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# The influence of urban forest structure on function

## A case study of urban forest carbon storage in Miami-Dade County, Florida

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### Introduction

Global warming is one of the most serious concerns of our generation. Increases in the level of carbon dioxide (CO<sub>2</sub>) are considered the major source of global warming. This increasing CO<sub>2</sub> level is widely believed to be caused by human activities, for example CO<sub>2</sub> emissions from the burning of fossil fuels. The influence of increasing CO<sub>2</sub> on climate change is very strong, especially in urban areas.

Cities are important nodes of human activity. In 2000 more than 47% of the world's population lived in cities, and 10% of these lived in megacities of 10 million or more. By 2025 it is projected that nearly two thirds of the world's population will live in cities, and tropical countries have the highest rate of urbanization. How to reduce urban atmospheric CO<sub>2</sub> concentration is a big challenge for managing the urban environment.

New opportunities to reduce greenhouse gas emissions have been implemented, including tree planting, which can be an important tool. Urban forests can reduce atmospheric C levels through growth processes, decreasing building cooling demand by shading and evapotranspiration, and urban forest soil can storage much carbon.

Urban forest characteristics are influenced by both human and environmental factors, which in turn influence urban forest carbon storage function. While carbon storage function has been studied in natural areas, not much is known about carbon storage function in urban forests, which may differ due to variances in forest composition and structure.

The objectives of this study were to:

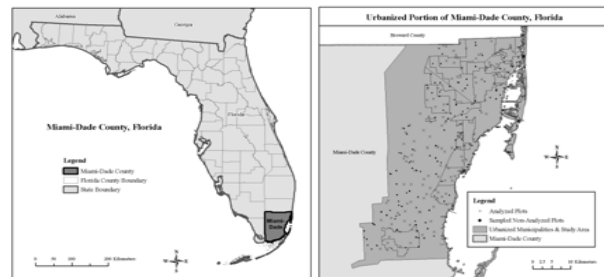
- (1) analyze the urban forest structure of Miami-Dade County,
- (2) quantify carbon storage in an urban forest.

Results from this study can be used to help manage urban forests and promote the potential role of urban forests in reducing atmospheric CO<sub>2</sub>.

### Methods

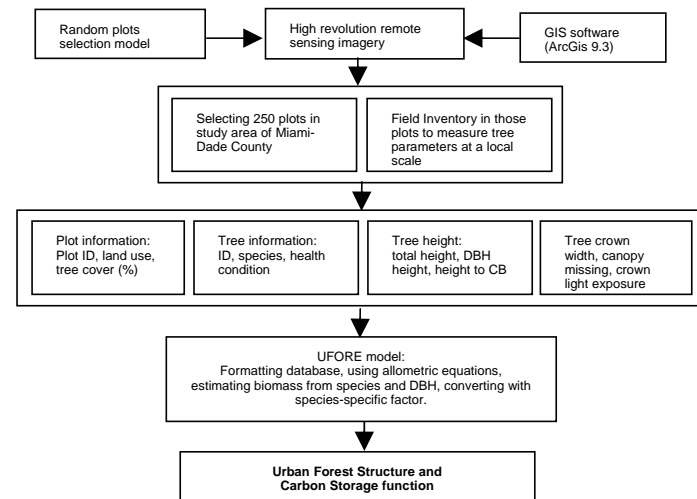
#### Study area

The study area encompassed 1273 km<sup>2</sup> of the urbanized portion of Miami-Dade County centered at 25° N and 80° W. Miami-Dade has a humid subtropical and tropical climate with mean annual precipitation of 147 cm and average maximum and minimum temperature of 28 °C and 20°C. Population density increased by 19% from 1980-1990, 16% from 1990-2000, and 7% from 2000-2006.



General location map and map of the urbanized portion of the Miami-Dade County study area.

### Using The Urban Forest Function Model (UFORE)



Step 1: Define the study area using remote sensing and GIS tools.

Step 2: Define the plots (circles with 37.2 ft radius) where field inventory will occur; locate on aerial photographs.

Step 3: Field data collection, including plot land use and tree biotic characteristics.

Step 4: Format field data according to UFORE model requirements and run the model.

Step 5: Analyze the results.



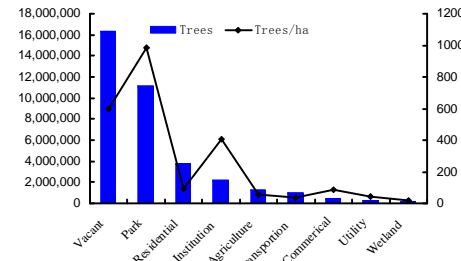
Left: Plot 30 location on an aerial photograph. A UFORE project typically begins with digital aerial photographs and land use maps of the study area. Digital versions of aerial photographs can greatly simplify and speed up the sampling process. A computer program is used to randomly select and located plots.



Below: Field inventory. UFORE requires that a set of basic measurements be made on each plot, which includes a GPS of plot locations, the type of cover on the ground, man made objects on the ground, tree species present, DBH, etc. All information is handwritten on data sheets and later entered into UFORE via a specially developed data input program.

### Results

#### Urban Forest Composition



There were 36,697,571 trees in the study area, and the number of trees per ha (tree density) varied considerably among different land uses.

#### Tree Health Status

##### Percent of tree health status by land use category

Land use	Trees Health Status (%)			
	Good	Medium	Poor	Dead or Dying
Agricultural	91.7	5.2	1	2
Commercial	94.6	1.8	0	3.6
Institution	55.4	11.3	13.1	20.2
Park	89.6	3	3	4.4
Residential	89	3.8	1.7	5.4
Transportation	100	0	0	0
Utility	100	0	0	0
Vacant	17.2	81.6	0.2	1
Wetland/Water	100	0	0	0
<b>Total</b>	<b>55.7</b>	<b>38.5</b>	<b>2</b>	<b>3.8</b>

Many trees were in good condition (55.7%) and many of the good condition trees were located in transportation and utility areas. Only 3.8% of the trees were dead or dying, and most of them were located in institution and residential areas.

#### Tree Size Structure

63.7% of the trees were smaller than 7.6 cm DBH, and many of the smaller trees were located in the park area. Most of the larger trees were in agricultural, commercial, and residential areas (DBH>30.6 cm).

##### The percent of tree DBH class distributions in different land use categories in Miami-Dade County, USA

Land use	DBH (cm)				
	2.5-7.6	7.7-15.2	15.3-30.5	30.6-61	>61
Agricultural	29.9	29.8	19.6	18.7	2.1
Commercial	25	39.3	17.8	17.9	0
Institution	37.1	41.8	18.3	2.8	0
Park	83.9	9	3.9	2.2	1
Residential	40	22.3	20.3	14.5	3
Transportation	23.5	23.5	41.2	11.8	0
Utility	0	40	60	0	0
Vacant	66.3	28.8	3.3	1.4	0.2
Wetland/Water	60	0	40	0	0
<b>Mean</b>	<b>63.7</b>	<b>22.8</b>	<b>8.5</b>	<b>4.2</b>	<b>0.7</b>

### Carbon Storage

Total carbon storage by Miami-Dade County urban forests was estimated at 1.5×10<sup>6</sup> t C (1 t=10<sup>3</sup>g), and carbon storage per hectare was 9.28 t C. Carbon storage varied largely by tree species, DBH classes, and land uses.

#### Number of trees, carbon storage, and carbon storage per tree by DBH class.

Objects	DBH class (cm)				
	2.5-7.6	7.7-15.2	15.3-30.5	30.6-61	>61
Number of trees	23,376,410	8,383,712	3,119,486	1,531,291	286,672
Percent (%)	63.70	22.85	8.50	4.17	0.78
C Storage (ton)	56,140	122,183	239,542	603,218	476,593
Percent (%)	3.75	8.16	15.99	40.28	31.82
C Storage/tree (t)	2.4	14.57	89.74	454.71	2,265.04

#### The number of trees, carbon storage, trees per hectare, and carbon density by land use categories in Miami-Dade County, USA

Land uses	Trees (n)	Percent %	C storage (t)	Percent %	Trees /ha	C (t/ha)
Commercial	489,811	1.33	48,972	3.27	87	8.65
Institution	2,245,610	6.12	78,052	5.21	405	14.07
Park	11,147,061	30.38	341,027	22.77	983	30.08
Residential	3,759,743	10.25	745,017	49.74	93	10.07
Transportation	978,268	2.67	100,275	6.70	38	3.91
Utility	252,662	0.69	10,131	0.68	41	1.65
Vacant	16,347,497	44.55	328,010	21.90	597	11.97
Wetland/Water	221,276	0.60	16,237	1.08	21	1.51
<b>Total/Mean</b>	<b>36,697,571</b>	<b>100</b>	<b>1,497,678</b>	<b>100</b>	<b>227</b>	<b>9.28</b>

### Implications

Urban forests are a tool to sequester atmospheric CO<sub>2</sub>

From this study, we can explore the following:

>The urban forest of Miami-Dade County has a large potential to store carbon in the near future, since most of the trees in Miami-Dade County are young trees, and the mean C storage per tree is increasing as the DBH becomes larger.

>Using this same method across different cities will provide an effective comparison of urban forest carbon storage function among cities, in the US or on a global scale.

>Choosing the proper species will improve urban forest carbon storage in Miami-Dade County. Meanwhile, improving urban forest biodiversity through increasing urban forest layers (including grasses, shrubs, and trees) is also an important way to improve carbon storage in urban areas.

>Planting new trees will be very important to maintain urban forest carbon storage. Appropriate planting and maintenance of trees is needed to ensure longer productive lifespan and to avoid C release.

### Acknowledgements

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