a comparison between the top ten tree species contributing to the canopy cover in southern Escambia County as defined by leaf area relative to their total numbers. For example, even though Carolina laurel cherry (*Prunus caroliniana*) and Chinese tallowtree are common in southern Escambia County, their overall leaf area contributes less to the area's canopy than their numbers would indicate. Live oaks, on the other hand, comprise only 5 percent of all trees in southern Escambia County, yet they contribute to 28 percent of the area's total leaf area.

It is important to realize that urban forest cover can change over time due to urban development, windstorms, tree growth, and land use. Many tree benefits are linked directly to the amount of healthy leaf surface area (Escobedo et al 2008b). By planning and managing tree canopy cover and the extent by tree species, the urban forest manager can develop comprehensive management goals and objectives to improve ecosystem services.

Carbon sequestration and storage

Climate change is an issue of global concern. Urban trees can help reduce concentrations of atmospheric carbon dioxide through their growth and by reducing energy use in buildings through shading and modifying winds. This reduction in building energy use can reduce carbon dioxide emissions produced at fossil-fuel based power plants as part of the process of generating electricity. By estimating the amount of carbon dioxide removed by trees and their shading and windbreak effects on buildings, we can determine the role of urban forests in mitigating climate change and also assign an economic value to the amount of carbon sequestered by an urban forest.

Young trees with a small DBH sequester little carbon due to the limited growth and size. Eventually if they continue to stay healthy and grow they will accumulate more carbon as their biomass increases. Large trees in southern Escambia County greater than 77 inches in DBH continue to sequester the most carbon (Table1). Live oaks, laurel oaks and slash pines store 53, 27 and 4 percent of all carbon respectively. Laurel oaks, live oaks, and slash pine sequester 36, 32 and 3 percent of all carbon, respectively.

Healthier and larger trees sequester the greatest amount of carbon annually (Escobedo et al 2008c). As trees grow, they store more carbon by assimilating it in their woody tissue. As trees die and decay, they release much of the stored carbon back into the atmosphere. Southern Escambia County's trees sequestered 10,189 mtCO_2 per year with an economic value of $56,411. Figure 6 depicts a comparison of the economic value and net carbon dioxide sequestered by trees located in areas dedicated to different land uses. Trees located on forest lands sequester more CO_2 than residential due to greater tree density in forest versus residential land uses.

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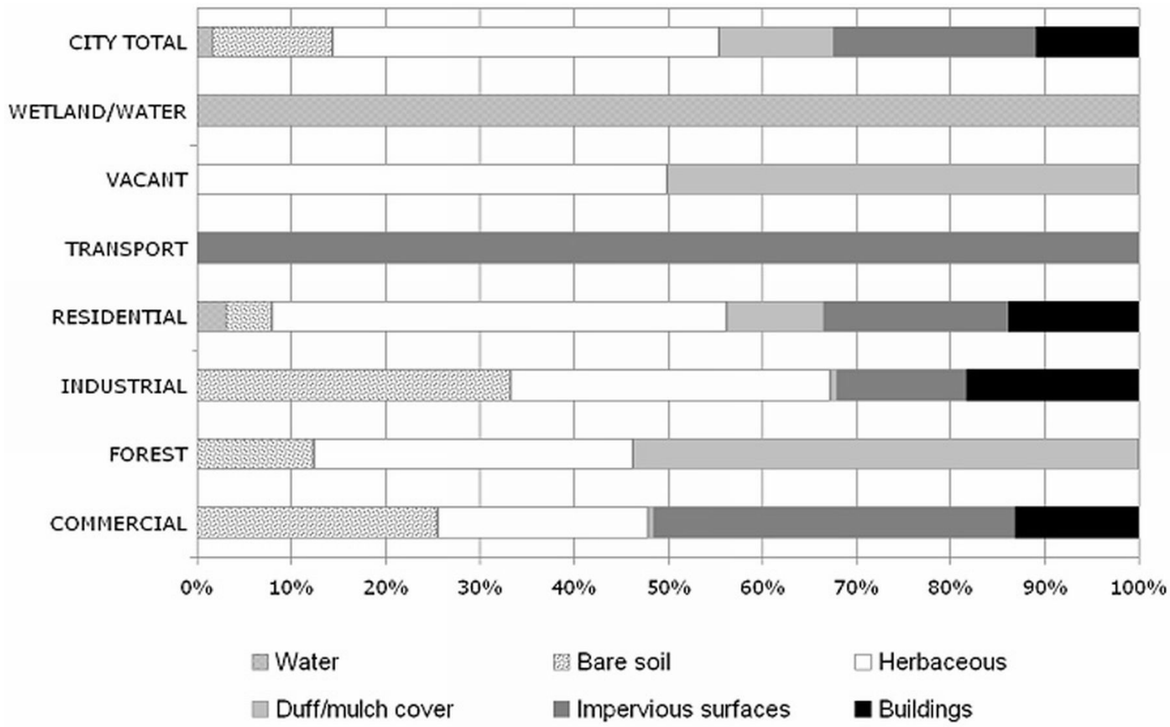

Figure 4. Surface ground covers by land use in southern Escambia County's urban forest.

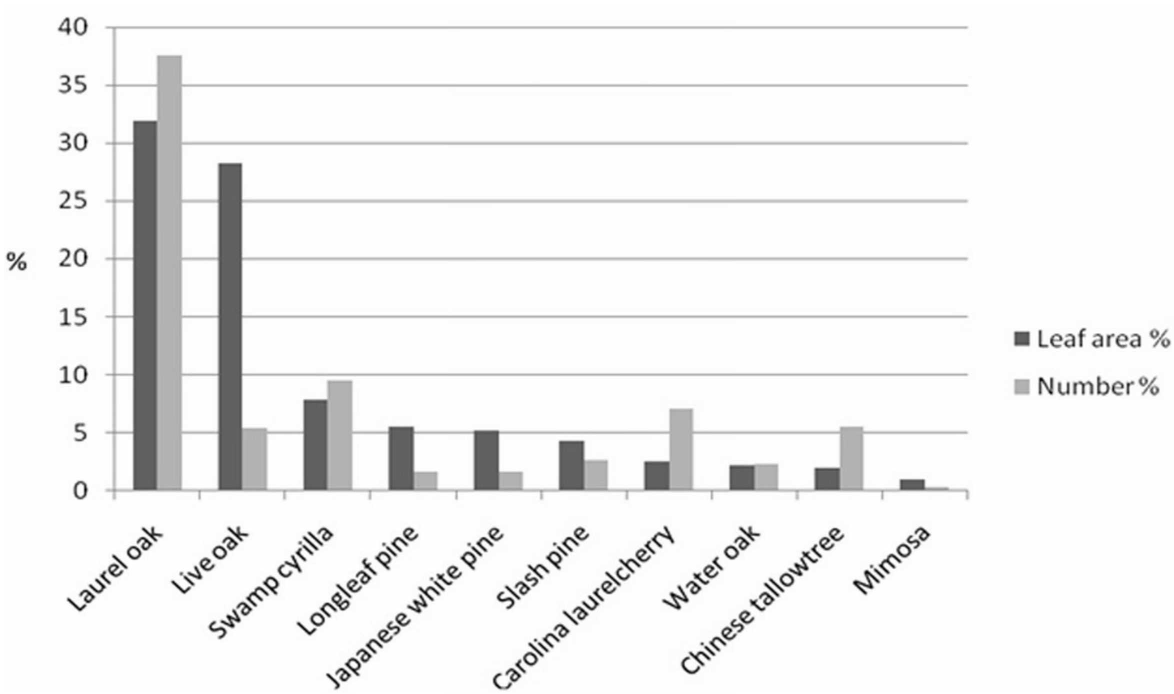

Figure 5. The top ten trees with highest total leaf area compared to their numbers in southern Escambia County's urban forest.

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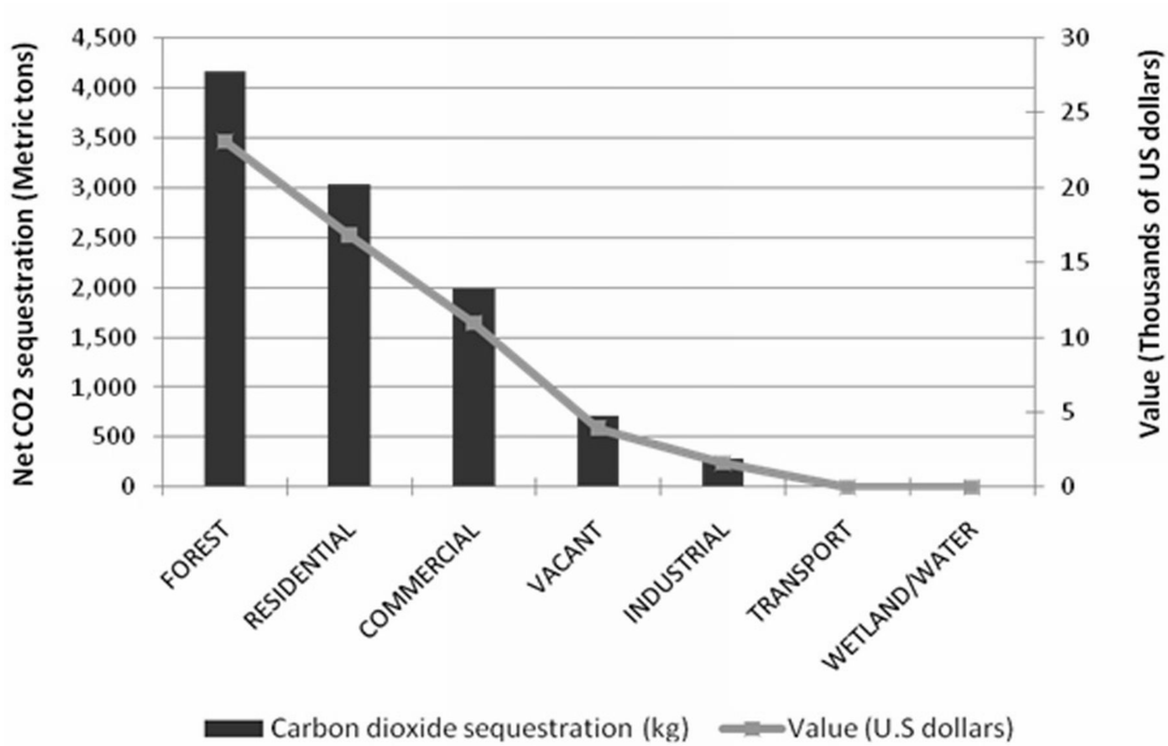

Figure 6. Net CO_2 sequestration per land use area and its associated value in southern Escambia County's urban forest.

Air pollution removal

On average, 1 square meter of tree cover removes 7 grams of air pollutants in southern Escambia County. Total pollution removal was greatest for particulate matter less than ten microns, followed by ozone, carbon monoxide, nitrogen dioxide and sulfur dioxide. Figure 7 compares the pollution removed and the resulting economic health benefits to society at large. It is estimated that annually trees in the study area removed 25 tons of air pollution (CO, NO_2, O_3, PM_{10}, SO_2). This is approximately $146,000 US dollars in health benefits per year.

Energy effects on residential buildings

Trees affect energy use by shading buildings, reducing temperatures by providing evaporative cooling, and blocking winter winds. Trees tend to reduce building air conditioning use in the summer months and can either increase or decrease building energy use in the winter months depending on the location of trees relative to a building. Based on the size of a building and the surrounding trees, we can place an economic value on the effects on energy use in residential buildings (Escobedo et al 2008d).

Based on the 2007 average retail price of electricity in Florida (EIA 2007), trees in southern Escambia County are estimated to provide about $306,000 in savings due to reduced air conditioning and heating use. However, trees can also increase heating use in winter by approximately $32,000 dollars annually due to the shading of the sun which results in increased heating. Table 2 provides a breakdown of the air conditioning and heating use and price savings as well as heat emissions costs by residential trees.

Trees clustered together near a building can create a microclimate cooling system via evapotranspiration (the evaporation of water from plant surfaces and bodies of water) and shade. Finally, trees properly positioned around a building can direct wind air flow to the building to help cool it down in warmer months or away from the building to diminish cooling effects during cooler months (Meerow and Black 2003).

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The placement of trees around a building can influence the amount of energy required to maintain acceptable temperatures inside the building. Trees planted on the west side block the increase of solar heat in the afternoon during summer, and trees on the east and south sides of the house will block the solar heat in the summer. In more northerly areas of Florida, the same trees will increase the heating requirement for the structure in the winter if they are not deciduous trees (McPherson and others 1999). This negative shading effect is caused by evergreen trees blocking solar heat from reaching a structure to warm it during north Florida's colder months. Relying on the principle of "the right tree in the right place" will allow the sun's heat to reach a structure if deciduous trees, which lose their leaves in the fall, are planted on the south and east sides. Ultimately homeowners determine how cool or warm they prefer the inside of their homes to be and tree placement effects may vary from person to person and home to home.

By influencing energy production in power plants, trees can also affect emissions of carbon dioxide (CO_2) and other green house gases. In doing so trees can indirectly lower (or increase) CO_2 emissions by power plants and this offset of avoided emissions can result in economic savings to the community (McPherson and others 1999). Using the average price of CO_2 on the Chicago climate exchange of $4 per ton of CO_2 emissions avoided (August 2008), the effect of trees on residential building energy use can result in $13,770 in benefits and $3,377 in costs; a benefit-cost ratio of 4:1. Table 3 provides a breakdown of the energy savings and costs due to southern Escambia County's urban forests.

In summary, it is important for homeowners to plant trees in the right place to maximize cooling benefits in the summer and solar heat gain in the winter. See Meerow and Black (2003) for more specific landscaping suggestions. It is important to consider that energy savings are also affected by the occupant's use of the air conditioning and heating systems as well as the energy use efficiency characteristics of buildings and heating-cooling units (Escobedo et al 2008d). It is important for homeowners and landscape architects to carefully consider placement of trees around structures to maximize energy benefits.

Comparing southern Escambia County's urban forest with others in Florida

It can be difficult to determine which tree species are the most important contributors to an urban forest. This is because certain species are numerous in an urban forest yet they have low leaf area and vice versa. But in general there are some methods to determine the overall role of a particular tree species in the urban forest. Ecologists overcome this uncertainty by calculating the Importance Value (IV) for each species based on its relative frequency (% of population) and relative leaf area. When these values are summed the IV can be used to standardize tree species and rank and compare the importance of tree species (Figure 8). Laurel and live oak are particularly important species in southern Escambia County relative to other tree species found in other urban areas in Florida. Certain tree species are found in high numbers only in southern Escambia County, while others are found only in other Florida cities.

Urban forests in southern Escambia County have a greater tree density (number of trees per hectare) in comparison to Gainesville, Miami-Dade County and Tampa (Table 4). Tree cover numbers in southern Escambia County are likely a result of the study area encompassing coastal, highly urbanized portions of the county. Larger trees in Gainesville might explain that city's larger amounts of carbon storage compared to other Florida cities.

The information presented in this document can be used to establish baselines and provide an insight into existing urban forest structure and its ecosystem services. It can be used to formulate management strategies and goals that maximize benefits and minimize safety risks to citizens. The information is especially useful for developing and establishing medium and long-term management goals and objectives (Escobedo et al. 2007). Understanding a community's urban forest structure, community perceptions and available resources can be used to maximize the benefits of an urban forest.

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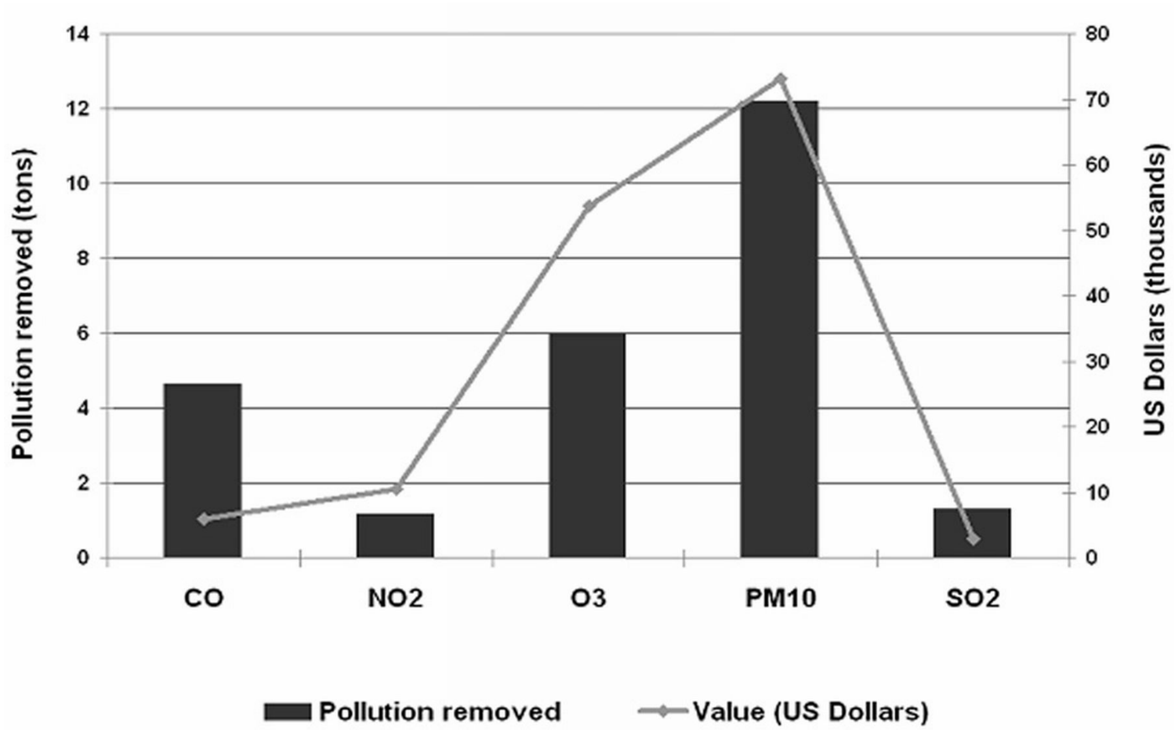

Figure 7. Comparison of the annual pollution removed in metric tons and the resulting health benefits in southern Escambia County.

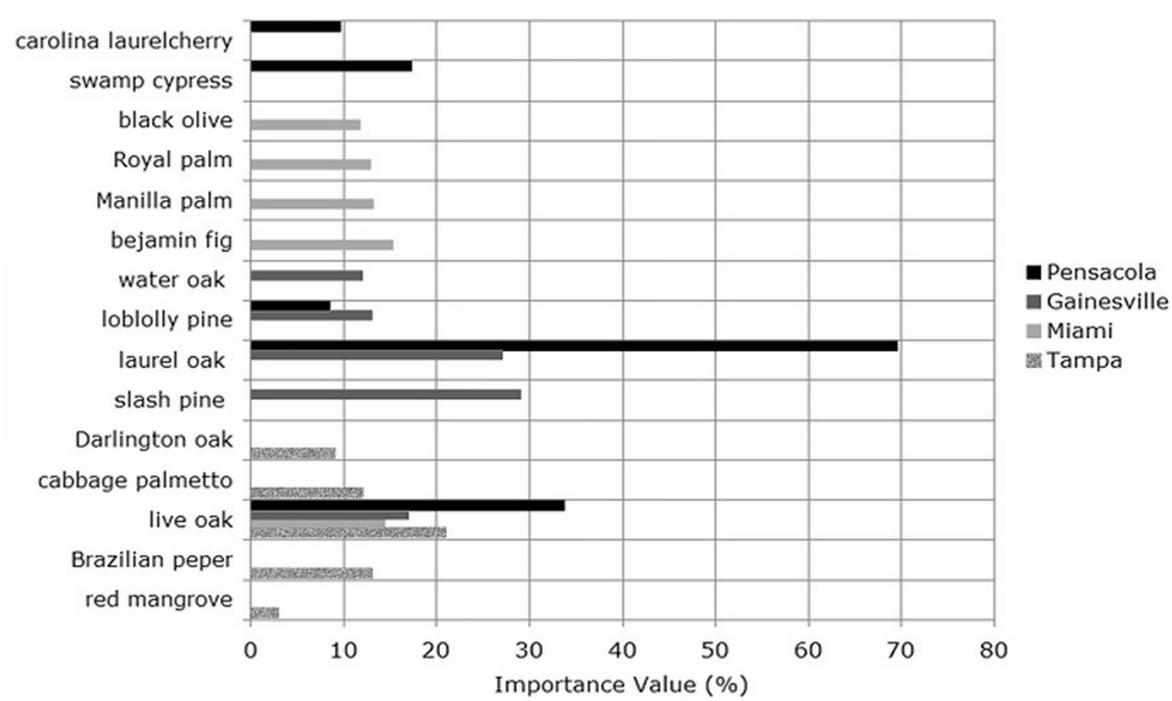

Figure 8. Importance values for species found in southern Escambia County and other urban areas in Florida.

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Literature Cited

Chicago Climate Exchange. 2008. "Market overview." Chicago Climate Exchange. http://www.chicagoclimatex.com/ (accessed August 19, 2008).

Energy Information Administration (EIA). 2007. Average retail price of electricity to ultimate customers by end-use sector, by state, April 2008 and 2007. Average retail price of electricity to ultimate customers by end-use sector, by state report, Energy Information Administration. http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html (accessed January 20, 2010).

Escobedo, F., J. Seitz, and W. Zipperer. 2009a. Gainesville's urban forest structure and composition. University of Florida- IFAS, EDIS FOR 214. http://edis.ifas.ufl.edu/document_fr276 (accessed October 1, 2009).

Escobedo, F., J. Seitz and W. Zipperer. 2009b. Gainesville's urban forest canopy cover. University of Florida- IFAS, EDIS FOR 215. http://edis.ifas.ufl.edu/document_fr277 (accessed October 1, 2009).

Escobedo, F., J. Seitz and W. Zipperer. 2009c. Carbon sequestration and storage by Gainesville's urban forest. University of Florida- IFAS, EDIS FOR 210. http://edis.ifas.ufl.edu/document_fr272. (accessed October 1, 2009).

Escobedo, F., J. Seitz and W. Zipperer. 2009d. The effect of Gainesville's urban trees on energy use of residential buildings. University of Florida- IFAS, EDIS FOR 211. http://edis.ifas.ufl.edu/document_fr273. (accessed October 1, 2009).

Escobedo F., Northrop, R., and Zipperer, W., 2007. Developing an urban forest management plan for hurricane-prone communities. University of Florida- IFAS, EDIS FOR 121/FR176. http://edis.ifas.ufl.edu/document_fr176. (accessed October 1, 2009).

McPherson, E.G. and J.R. Simpson. 1999. Carbon dioxide reduction through urban forestry: Guidelines for professional and volunteer tree planters. Gen. Tech. Rep. PSW-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p.

Meerow, A.W. and R.J. Black. 2003. Enviroscaping to conserve energy: a guide to microclimate modification (CIR EES43) http://edis.ifas.ufl.edu/EH143. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Nowak, D.J. and D.E. Crane. 2002. Carbon storage and sequestration by urban trees in the United States. *Environ. Poll.* 116(3): 381-389.

Nowak, D.J., R.E. Hoehn, D.E. Crane, J.C. Stevens, J.T. Walton, and J. Bond. 2006. Assessing urban forest effects and values: Minneapolis' urban forest (Resource Bulletin NE-166). Newtown Square PA: United States Department of Agriculture, Forest Service, Northeastern Research Station.

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Table 1. Comparison of estimated average carbon stored and sequestered per tree in one year by diameter at breast height (DBH) size classes in southern Escambia County.

DBH Class (cm)	Per Tree C Storage (kg)	Per Tree Net Sequestered (C kg/year)	Per Tree Net Sequestered (CO_2 kg/year)
0 – 15	22	4.0	14.7
16 – 30	250	16.8	61.6
31 – 45	604	18.5	67.9
46 – 60	1,169	35.6	130.6
61 – 76	2,664	72.7	266.4
77+	15,034	187.3	686.7

Table 2. The benefits and costs based on energy use effects due to tree shading, windbreak, and climate effects near residential buildings in southern Escambia County.

	MWhs[1]	**Benefits***	**Cost***
Heating avoided due to wind break	287	$31,570	
Heating avoided due to tree effects on surrounding climate	460	$50,600	
Air conditioning use avoided due to tree shading	1,481	$162,910	
Air conditioning use avoided due to tree effects on surrounding climate	556	$61,160	
Increased heating due to shading	294		$32,340
Annual Sum of Benefits and Costs		$306,240	$32,340
1 Kwh = 0.001 megawatt hours (MWh), *assuming $0.11 average price per kilowatt hour for Florida end-user (EIA 2007).			

Table 3. Annual energy savings and costs due to tree location around residential buildings in southern Escambia County.

	Benefit or Cost	**C mt/yr**	**CO_2 mt/yr**	**US$ CO_2 savings/year**
Heating avoided due to windbreak	Benefit	239	877	3,509
Heating avoided due to local climate effects	Benefit	373	1369	5,476
Cooling avoided due to shading	Benefit	237	870	3,479
Cooling avoided due to climate effects	Benefit	89	327	1,307
Heating emissions due to shading	Cost	230	844	3,377

C, Carbon; CO_2, Carbon dioxide

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Table 4. Urban forest cover, composition and carbon storage for four cities within the state of Florida.

Urban area	Urban forest cover	Most common trees and palms (Average number of trees or palms per ha)	Average tree density (Number of trees/ha)	Average C storage kg/ha
Gainesville	Tree 50% Palm 1% Shrub 16%	Laurel oak (23) Carolina laurel cherry (21) Slash pine (15)	242	30,800
Southern Escambia County	Tree 13% Palm 1% Shrub 24%	Laurel oak (31) Chinese tallow tree (11) Carolina laurel cherry (9)	315	27,400
Miami-Dade County	Tree 9% Palm 3% Shrub 5%	Surinam cherry (6) Christmas palm (5) Live oak (5)	83	9,300
Tampa*	Tree 28% Palm 7% Shrub 14%	Black mangrove (30) White mangrove (16) Laurel oak (15)	257	15,331

*http://www.sfrc.ufl.edu/urbanforestry/Files/TampaUEA2006-7_FinalReport.pdf