Monitoring Urban Forest Structure and Function after Hurricane and Assessing Ecosystem Services for Louisiana Cities

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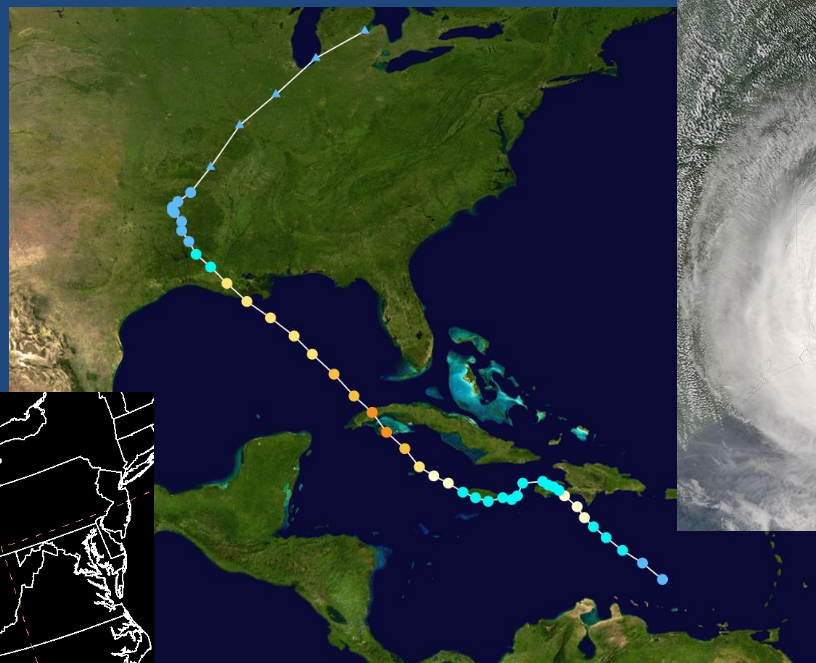
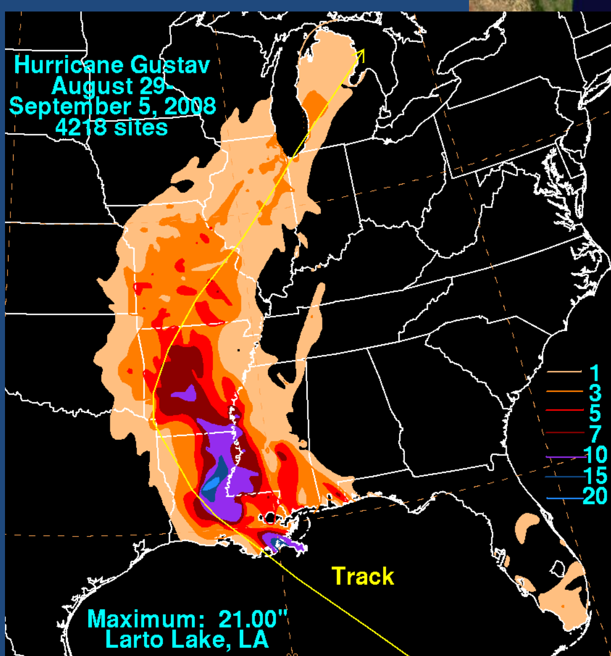
Post-Hurricane Gustav and the need for Baton Rouge Urban Forest Assessment



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Urban Forest Ecosystem Analysis for Baton Rouge, Louisiana

BATON ROUGE

URBAN FOREST ECOSYSTEM

STRUCTURE, FUNCTION AND VALUE

2012

SU URBAN FORESTRY PROGRAM

UFORE
Urban Forest Effects Model

Southern University AGRICULTURAL Research & Extension CENTER

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Southern University Agricultural Research & Extension Center

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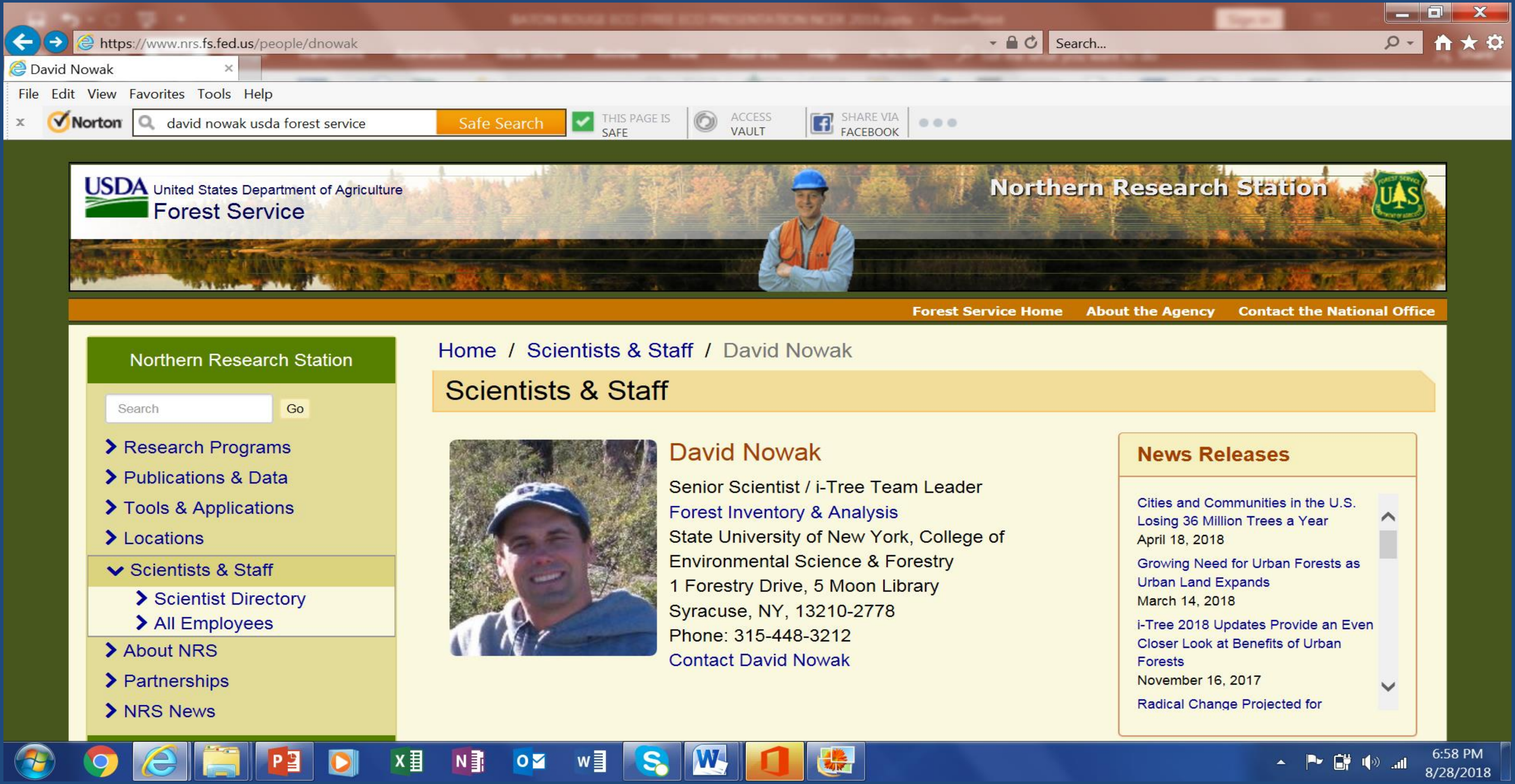


Introduction

- Trees in cities can make a significant contribution to human health and environmental quality.

- Relatively little is known about the urban forest resource and its contribution to the local and regional society and economy.

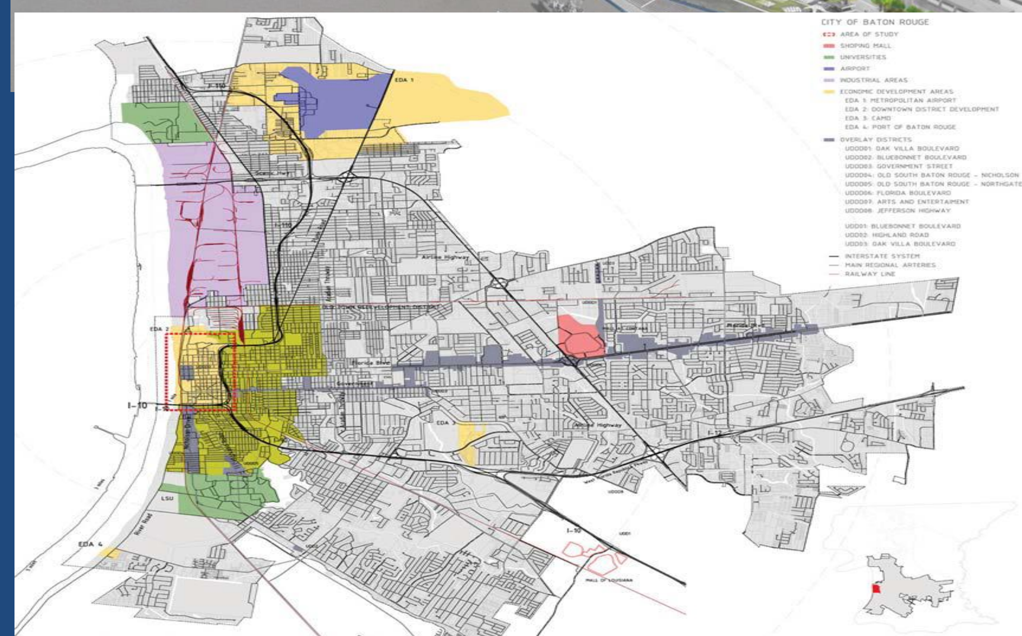
- Information on the structure and functions of the urban forest can be used to inform urban forest management programs and to integrate urban forests within plans to improve environmental quality in the city of Baton Rouge.

Introduction

- Urban forest structure is a measure of various physical attributes of the vegetation, including tree species composition, number of trees, tree density, tree health, leaf area, biomass, and species diversity.
- Urban forest functions, which are determined by forest structure, include a wide range of environmental and ecosystem services such as air pollution removal and cooler air temperatures.
- Urban Forest values are an estimate of the economic worth of the various urban forest functions.
- To help determine the vegetation structure, functions, and values of trees in the City of Baton Rouge LA, a vegetation assessment was conducted (2010-2012). For this assessment, 0.1-acre field plots were sampled and analyzed using the UFORE model. This report summarizes results and values of:
- • Forest structure
- • Potential risk to forest from insects or diseases
- • Air pollution removal
- • Carbon storage
- • Annual carbon removal (sequestration)
- • Changes in building energy use

Pre-Hurricane Gustav
Baton Rouge Urban Forest

- Tree Canopy Coverage Assessment : 55% in 1992
- Tree Canopy Coverage Assessment : 50% in 2001
- Only Street Tree Inventory was conducted for historic downtown area



METHODOLOGY
(Based on iTree-Eco Model Protocol)

- **Urban Forest Effects Model and Field Measurements**
- Though urban forests have many functions and values, currently only a few of these attributes can be assessed due to a limited ability to quantify all of these values through standard data analyses. To help assess the city’s urban forest, data from 400 field plots located throughout the City of Baton Rouge were analyzed using the Forest Service’s Urban Forest Effects (UFORE) model. UFORE is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects, including:
- • Urban forest structure (e.g., species composition, tree density, tree health, leaf area, leaf and tree biomass, species diversity, etc.).
- • Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns).
- • Total carbon stored and net carbon annually sequestered by the urban forest.
- • Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants.
- • Compensatory value of the forest, as well as the value of air pollution removal and carbon storage and sequestration.
- • Potential impact of infestations by Asian longhorned beetles, emerald ashborers, gypsy moth, or Dutch elm disease.
- For more information go to http://www.ufore.org or www.itreetools.org
- In the field, 0.1-acre plots were selected based on a randomized grid with an average density of approximately 1 plot for every 865 acres. Based on these criteria the City of Baton Rouge is divided into 300 plots which are used for this study.

Acknowledgements

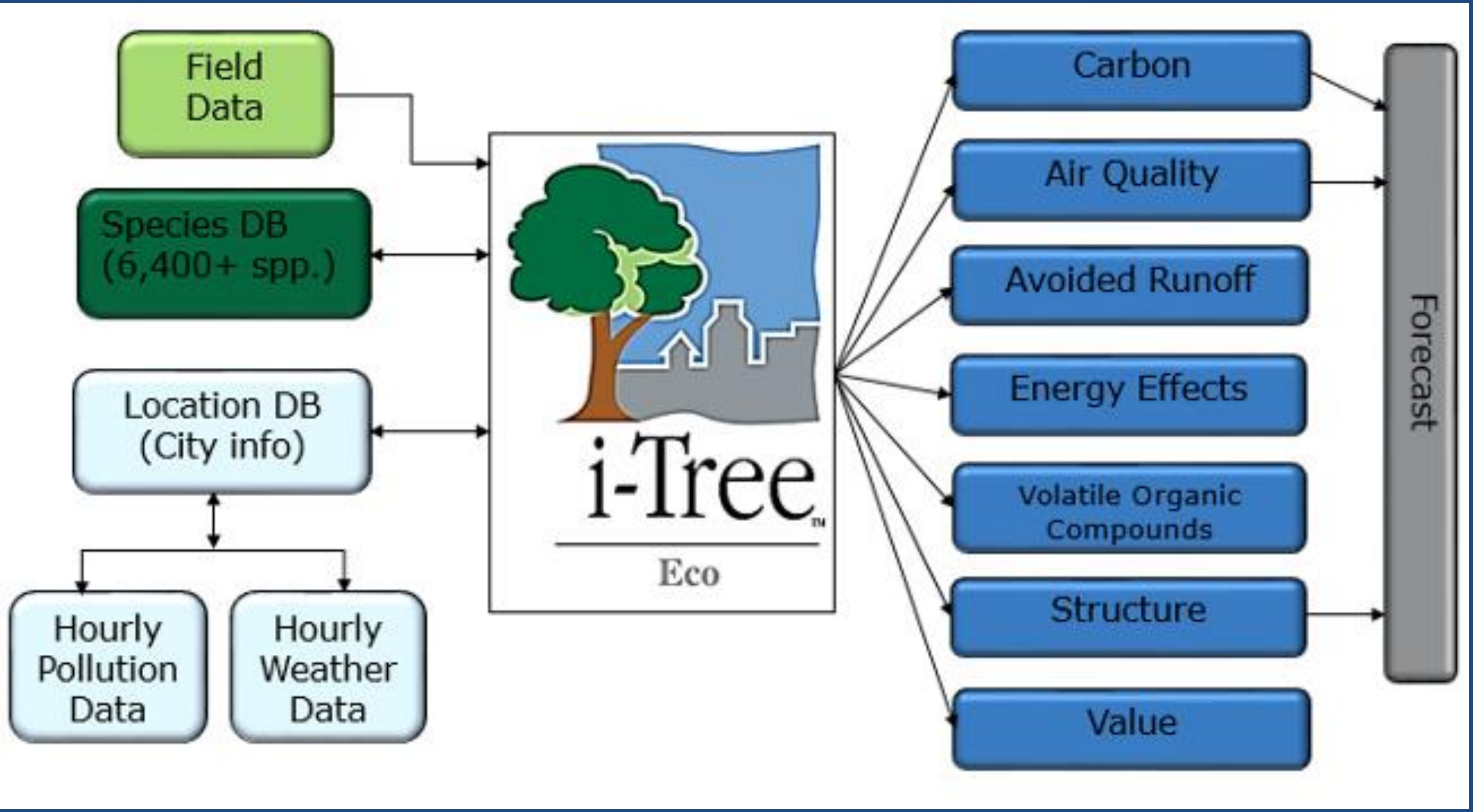
i-Tree Eco Model

- i-Tree Eco is an adaptation of the Urban Forest Effects (UFORE) model, which was cooperatively developed by the U.S. Forest Service Northern Research Station (NRS), USDA State and Private Forestry's Urban and Community Forestry Program and Northeastern Area, Davey Tree Expert Company, and SUNY College of Environmental Science and Forestry.

Urban Forest Effects Model (UFORE)

- The UFORE model was conceived and developed by David J. Nowak and Daniel E. Crane (USFS, NRS), and Patrick McHale (SUNY-ESF). The UFORE software was designed and developed by Daniel E. Crane and its graphical user interface (GUI) by Lianghu Tian and Mike Binkley (The Davey Institute). Many individuals contributed to the design and development process of the UFORE application including Mike Binkley (The Davey Institute), Jaewon Choi (SUNY-ESF), Daniel E. Crane (NRS), Greg Ina (The Davey Institute), Robert E. Hoehn (NRS), Jerry Bond and Christopher J. Luley (Urban Forestry LLC), Patrick McHale (SUNY-ESF), David J. Nowak (NRS), Jack C. Stevens (NRS), Lianghu Tian (The Davey Institute), Jeffrey T. Walton (Paul Smiths College), and Robert Sacks (Bluejay Software).

iTree Eco Model



What Does i-Tree Eco Model Provide?

- i-Tree Eco provides extensive forest and individual tree analyses including the following:
- **Functional Analyses:**
- Pollution removal and human health impacts
- Carbon sequestration and storage
- Avoided runoff
- Building energy effects
- Tree bioemissions

- **Structural and compositional analyses:**
- Species condition and distribution
- Leaf area and biomass
- Species importance values
- Diversity indices and relative performance

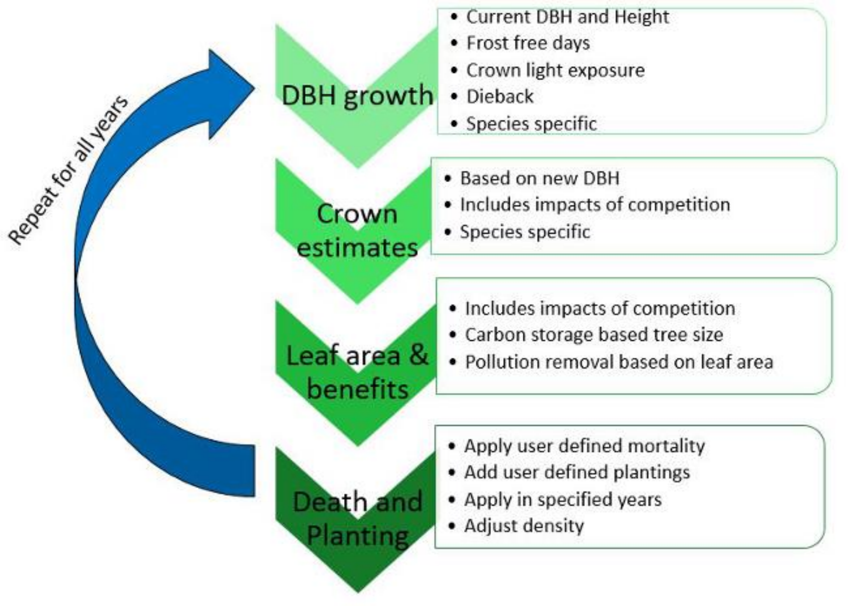
Tree Data and Model Function Relationships

	DERIVED VARIABLES		ECOSYSTEM SERVICES										
DIRECT MEASURES	Leaf Area	Leaf Biomass	Carbon Storage	Gross Carbon Sequestration	Net Carbon Sequestration	Energy Effects	Air Pollution Removal	Avoided Runoff	Transpiration	VOC Emissions	Compensatory Value	Wildlife Suitability	UV Effects
Species	D	D	D	D	D	D	I	I	I	D	D		
Diameter at breast height (DBH)			D	D	D						D	D	
Total height	D	D	D	D	D	D	I	I	I	I		D	
Crown base height	D	D	C				I	I	I	I			
Crown width	D	D	C				I	I	I	I			
Crown light exposure (CLE)				D	D								
Percent crown missing	D	D	C			D	I	I	I	I			
Crown health (condition/dieback)				D	D						D	D	
Field land use			D	D	D						D	D	
Distance to building						D							
Direction to building						D							
Percent tree cover						D	D	D				D	D
Percent shrub cover												D	
Percent building cover						D							
Ground cover composition												D	

D Directly used · I Indirectly used · C Conditionally used

i-Tree

- **Forecasting modeling options including:**
- Tree planting inputs
- Extreme event impacts for weather and pests
- Annual mortality adjustments
- **Management information including:**
- Pest risk analysis
- User defined optional fields
- Cost benefit analysis



Who is Using i-Tree Eco

- Thousands of people in the United States and International have used Eco for projects ranging from small tree inventories to regional scale assessments.

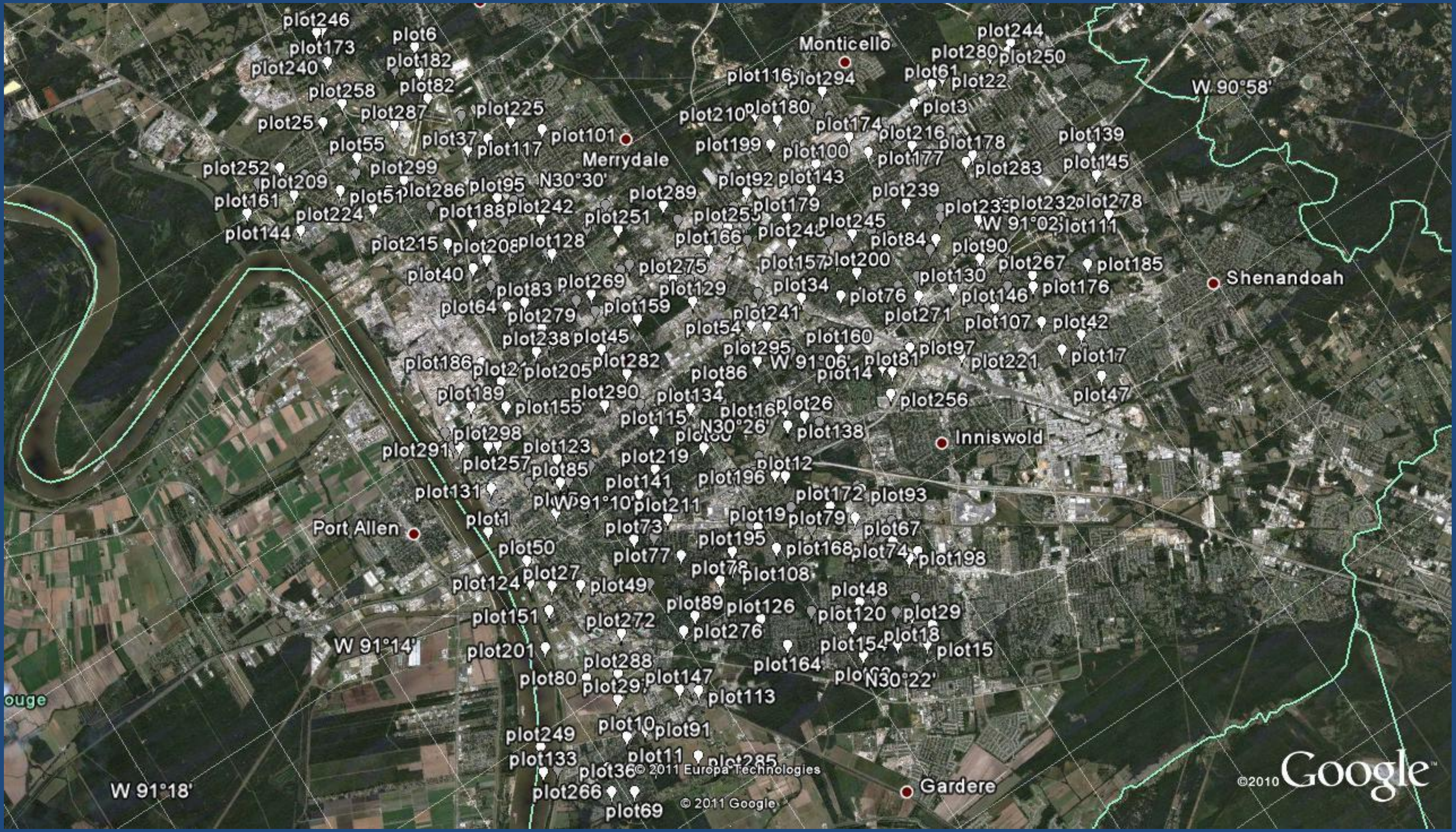
- Eco users include government agencies, consultants, nonprofits, universities, researchers, volunteers, educators, advocates and more.

DATA COLLECTION

iTree Eco Protocol

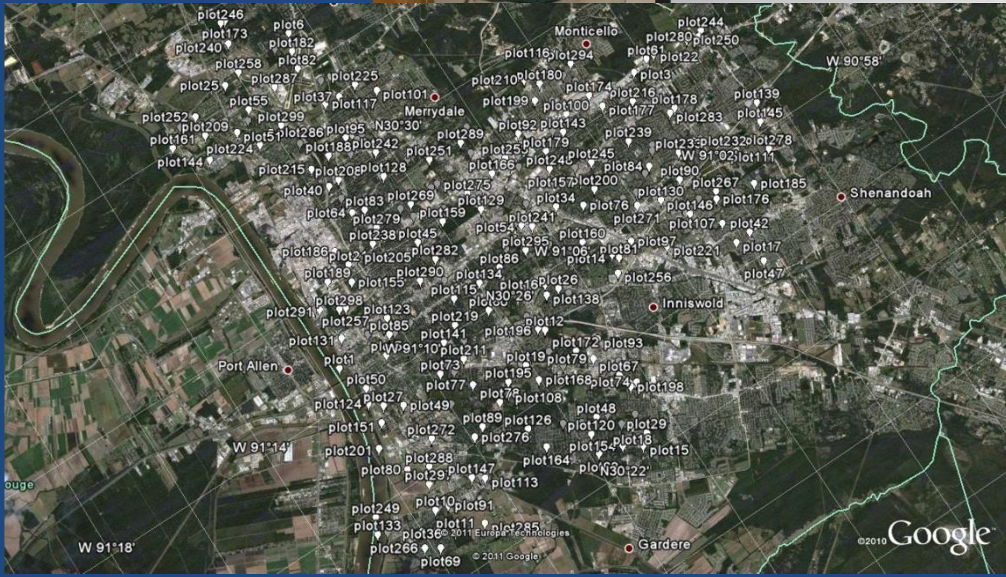
- Field data were collected by the Southern University A & M College, Urban forestry graduate students; data collection took place during the leaf-on season to properly assess tree canopies. Within each plot, data included land-use, ground and tree cover, shrub characteristics, and individual tree attributes of species, stem diameter at breast height (d.b.h.; measured at 4.5 ft), tree height, height to base of live crown, crown width, percentage crown canopy missing and dieback, and distance and direction to residential buildings. Trees were recorded as woody plants with a d.b.h. greater than or equal to 1 inch. As many species are classified as small tree/large shrub, the 1-inch minimum d.b.h. of all species means that many species commonly considered as shrubs will be included in the species tallies when they meet the minimum d.b.h. requirement. In addition, monocot plants that reached minimum d.b.h. were also tallied in Baton Rouge (e.g. palm trees).

400 PERMANENT PLOTS

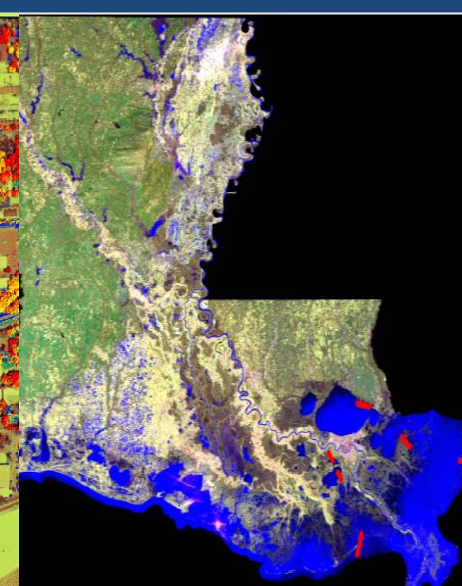


USDA FOREST SERVICE and iTree TRAINING

- Knowledge of iTree Suite and ability to conduct and analyze inventory data to model future urban forest changes, assess green space, and monitor tree health.



SU Urban Forestry
GIS & Remote Sensing Laboratory



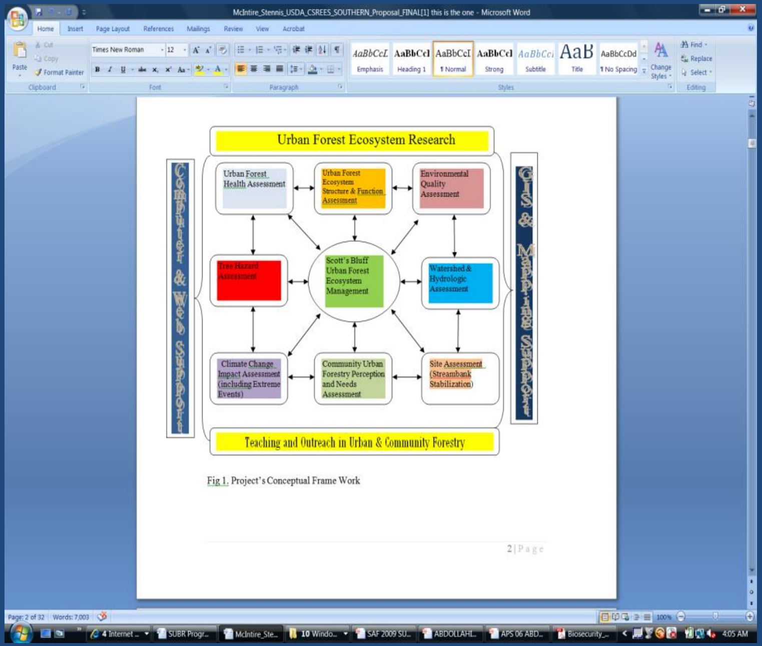
Permanent Plots and
Urban Tree & Shrub Species Inventory

Permanent Plots and Measuring Urban Soil, Water and Air

- **Understanding of soil properties, biology, and processes, especially soil nutrients, soil compaction issues and mitigation, hydrology, water quality, and watershed function.**

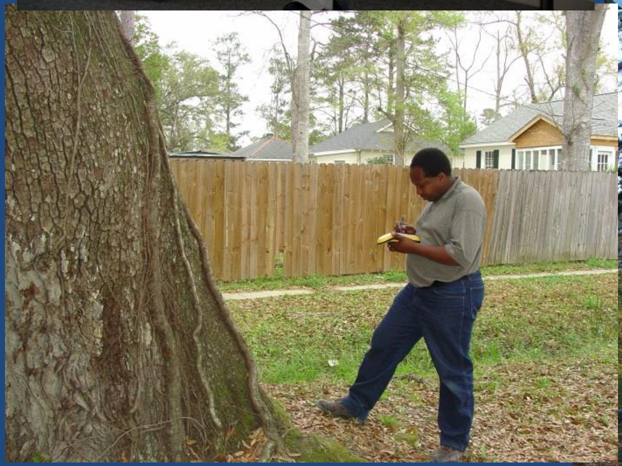
i-Tree-Eco
Urban Forest Structure & Function

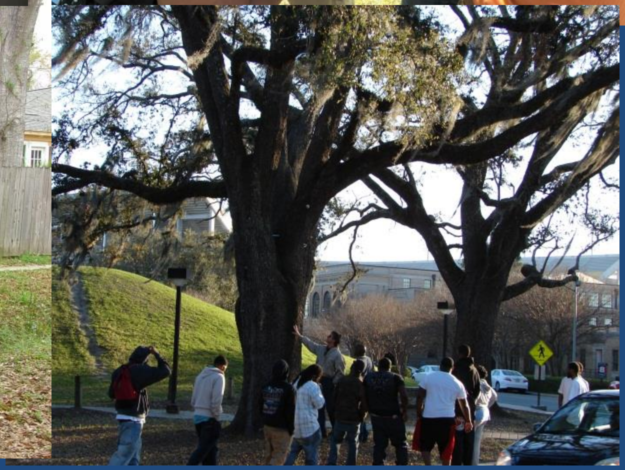
- **Understanding of ecological concepts and principles including the structure and function of ecosystems and especially the growth and performance of various tree species in urban/suburban settings, plant and animal communities common to urban forests, diversity, and disturbance.**



Urban Forest Ecosystem Analysis Using i-Tree Eco (UFORE Model)

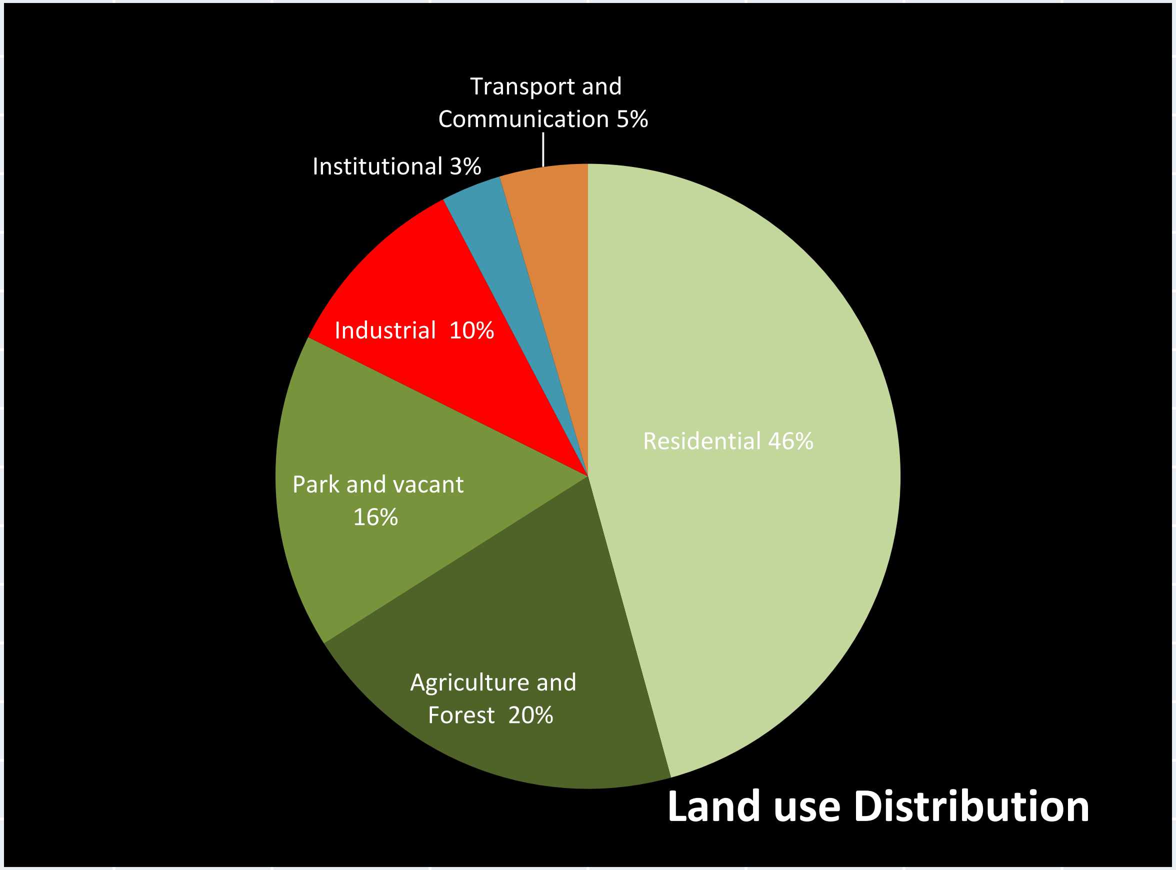
- iTree Suite
- UFOR Inventory
- UFOR GIS/GPS



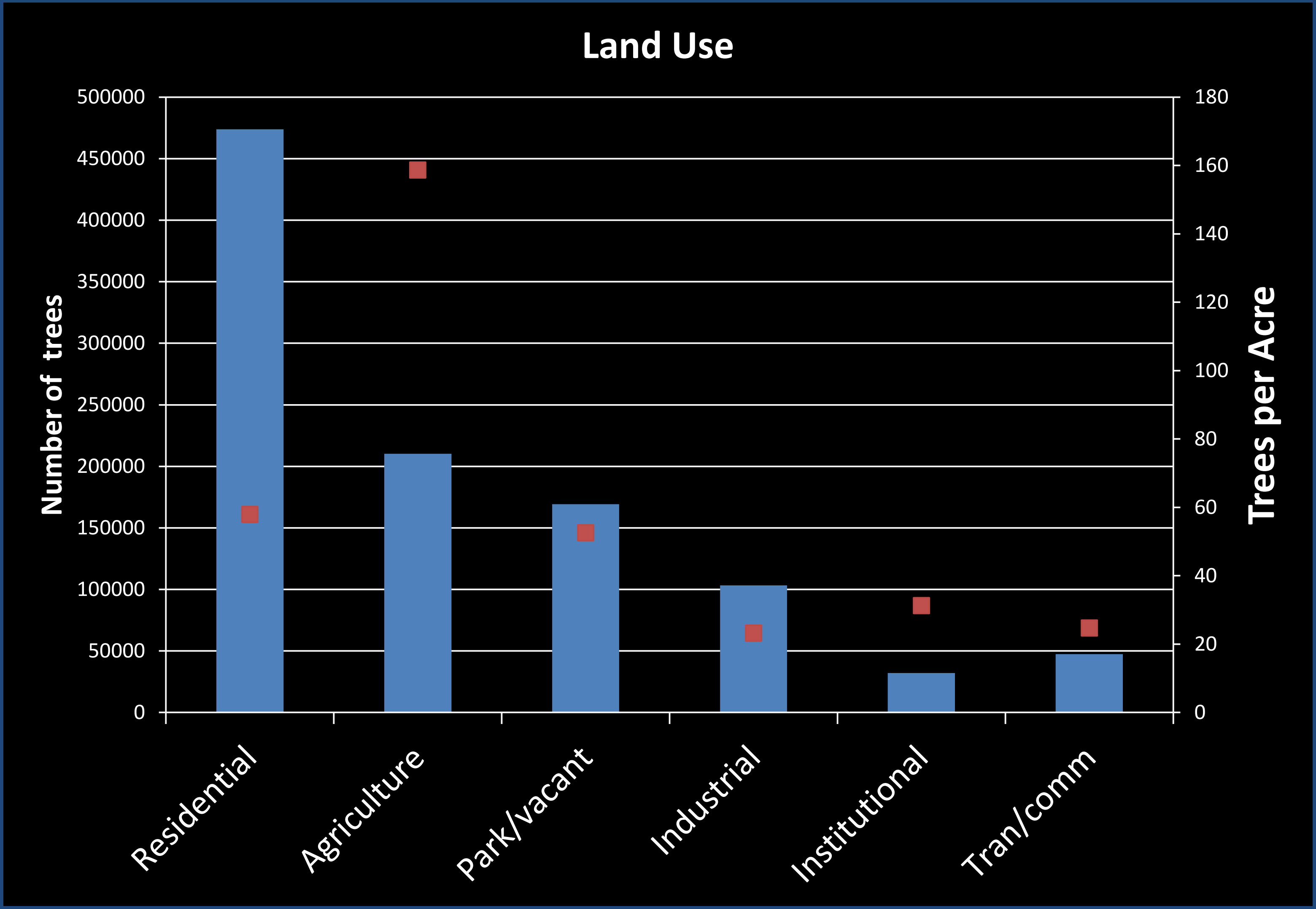


RESULTS

Land Use Distribution in Baton Rouge

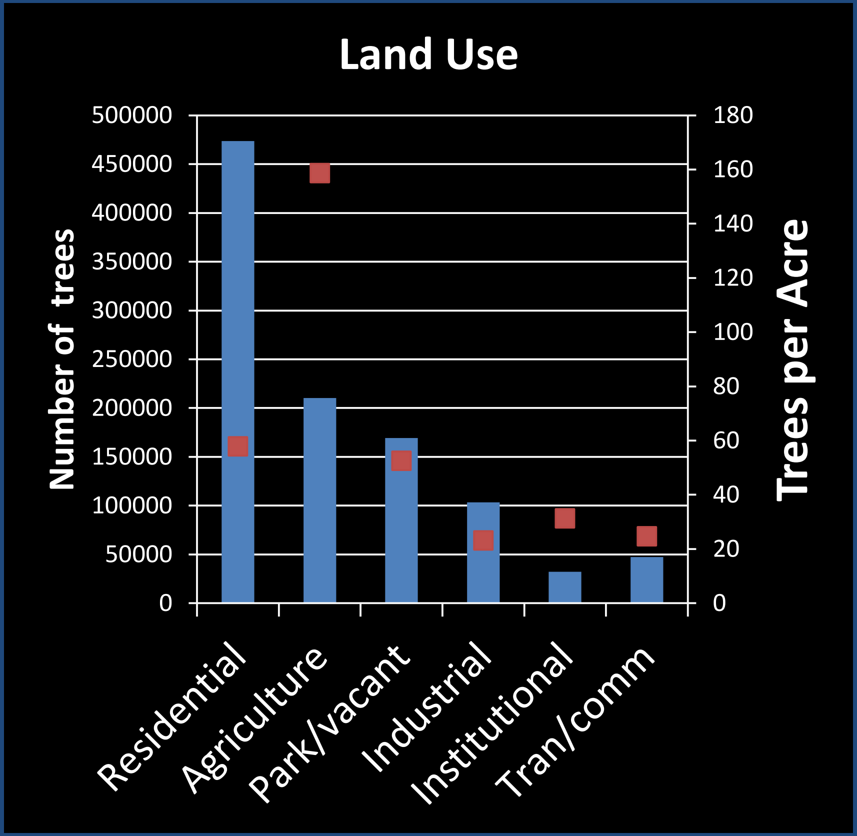


Land use and Trees



LAND USE AND
TREE POPULATION & TREE DENSITY

- The highest density of trees occurs in forest-agricultural lands (158.7 trees/acre),
- followed by residential (57.9 trees/acre) and vacant land and parks (52.6 trees/acre), institutions (31.3 trees /acre), industrial (22.0 trees/acre) and transportation (24.7 trees / acre).



Forest and Agriculture Land Use

- The highest density of trees occurs in forest-agricultural lands
  - (158.7 trees/acre)
- Tree Population
  - 205,000 Trees

RESIDENTIAL LAND USE

- TREE DENSITY
  - (57.9 trees/acre)
- TREE POPULATION
  - 455,000 TREES

Institutional Land Use

- Institutional
  - Density: (31.3 trees /acre),
  - Population: 40,000 trees

Transportation-Communication Land Use

- Density (24.7 trees / acre)
- Population: 48,000 trees

Commercial and Industrial land use

- Density: 22 tree/acre
  - 100,000 trees

Tree density and Land Use

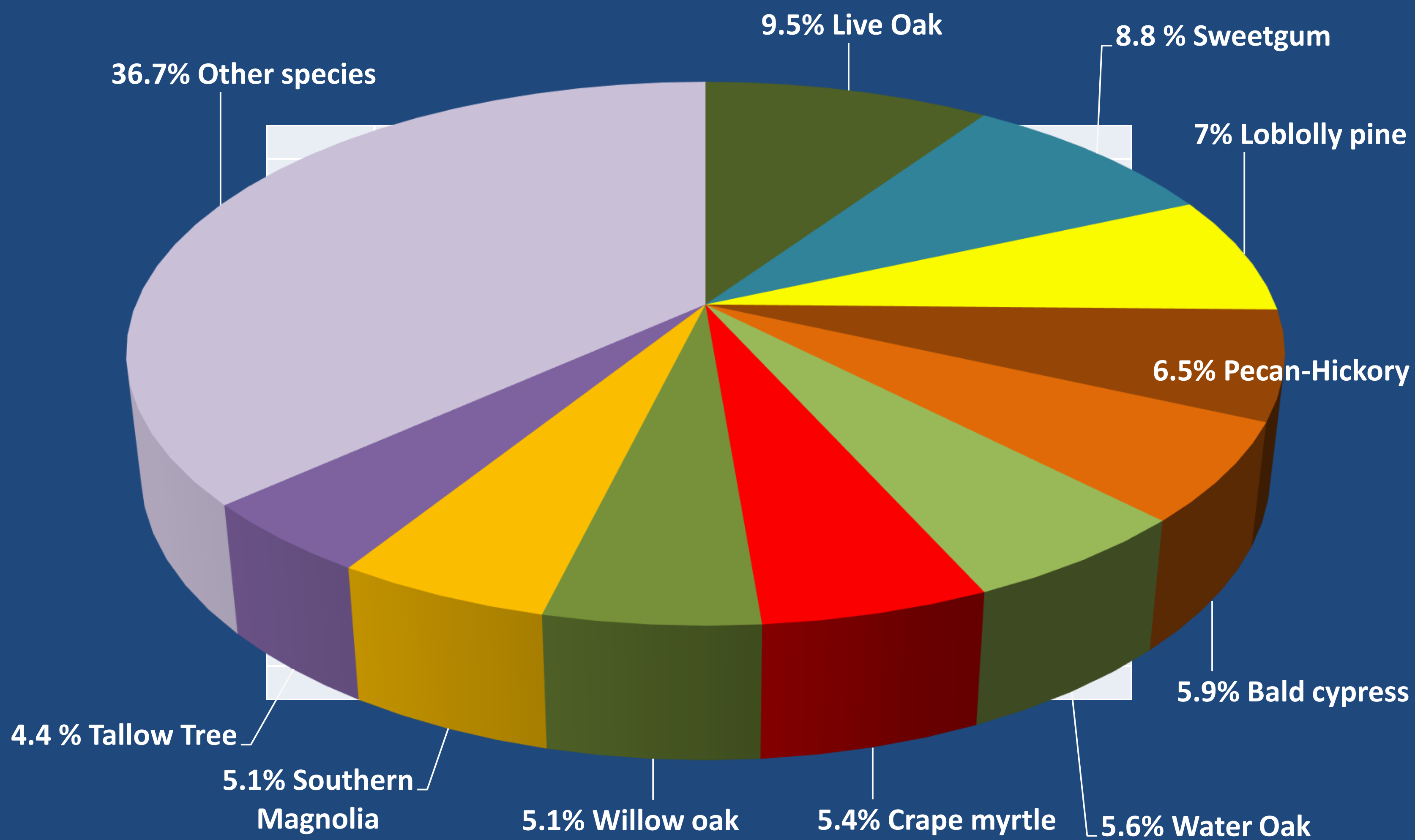
- The highest density of trees occurs in forest-agricultural lands (158.7 trees/acre),
- followed by residential (57.9 trees/acre) and vacant land and parks (52.6 trees/acre), institutions (31.3 trees per/acre) and transportation (24.7 trees / acre).
- The overall tree density in the City of Baton Rouge is 52.6 trees/ acre, which compared well to other city tree densities which range between 9.1 and 119.2 trees/acre (Appendix III). Trees that have diameters less than 6 inches account for 33.0 percent of the population. Land uses that contain the most leaf area are forest-agricultural land) and residential lands (30.0 percent of total tree leaf area)

Total Number of Trees and % Canopy Cover

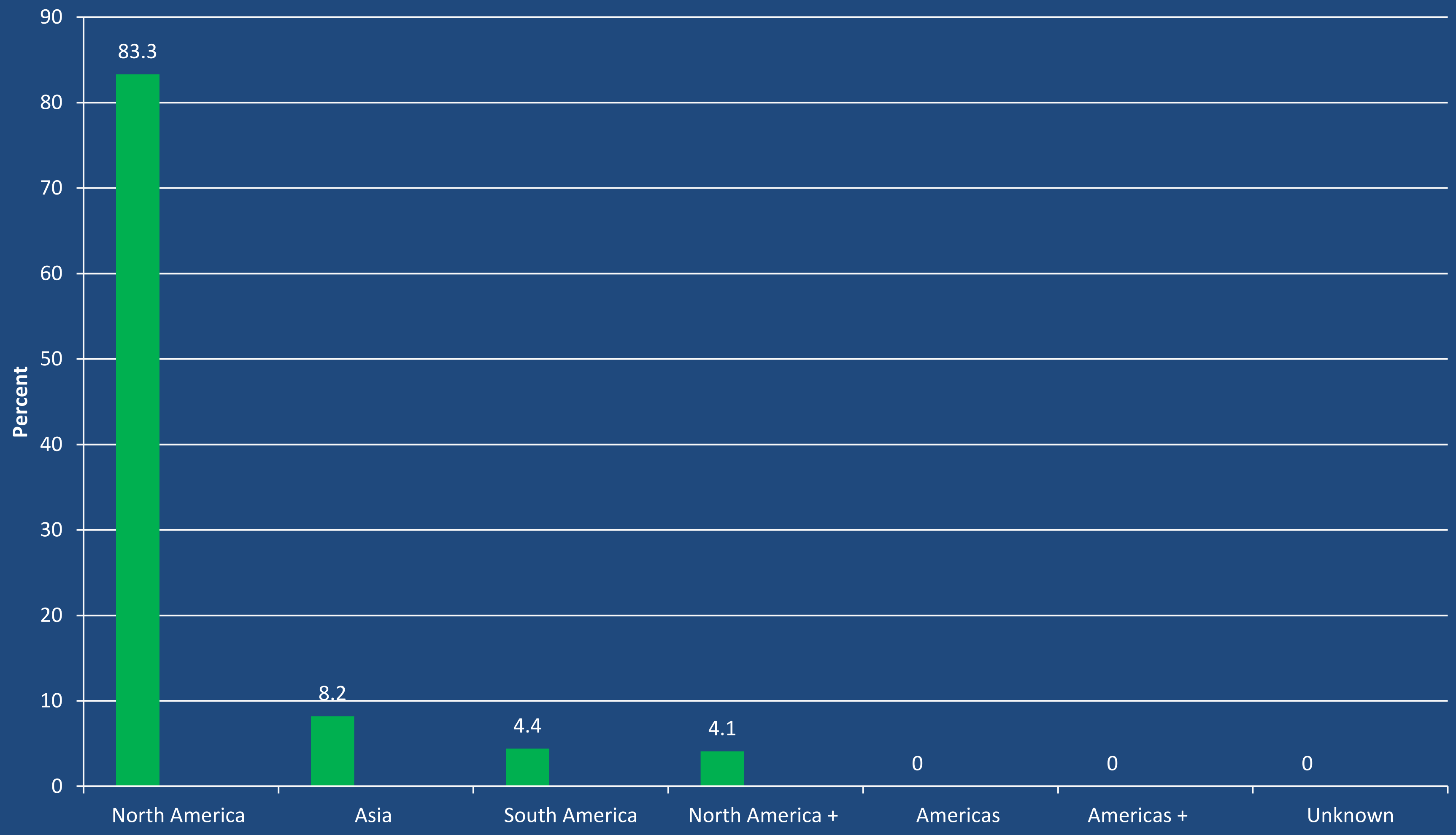
- An analysis of trees in the city of Baton Rouge, LA, reveals that this area has about **1,036,175** trees with tree and shrub canopies that cover **44.6 %** percent of the city.

Tree Characteristics

Baton Rouge Urban Forest



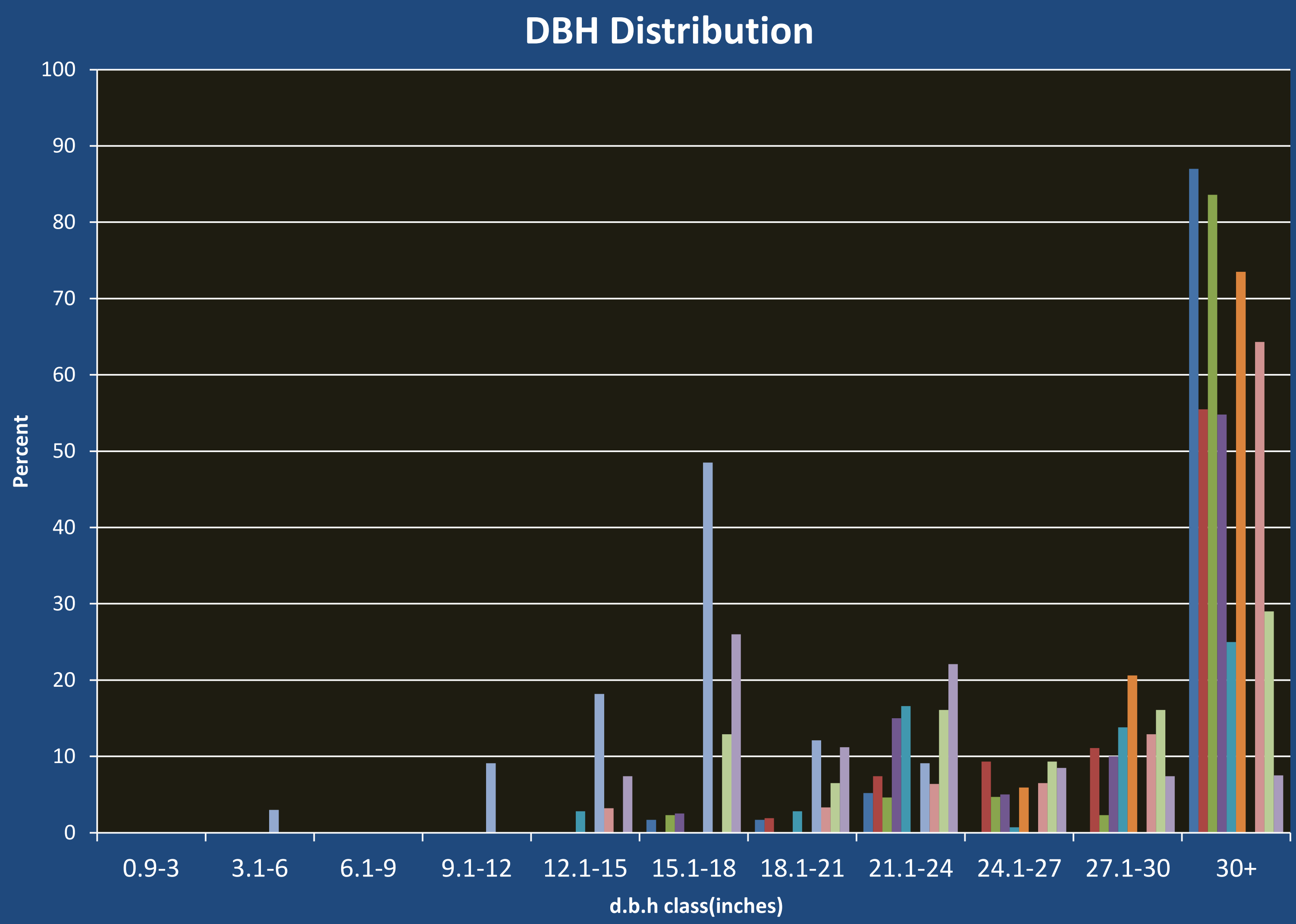
PERCENT NATIVE LIVE TREE SPECIES FOR THE CITY OF BATON ROUGE



+ native to North America and one other continent, excluding South America

++ native to North America and South America, and one other continent

DBH Distribution top 10 Tree Species



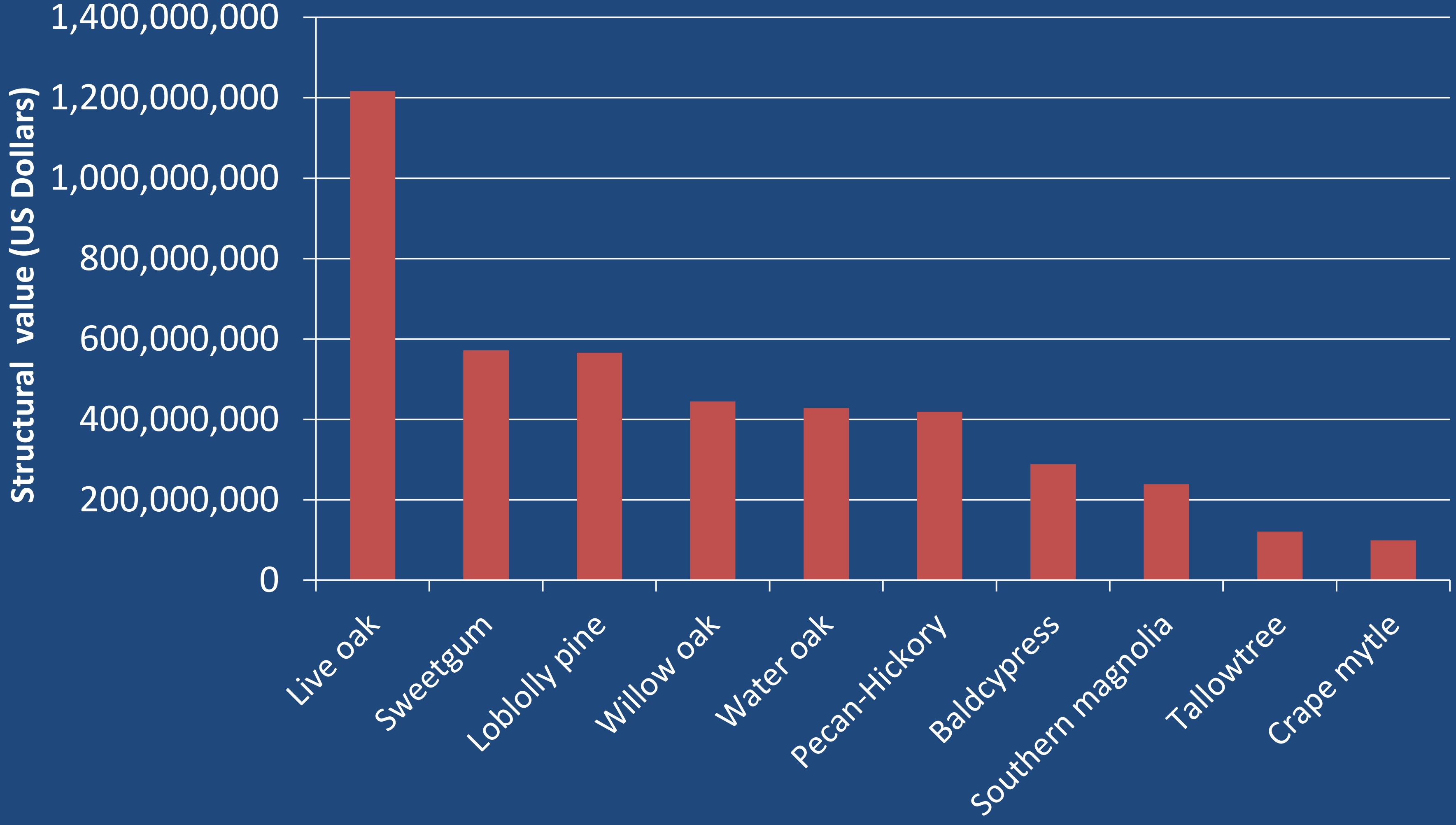
Structural Values

- **Structural Values Based on the Tree itself (e.g., the cost of having to replace the tree with a similar tree).**
  - **ISA Method Replacement Value**

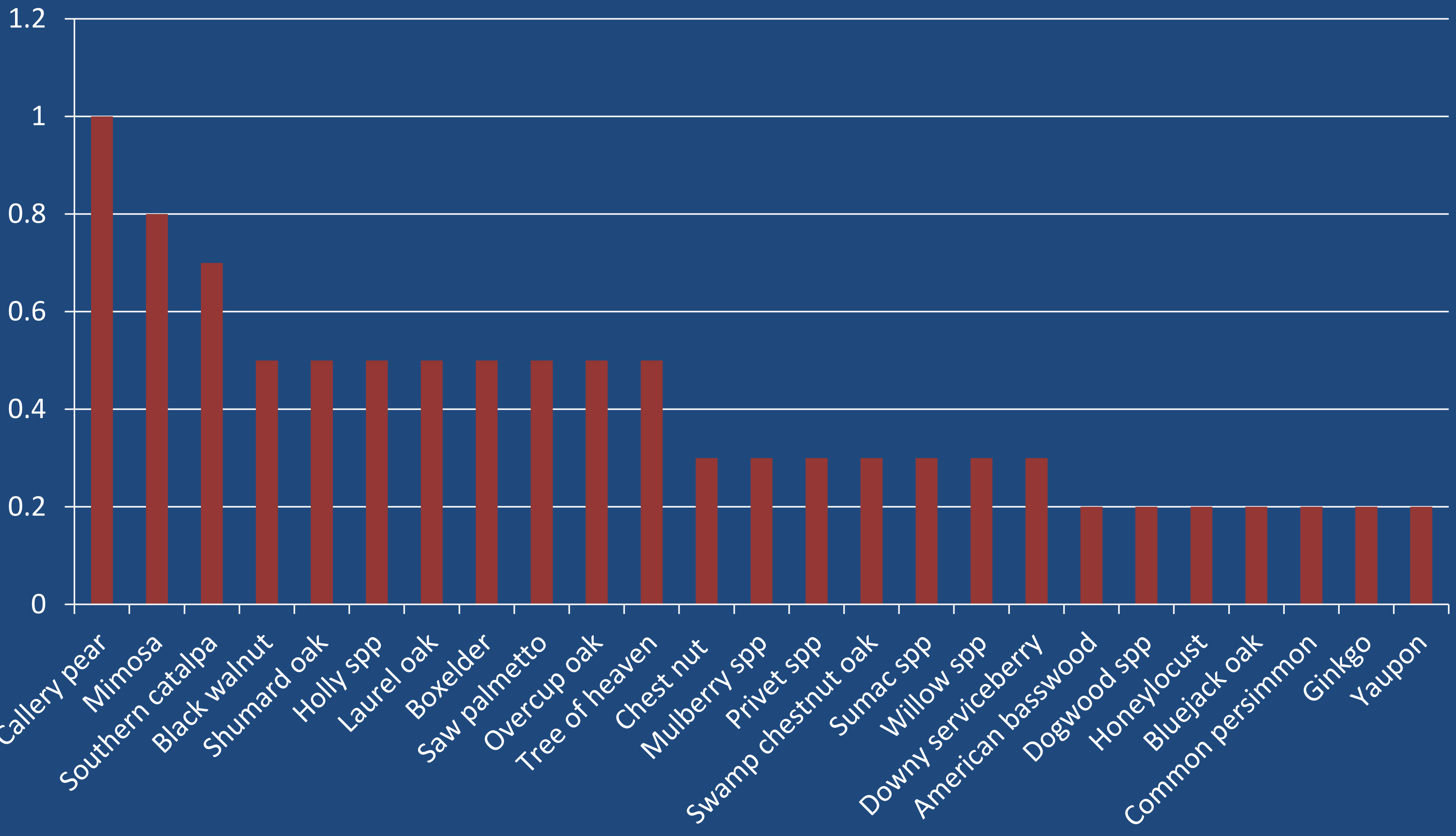
The structural value of the trees is estimated at

$ 6.2 billion.

Structural Value of top 10 Tree Species

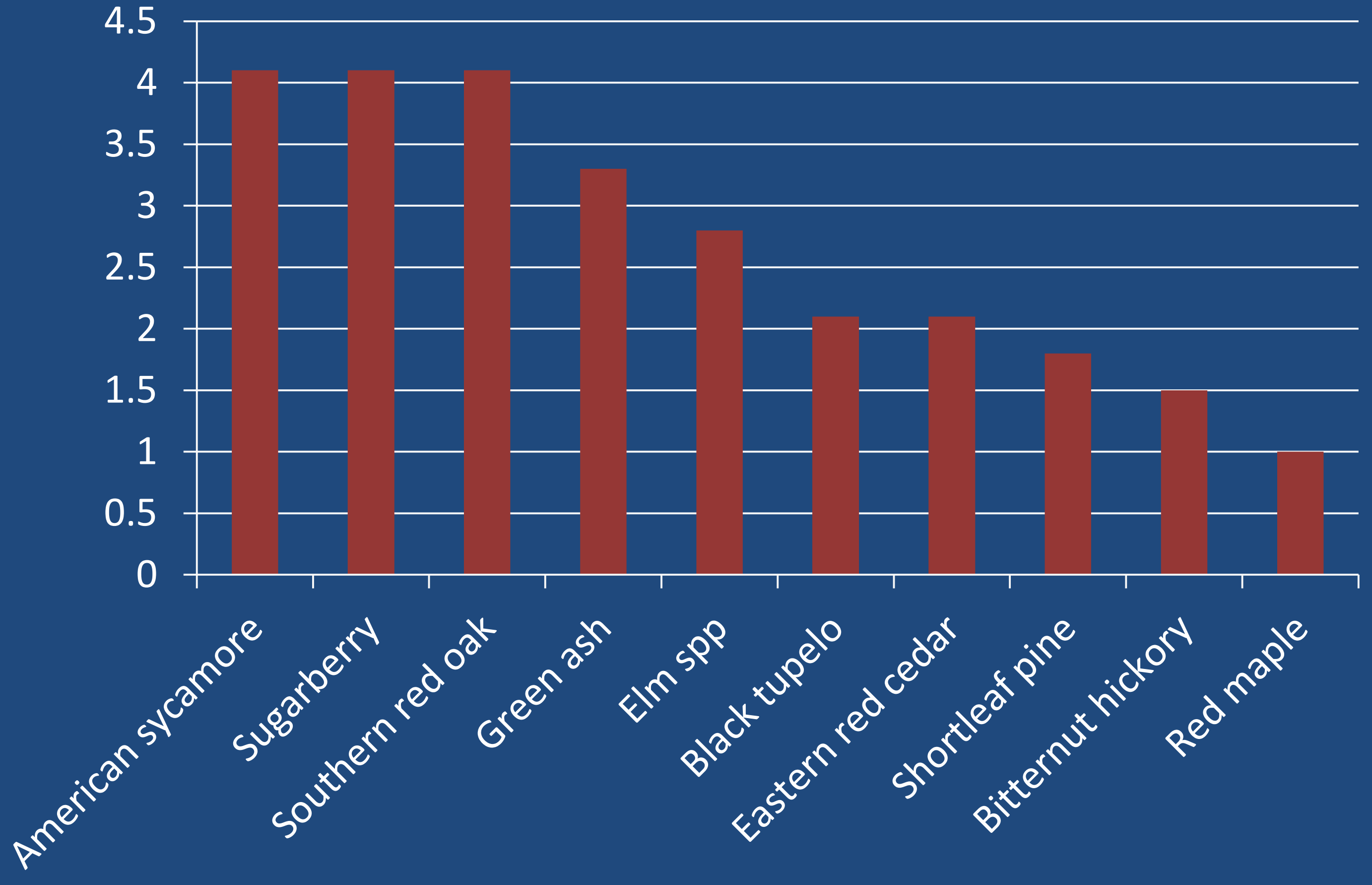


Structural Value of other Tree Species in Baton Rouge ($ Millions)



Structural Value of Tree Species in Baton Rouge

($ Million)



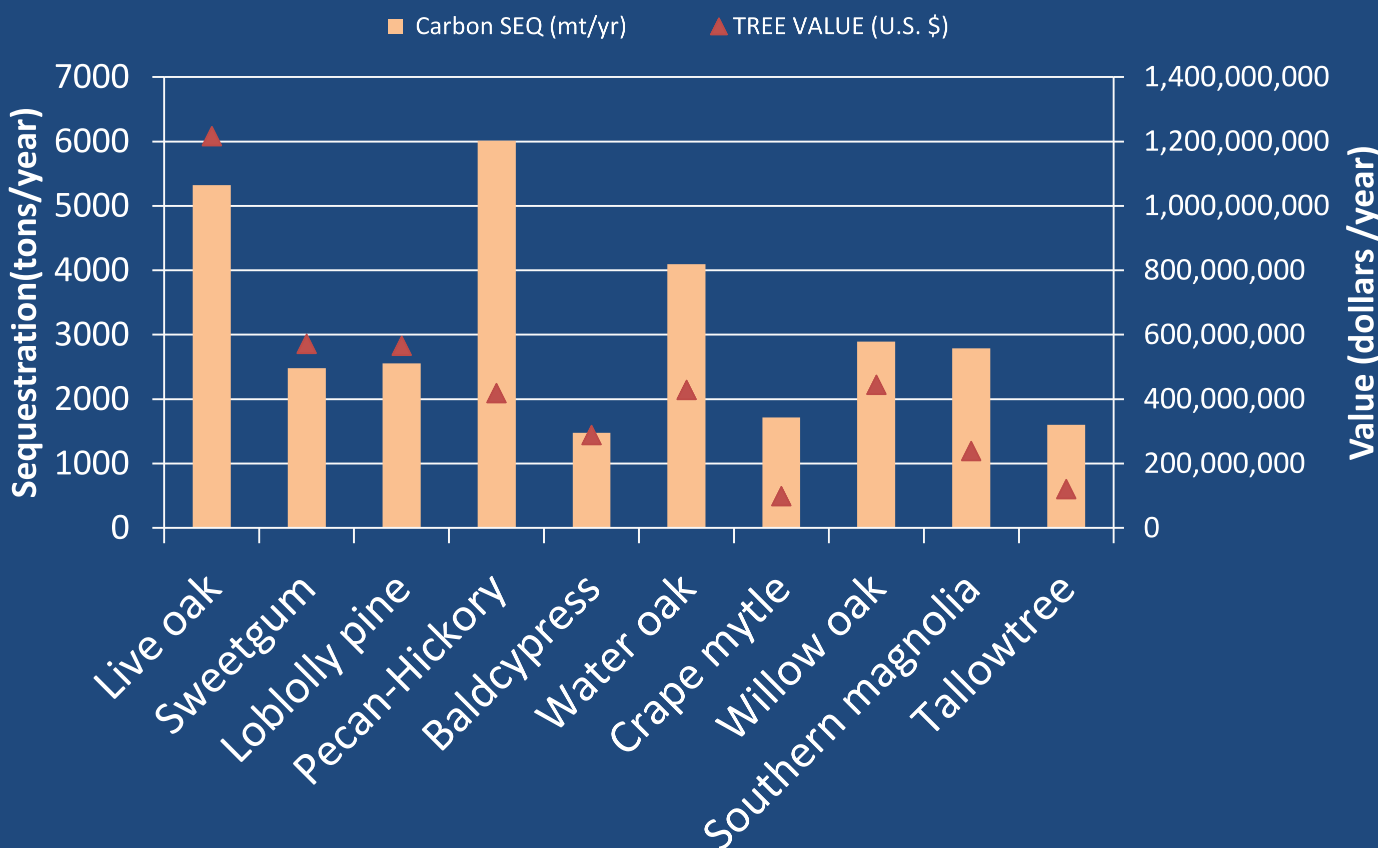
Functional Values

- Annual Functional Values:
  - Carbon Sequestration
  - Pollution Removal
  - Reduced energy costs

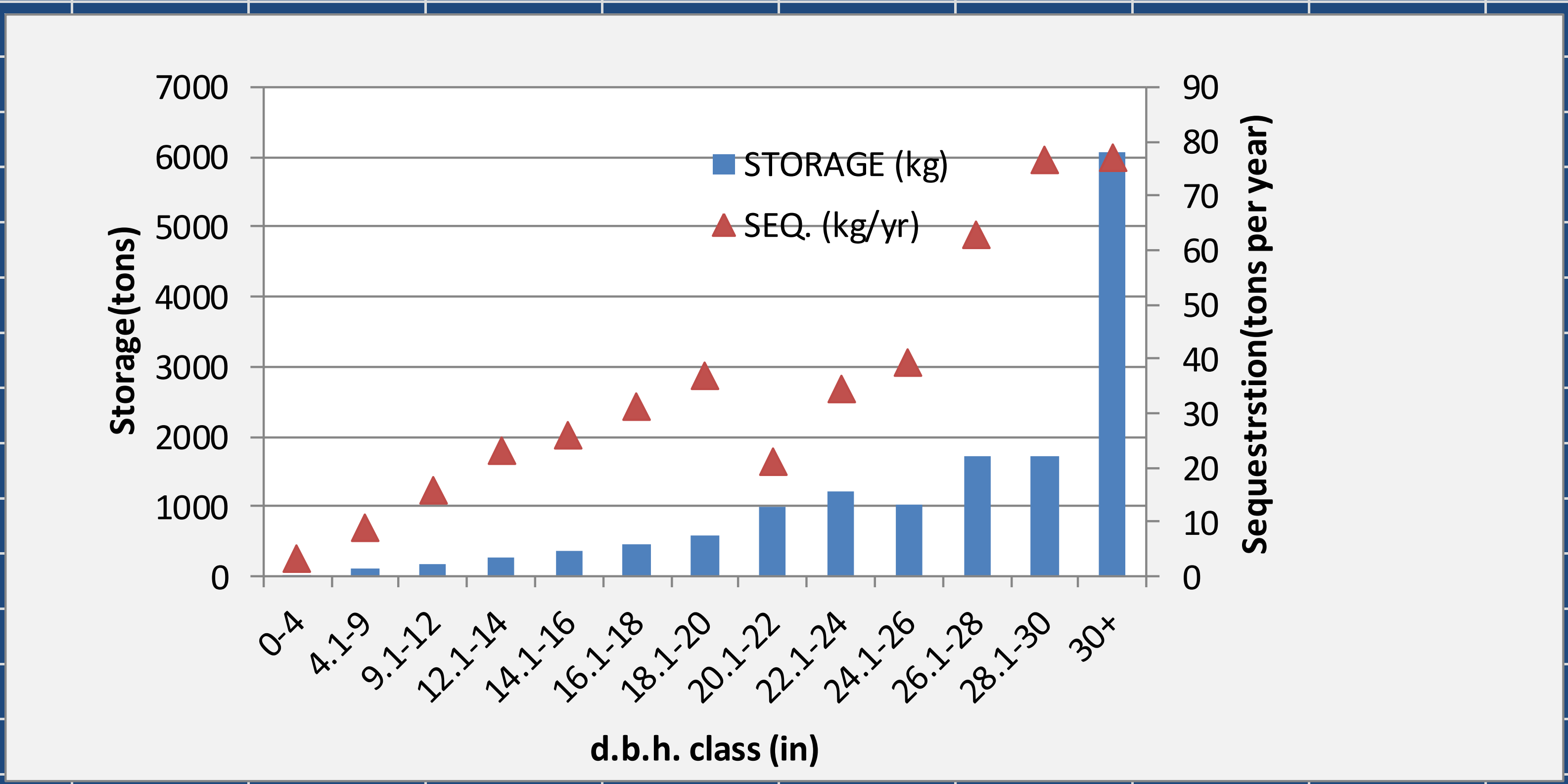
Carbon Sequestration

- **Trees in Baton Rouge remove about 48,699.38 tons of carbon per year (178,354. tons CO_2/year)**
  ($1.1 million per year)

Carbon Sequestration by Tree Species



Carbon Storage and Sequestration by DBH class

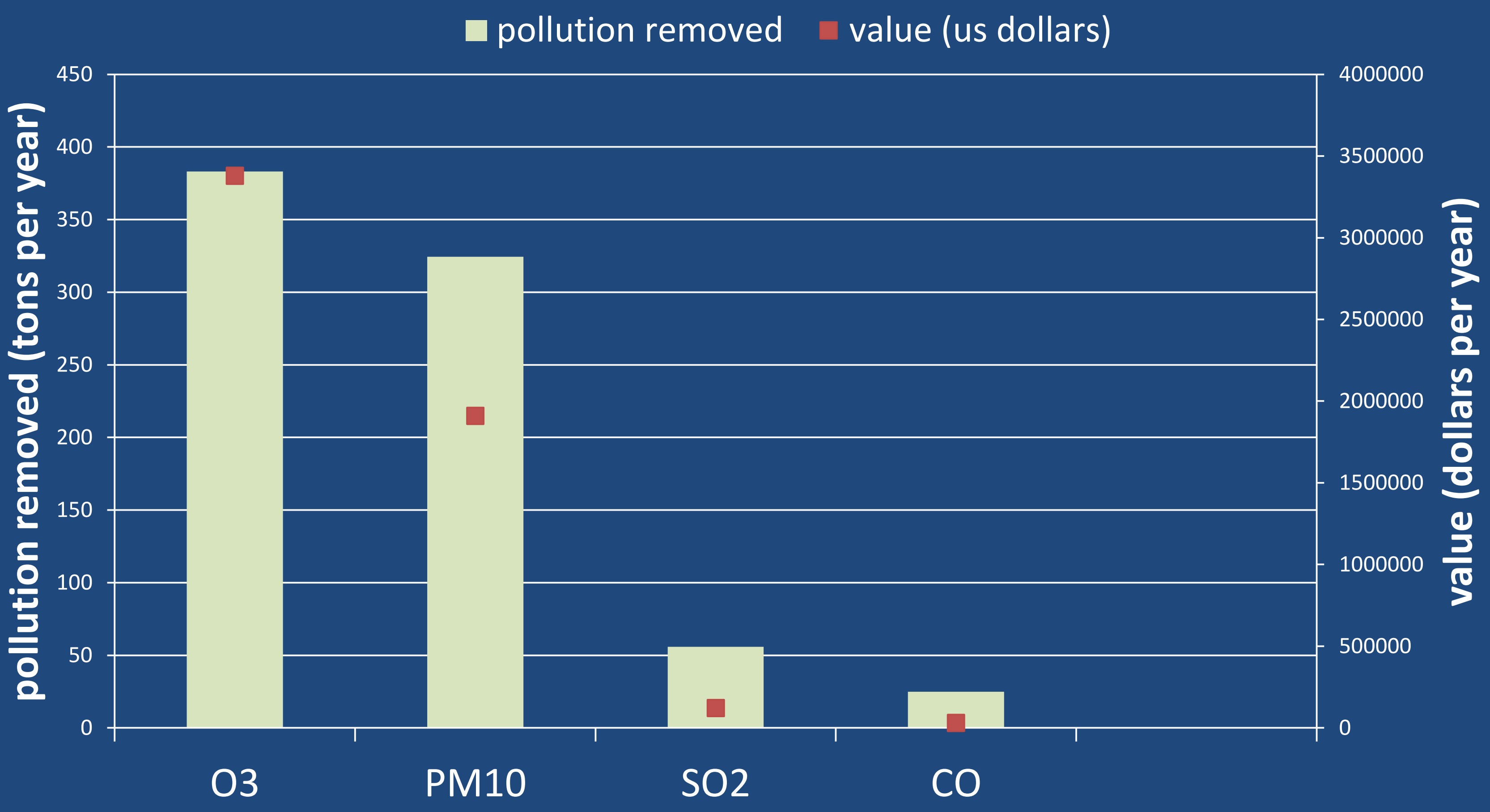


Carbon Storage ($)

- **Trees in Baton Rouge currently store about 2,029,342.2 tons of carbon with an associated estimated value of**

$ 41.0 Million

Pollution Removal by Trees in Baton Rouge ($6.86 million annually)



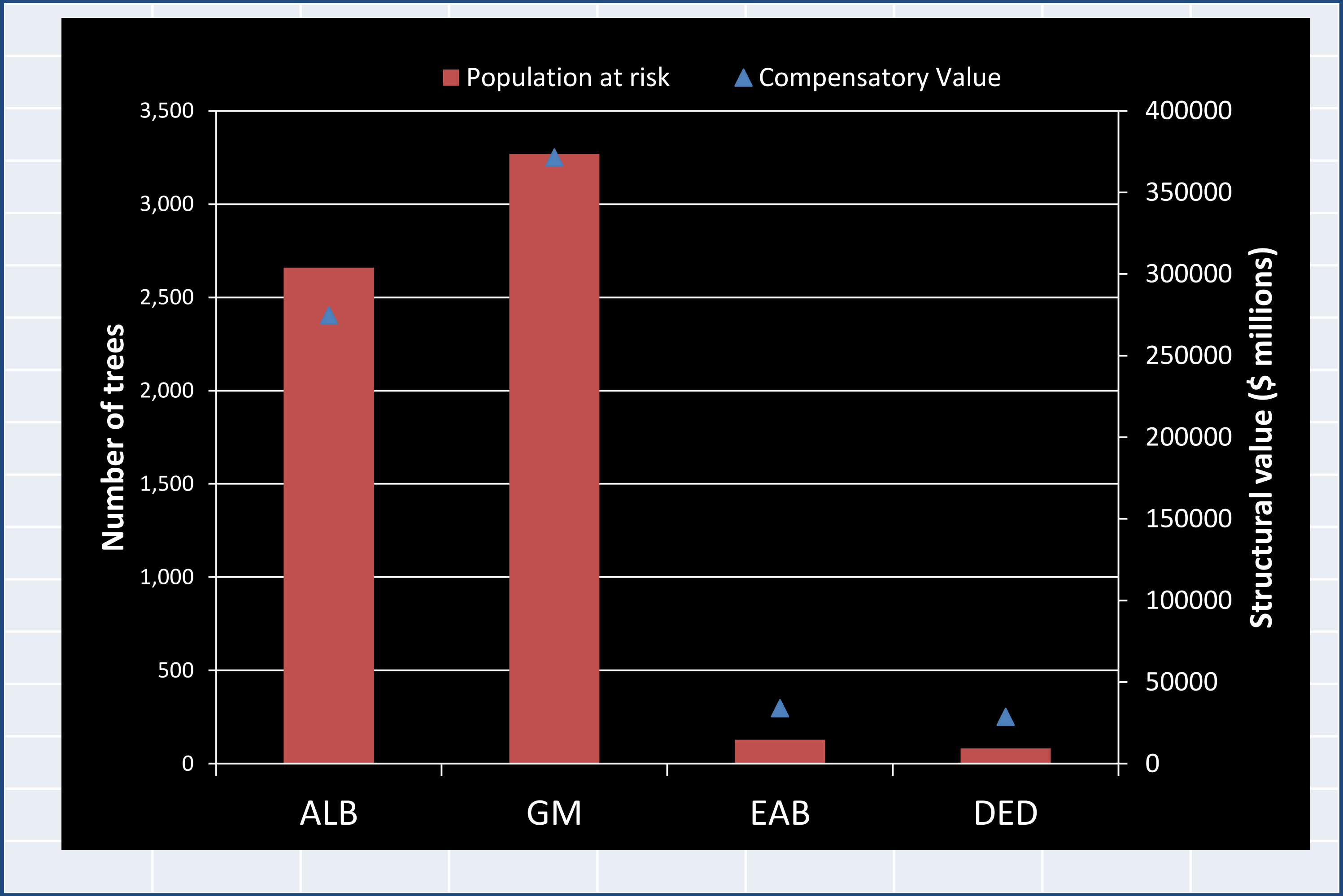
Annual savings(US$) in residential energy expenditures during heating and cooling

Trees in Baton Rouge are estimated to reduce annual residential energy costs by $8.0 million annually.

Annual savings(US$) in residential energy expenditures during heating and cooling seasons								
	Heating		Cooling		Total			
MBTUa	-1566978		n/a		-1566978			
MWHb	-1064146		12877518		121843372			
Carbon avoided	-1830710		2231445		400735			

[a]Million British Thermal Units	
[b]Megawatt-hour	

Potential Insect and Disease Impacts (Asian longhorn beetle (ALB), gypsy moth (GM), emerald ash borer (EAB), and Dutch elm disease (DED)



Summary
Structural and Functional Values
Post-Hurricane Gustav

- **Structural Values: $6.2 Billion**
- **Carbon Storage: $ 41.0 Million**

- **Annual Functional Values:**
  - **Carbon Sequestration : $1.1 million annually**
  - **Pollution Removal: $6.86 million annually**
  - **Reduced energy costs: $8.0 million annually**

SUMMARY

An analysis of trees in the city of Baton Rouge, LA, reveals that this area has about 1,036,175 trees with tree and shrub canopies that cover 44.6 % percent of the city. The most common tree species are live oak, sweet gum, loblolly pine, pecan, bald cypress and water oak. Trees in the City of Baton Rouge currently store about 2,029,342.2 tons of carbon per year with an associated estimated value of $ 41.0 million . In addition, these trees remove about 48699.38 tons of carbon per year (178354. tons CO_2/year) (($1.1 million per year). Baton Rouge's trees are estimated to reduce annual residential energy costs by $8.0 million annually. The structural value of the trees is estimated at $ 6.2 billion. Information on the structure and functions of the urban forest can be used to inform urban forest management programs and to integrate urban forests within plans to improve environmental quality in the city of Baton Rouge.

Abstract

Hurricane Gustav was the second most destructive hurricane of the 2008 Atlantic hurricane season. In Baton Rouge, Louisiana the wind damage from Gustav was the worst of any storm in memory. Thousands of urban forest trees were uprooted and snapped in half by Gustav's fierce winds. The damage was severe enough to effectively shut the city down for over a week. A post hurricane analysis of the Baton Rouge's urban forest ecosystem was conducted using i-Tree Eco software application and based on the Urban Forest Effects Model (UFORE). The analysis revealed that this area has about 1,036,175 trees with tree canopies that cover 44.6 % percent of the city. The analysis reveals a significant tree canopy reduction. The city has more than 45 tree species. The most common tree species are Quercus virginiana (9.5%), *Liquidambar styraciflua* (8.8%), *Pinus taeda* (7.0%), *Carya spp*. (6.5%), *Taxodium distihum* (5.9%), *Quercus nigra* (5.6%), *Quercus phellos* (5.1%), *Magnolia grandiflora* (5.1%), and *Lagerstroemia indica* (5.4%). Trees are currently store about 2 million tons of carbon per year with an associated estimated value of $ 41 million per year. In addition, these trees remove about 178,354 tons of CO2 per year with an associated estimated value of $1.1 million per year. Baton Rouge's trees are estimated to reduce annual residential energy costs by $8.0 million annually and reduce air pollution (ozone, particulate matter, sulfur dioxide, and nitrogen dioxide) by 860 tons per year with an associated estimated value of $6.2 million per year. The structural value of the trees is estimated at $ 6.2 billion. With the increase in climate variability, increased frequency and intensity of storms, and urbanization pressure, more trees need to be planted and maintained to sustain the current level of structural values and ecological services.

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- i-Tree Eco
- Application Overview
- Complete Inventory
- Sample Inventory
- International
- Eco v5 - v6 Considerations
- Acknowledgements
- Eco FAQs
- System Requirements

i-Tree Eco

i-Tree Eco v6 overview

Eco v6 is a model that uses tree measurements and other data to estimate ecosystem services and structural characteristics of the urban or rural forest. Eco is a complete package that provides:

- **Sampling and data collection protocols** - For plot-based sample projects, total population estimates and standard error of estimates are calculated based on sampling protocols. For complete inventories, eco calculates values for each tree.
- **Flexible data collection options** – Use the mobile data collection system with web-enabled smartphones, tablets or traditional paper sheets.
- **Automated processing** - A central computing engine that makes estimates of the forest effects based on peer-reviewed scientific equations to predict environmental and economic benefits.
- **Reports** - Summary reports that include charts, tables and a written report.

Eco model basics

How does Eco work?

Tree measuremen ... co application either by web form or by manual data entry, they are me ... with local preprocessed hourly weather and air pollution concentration data. These