Values and Ecosystem Services of Gainesville's Urban Forest in 2016[1]

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From May to October 2016, an urban forest ecological analysis was conducted in Gainesville, Florida, to quantify the vegetation structure, functions, and values of the urban forest. This research was done in partnership with the University of Florida and the City of Gainesville's Parks, Recreation, and Cultural Affairs Department.

The team used the i-Tree Eco model developed by the U.S. Forest Service to functions and benefits based on the structure and composition of the forest. To help managers, citizens, and other stakeholders communicate with one another about these large metrics of carbon, air pollution, energy, etc., researchers converted the metrics to dollar values. The values included a compensatory value, a residential energy savings value, an avoided air pollution value, a public health savings value, an avoided stormwater runoff value, a carbon sequestration value, and a carbon storage value.

Urban forest benefits are considered ecosystem services because of their beneficial effects on the health and well-being of humans (Escobedo, Kroeger, and Wagner 2011). These ecosystem services and their values (summarized in Table 1) are discussed in the following sections.

Table 1. Summary of ecosystem services provided by Gainesville's urban forest and associated annual values.

Ecosystem Service	Annual Value (million $)
Tree-shading energy savings	7.7
Avoided carbon emissions	1.7
Air pollution capture	2.7
Avoided health care costs	2.7
Avoided stormwater runoff costs	3.8
Carbon sequestration	5.9
Total Annual Urban Forest Benefits	24.4

Energy Conservation

Trees can reduce the need to heat or cool a building. This reduction in energy use saves consumers money, reduces the amount of carbon emitted into the atmosphere by power plants, and decreases the demand for non-renewable fossil fuels, which is a global concern.

Deciduous trees, such as red maple, lose all or most of their leaves in fall and winter each year. Deciduous trees are excellent energy conservation trees because they generally grow a large canopy of foliage that can shade a building during the hot summer months, but then lose their leaves during the winter months, allowing sunlight to warm the building. Evergreen trees, such as loblolly pines and live oaks, do not lose all of their foliage during the winter. They can therefore act as a wind barrier, protecting homes from winter winds (Andreu et al. 2008b).

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Energy Conservation in Gainesville

Gainesville's urban forest resulted in an estimated reduction of residential energy use for cooling of 58,770 MWHs valued at $6.8 million dollars. The estimated reduction of carbon emissions due to reduced energy production by power plants was 12,900 tons with an associated value of about $1.7 million. In 2016, trees saved Gainesville residents an estimated $7.7 million dollars in total heating and cooling costs.

Air Pollution Removal

Air pollution in cities causes deleterious health impacts for residents. Some of the most serious air pollutants in urban environments are carbon monoxide (CO), nitrogen dioxide (NO_2), ground-level ozone (O_3), fine particulate matter ($PM_{2.5}$), and sulfur dioxide (SO_2). Carbon monoxide is a toxic gas that enters the atmosphere through the combustion of fossil fuels (e.g., vehicles and power plants). Nitrogen dioxide is a respiratory irritant, and it is an ingredient in the formation of ground-level ozone (O_3; smog). Smog is created in the presence of sunlight when NO_2 and other volatile organic compounds react with one another. This reaction rate increases as temperatures increase. Trees can play a vital role in lowering temperatures in urban areas, reducing the rate of ground-level ozone formation (Nowak and Dwyer 2007).

One way trees remove gaseous air pollution is by direct uptake through their leaves during the process of photosynthesis. Once inside the leaf, gases may be absorbed by water to form acids, or they may react with inner-leaf surfaces. Trees also remove pollution by intercepting airborne particles. Some particles can be absorbed into the tree, but most particles are retained on the plant's surface. Particles remaining on the plant surface are often re-suspended into the atmosphere, washed off by rain, or dropped to the ground when the leaves and twigs fall (Nowak, Hirabayashi, Bodine, and Greenfield 2014). Consequently, vegetation is only a temporary retention site for many atmospheric particles.

Trees also play a key role in lowering temperatures in urban areas by shading buildings and pavement. The hotter it is in the city, the more likely it is that smog will form. Therefore, shade produced by trees can translate to a cooler, cleaner city. An individual tree or shrub's ability to remove pollutants from the air is related to its canopy size and leaf area, as well as the concentration of air pollutants nearby.

The i-Tree Eco model estimated that Gainesville's trees and shrubs remove 846 tons of pollution per year with a value of $2.7 million dollars. In addition, the public health benefits from this pollution removal are estimated to be an additional $2.7 million per year, based on the U.S. EPA's BenMAP model.

Carbon Sequestration

Carbon dioxide (CO_2) is a greenhouse gas that contributes to climate change. During the process of photosynthesis, trees incorporate some atmospheric carbon into the tissue in their new growth. That carbon is then considered to be sequestered or locked up for the life of the tree or plant part (leaves, branches, trunk, or roots) (Abdollahi, Ning, & Appeaning 2000). Carbon sequestration rates vary by species, but healthier and more vigorous trees tend to sequester carbon at higher rates than unhealthy trees. The urban forest of Gainesville is a carbon sink, meaning it stores more carbon than it releases. Net carbon sequestration is the amount of carbon sequestered minus the estimated amount of carbon emitted as dead trees decay. The Eco model estimated that in 2016 Gainesville's urban forest sequestered or removed 44,200 gross tons of carbon from the atmosphere, valued at $5.88 million.

The rate of carbon sequestration by an individual tree is a function of the tree's size, species, and condition. The tree species with the highest rate of carbon sequestration in Gainesville is loblolly pine, which is also the species that stores the greatest amount of carbon (Figure 1).

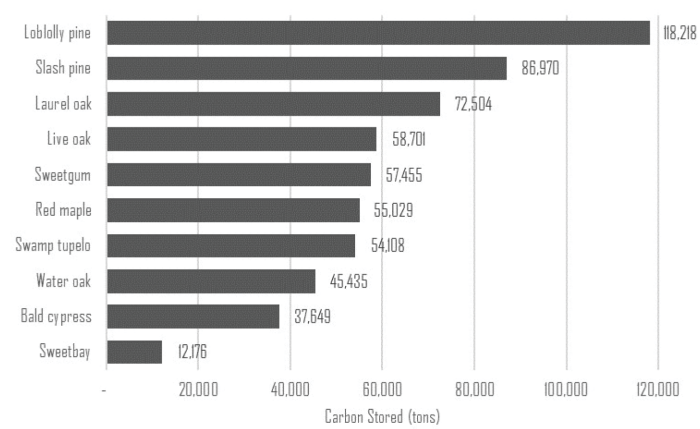

Figure 1. Carbon stored in Gainesville by species.

Carbon Storage

The amount of stored carbon in a tree fluctuates as the tree grows (increases), dies (ceases), or decays (decreases). To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5. The total amount of carbon stored by the trees of Gainesville's urban forest is estimated to be 746,000 tons valued at $99.2 million. In Gainesville, 27% of the stored carbon is in loblolly pines and slash pines combined. An additional 18% of carbon is stored in live oak and laurel oak combined.

Compensatory Value

In addition to its annual benefit values, the urban forest has an overall estimated value referred to as its compensatory value. This value considers tree size, species, condition, and location. The compensatory value is an estimate of the cost to replace all trees in the city if they were removed (e.g., deliberately or due to a storm). The compensatory value of trees in Gainesville's urban forest is over $1.4 billion dollars. This value was calculated by the ECO model using the industry standard methodology developed by the Council of Tree and Landscape Appraisers.

Summary

Urban forests play an important role in our lives because of the services they provide. It is important to think about the urban forest as our habitat, and manage it in ways that will provide the benefits we need and desire. The urban forest is a crucial factor in the well-being of the community because of the aesthetics, health benefits, and cost-savings that it provides.

The content of this fact sheet was derived from the "City of Gainesville Urban Forest Ecological Analysis 2016." The full report can be viewed via this link: http://sfrc.ufl.edu/wp-content/uploads/GNV-ECO-Report-2016.pdf

References

Abdollahi, K., A. Ning, and A. E. Appeaning. 2000. *Global climate change and the urban forest*. Baton Rouge, LA: GCRCC and Franklin Press.

Andreu, M. G., D. Fox, S. Landry, R. Northrop, and C. Hament. 2017. Urban Forest Ecological Analysis. Report to the City of Gainesville, March 2017. City of Gainesville, Florida.

Andreu, M. G., B. J. Tamang, M. H. Friedman, and D. Rock-wood. 2008. *The Benefits of Windbreaks for Florida Growers*. FOR192. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr253

Nowak, D, S. Hirabayashi, A. Bodine, E. and Greenfield. 2014. *Tree and forest effects on air quality and human health in the United States*. Environmental Pollution. 193: 119-129.

Nowak, D., and J. Dwyer. 2007. "Understanding the benefits and costs of forest ecosystems." In J. Kuser, *Handbook of Community Forestry in the Northeast* (2 ed., pp. 25–46). Syracuse, NY: USDA Forest Service.