LESSONS LEARNED: APPLYING I-TREE FOR RESEARCH, MANAGEMENT AND EDUCATION INTERNATIONALLY

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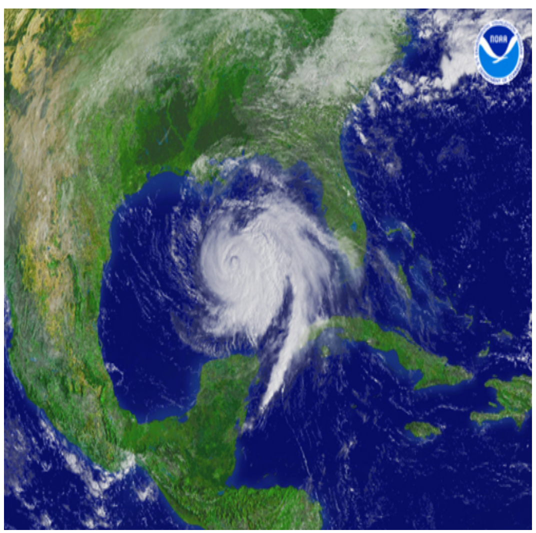
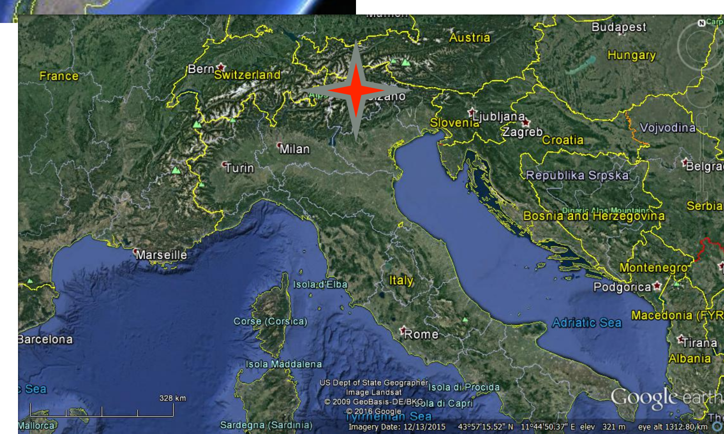


Presentation Overview

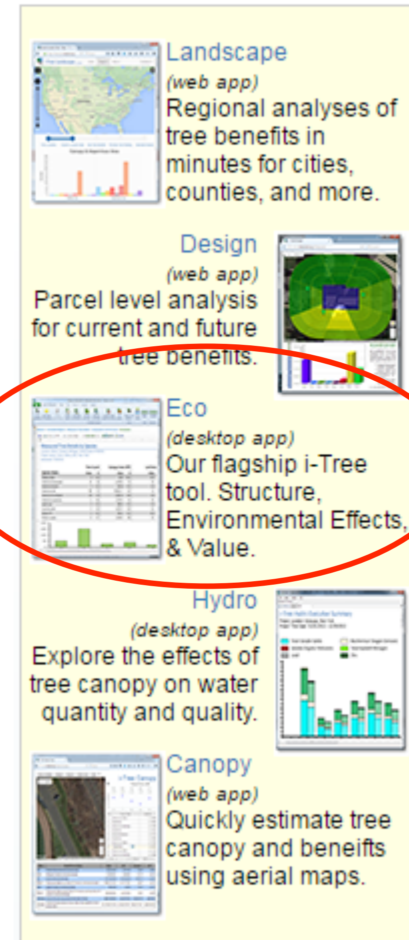
1. Objective overview
2. Research, Teaching, Extension examples:
   - ✓ *Case studies: Texas & Florida US, Chile, Puerto Rico, Italy*
   - ✓ *Adapting i-Tree process to context*
3. Certainty
   - ✓ *Quantitative and Political (Governance)*
4. +/- of i-Tree



https://www.itreetools.org/

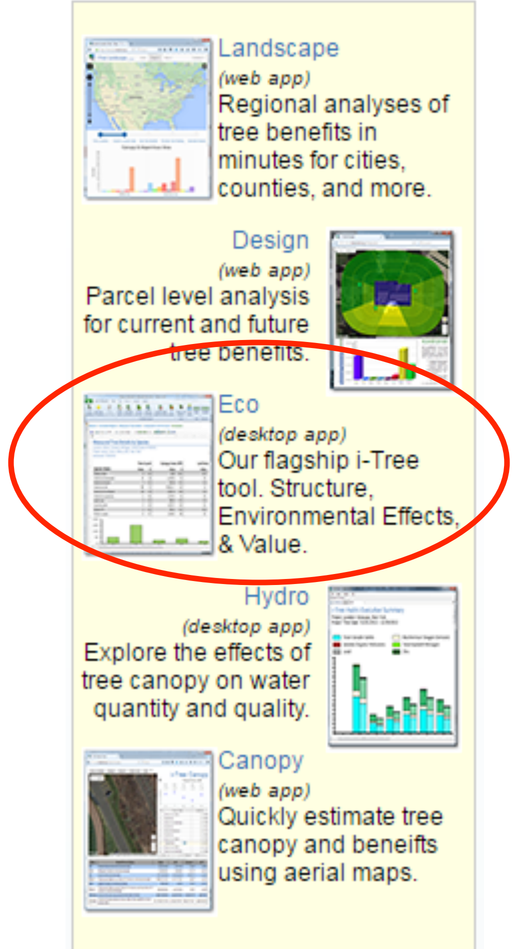
i-Tree
Tools for Assessing and Managing
Forests & Community Trees

- Suite of Softwares and Tools
  - UFORE > ECO; STRATUM -> STREETS
  - MCTI, SDAP gone,
  - Now has Canopy, Hydro, Landscape
- Will focus on ECO (previously UFORE)
  1. UFORE is model and ECO the interface
  2. Monitoring, Inventory and Sampling protocol
  3. Urban Forest Structural and Services model
  4. Systems level look at the "urban forest"
- Also discuss STREETS and Canopy



i-Tree Background

- 1990s-2005: Originally tree- air quality models
  - 2 different USDA Forest Service Research Units: (Davis CA and Syracuse NY)
- Mid 2000s: Were “forced” to collaborate; i-Tree (UFORE/ ECO, STREETS/ STRATUM, etc)
- 2006-2015: Slowly being modified for users and international applications
  - “Cooperative”: Arbor Day Found. SMA, ISA, Casey Trees
  - Science- D. Nowak, USFS; Marketing- S. Maco, Davey Resource Group
- 2016: USDA National Forest Inventory and Analysis (FIA) Program has “fused” with i-Tree
Available “datamart” and potential model improvements



Extension (Community Education)

- Florida, USA in 2008-2009: 4 “Train the Trainer” Workshops (45 participants)
  - **Tampa**: Results integrated into municipal urban forest management plan and sustainability indicators
  - **Pensacola**: Results for Q. virginiana protection ordinance
  - **Orlando** (2010): *“Because STREETS and ECO…accepted as valid….after 4 years of austere cuts…. even fire and police departments suffered some losses; Forestry exception…budget …. was doubled in direct response to the presentation to mayor on value of trees..”*
- Chile 2011: 2 workshop at University of Concepcion (25 participants); post-tsunami

i-Tree Teaching

University of Florida:

- 1 PhD, 5 MS Graduate Student projects
  - Hurricane assessments, growth-mortality, urban forest ecosystem service indices, urban soil quality, carbon offsets, invasives
- 4th year Undergraduate Urban Forestry
  - 2009-2015: STREETS, Canopy, ECO, STORMS
  - Annual urban forest /street tree management plan term project

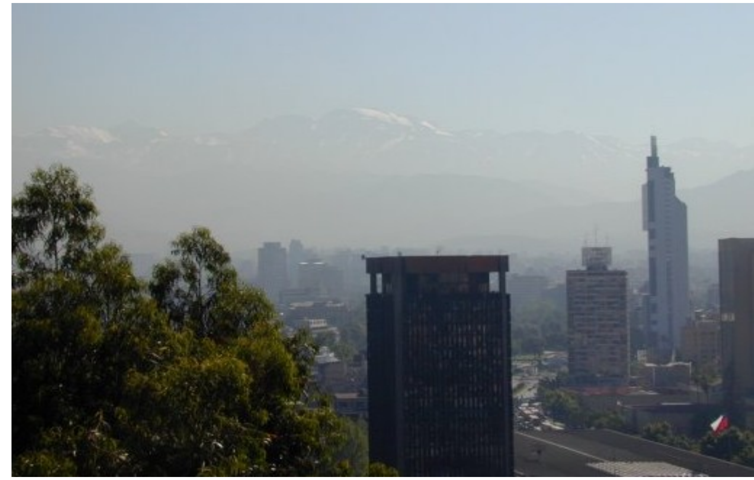
University of Chile: Post-graduate Urban Ecology Course (2012-2013)

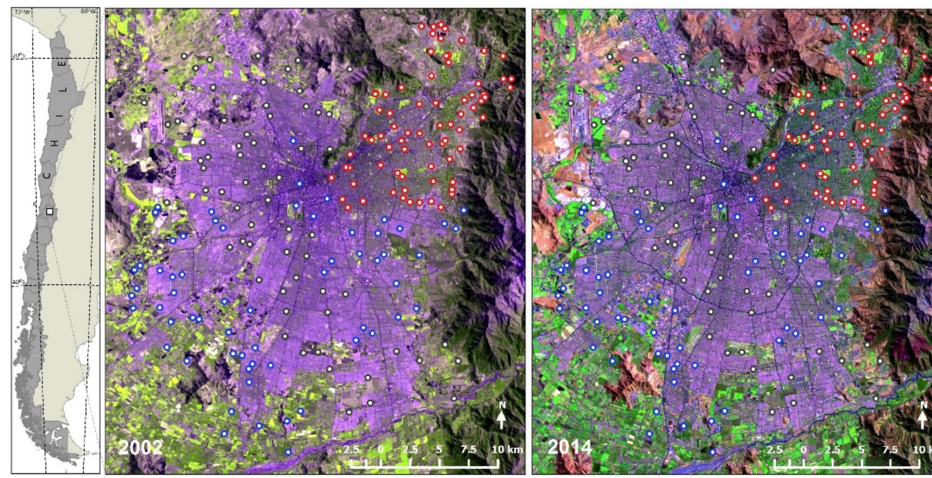
  - Municipality and Ministry Employees

Adapting UFORE 2002

- Southern hemisphere
- Trees, shrubs, grasses
- Cost-effectiveness analysis
- Remeasurements 2014

- Results used in National Particulate matter compensation program





Urban Forests and particulate matter (PM) in Santiago, Chile (2002-2014)

Escobedo, et al. 2008. Analyzing the cost-effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. Journal of Environmental Management, 86: 148-157

Orlando, Florida US

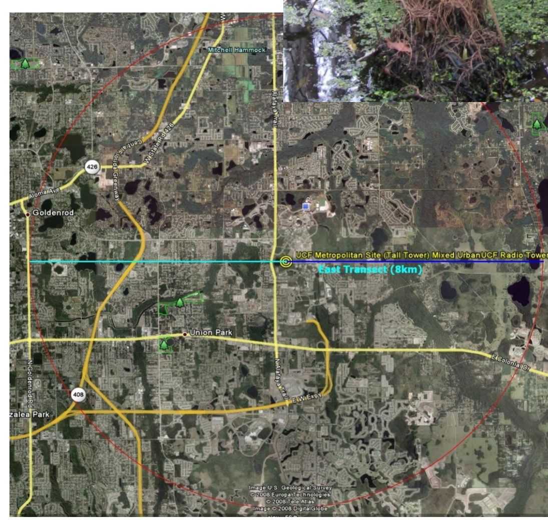
i-TREE STREETS 2007

Reference city

i-Tree ECO 2008-2010

Ideal situation

- Planners-foresters involved in process
- Surveys- Carbon emissions from maintenance
- Carbon in palms, native-invasive trees



Horn, et al.,. 2015. The role of composition, invasives, and maintenance emissions on urban forest carbon stocks. Environmental Management, 55:431–442.

Adapting to Subtropics: 2008-2009 Miami-Dade County, USA

i-Tree ECO

Little Interest

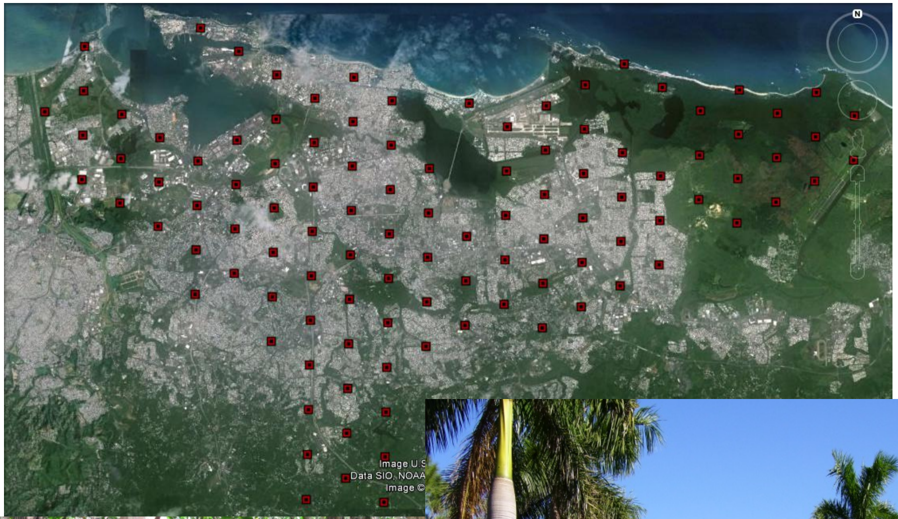
-Research Focus

-Problems:

- Quarter plots with expansion factor (shrubs/invasives)
- Palm/monocots measurements
- Dieback

San Juan Puerto Rico 2001-2011

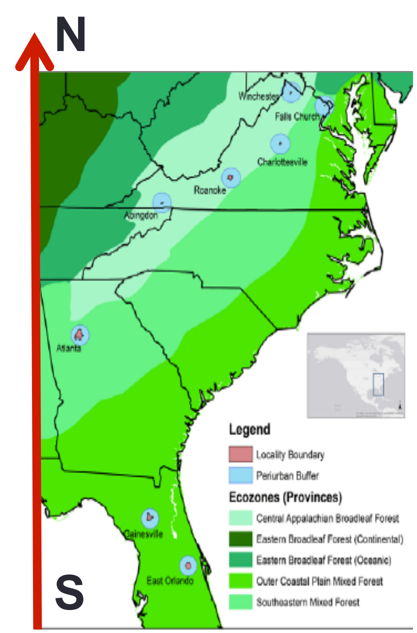
- Coastal, Subtropical moist forests
- High pop.- bldg. densities, access /safety issues
- **High woody plant - palm diversity**
- **Palms, mangroves**
- Crown width> height
  - Leaf area/ LAI
- Energy use savings!



Use is Addressing Other Regional-Local Issues

Are Urban Tree Species the Same across SE US? (2016; n= 8 cities)

- Tree species composition more dissimilar along latitude than between Urban and Peri-urban forests
- Crown-diameter allometric equations



What drives changes in Gainesville's urban forest?

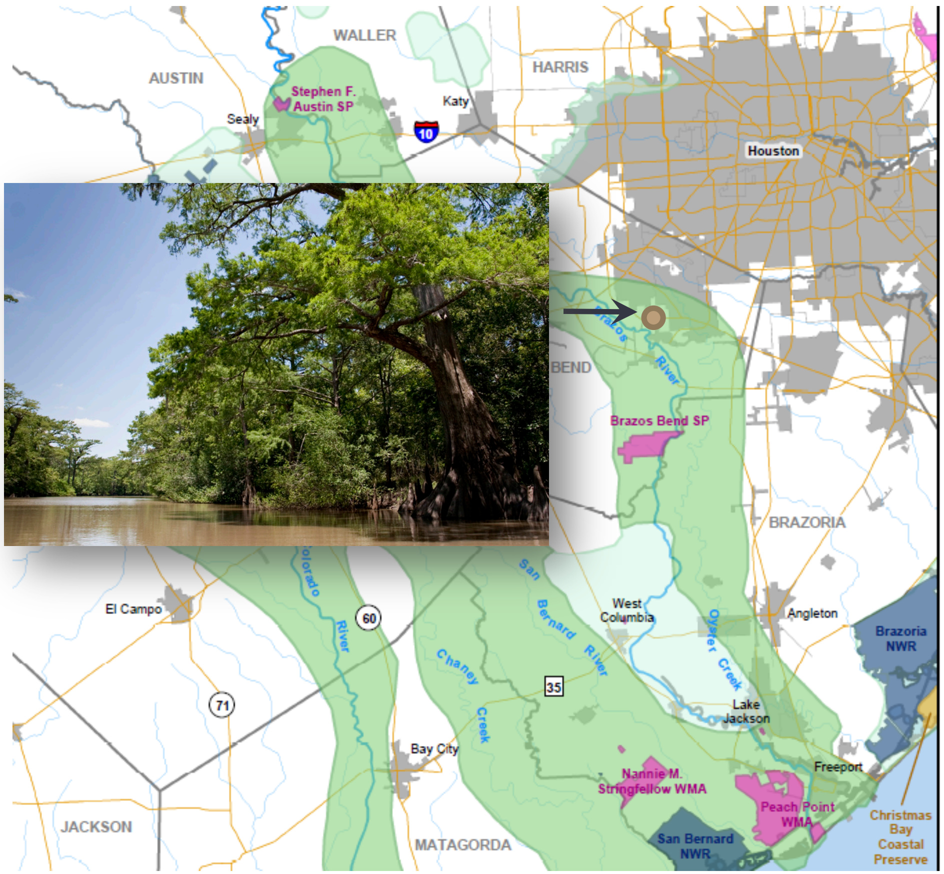
Determinates of tree mortality:

- Softwoods: tree density
- Hardwoods: landuse, %grass, tree density
- Less tree growth = > tree density and soil P

Blood, A. et al., 2016. How Do Urban Forests Compare? Tree Diversity in Urban and Periurban Forests of the Southeastern US. Forests, 7(6), 120

“Proving” Peri-urban Reforestation is Cost-Effective in Mitigating Ozone Pollution

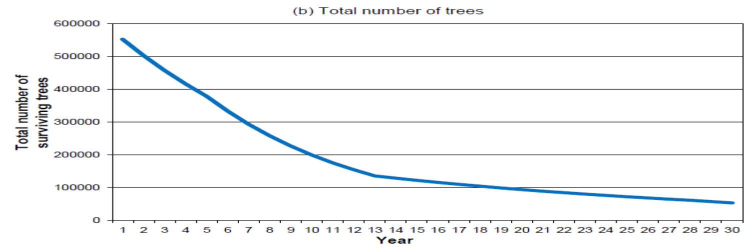
- 2004 US Environmental Protection Agency’s
  - Emerging measures and Voluntary State Implementation Plans for Ozone Control Policy
- Emerging measures (planting trees)- Allows greater uncertainty but must be:
  - *Additional,*
  - *Executable,*
  - *Quantifiable,*
  - *Permanent*

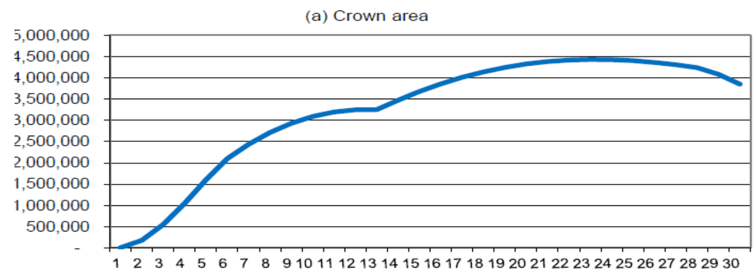


**Houston USA: NOx limited, Non-attainment area for ozone*
**405 ha hypothetical peri-urban reforestation of DOW chemical site*

Integrating Monitoring and Modelling

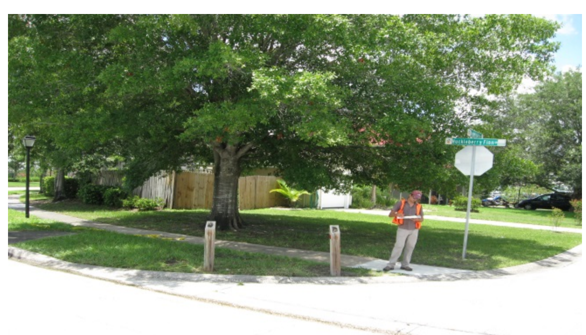
- Urban Forest Monitoring Plots Houston USA
  - *Measurements 2001& 2011*
    - *Temporal Mortality-Growth-Canopy Model 30 years*
  - *UFORE: Ozone and NO_2 removal*
  - *Reforestation Costs*



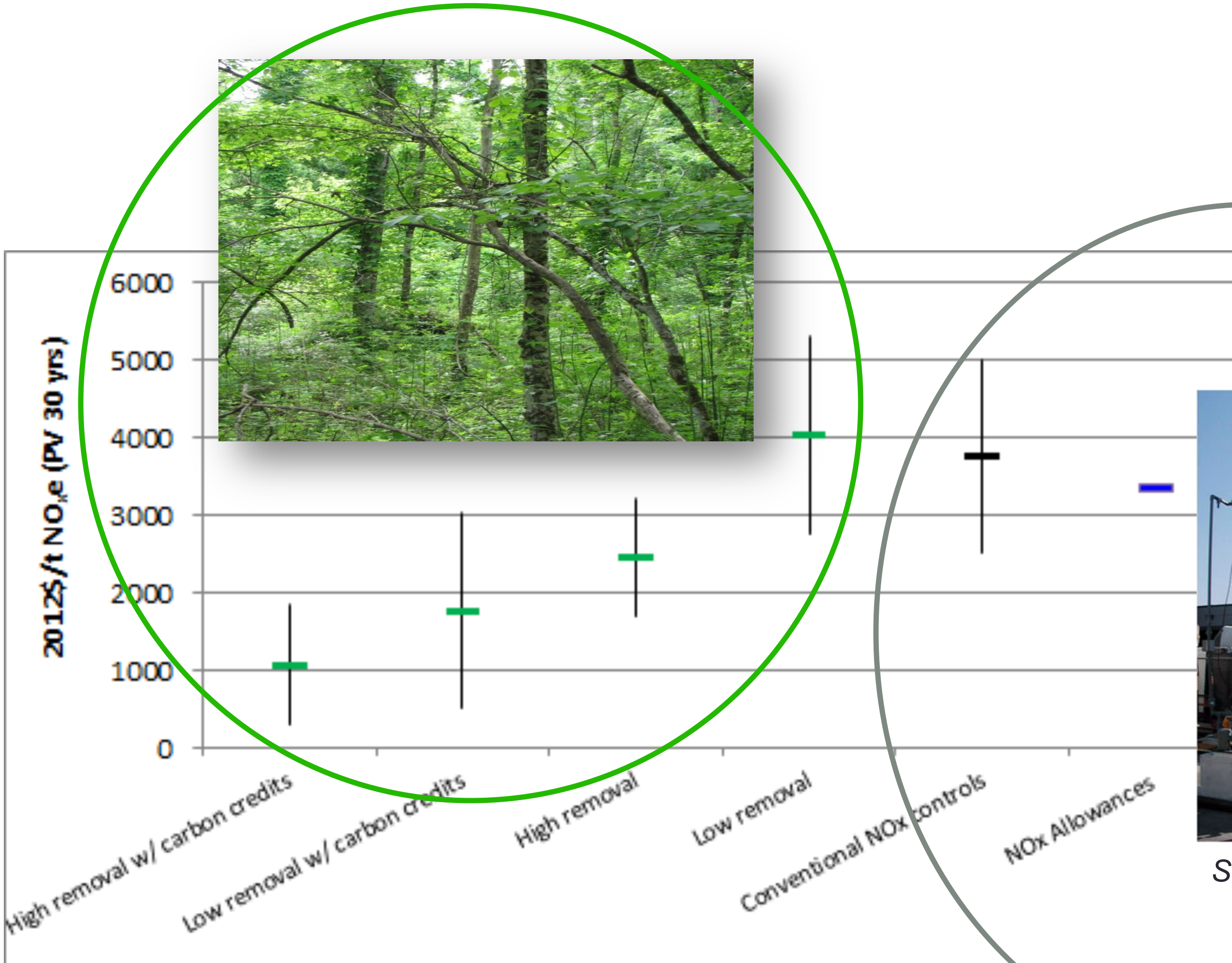


	Phase 1 (DBH < 12.7 cm)	Phase 2 (DBH ≥ 12.8 cm)
Forest structure parameter		
Number of trees	502,698	94,440
Average DBH (cm)	7.6	25.4
Average tree height (m)	7.8	15.9
Average crown height (m)	3.1	6.4
Average crown width (m)	3.0	7.1
UFORE modeled forest structure		
Average LAI	3.17	3.42
Total leaf area (m^2)	1,861,620	2,298,500
UFORE modeled air quality effects—Pollution removal		
NO_2 (g/m^2 crown area/y)	0.579	0.600
O_3 (g/m^2 crown area/y)	3.116	3.194

USDA Forest Service (UFORE) Urban Forest Effects Model



Reforestation More Cost-Effective than Burner and Catalytic Technologies for Ozone Control



Source: Envitech Inc

Kroeger, T, et al 2014. Reforestation as a novel abatement and compliance measure for ground-level ozone. Proceedings of the National Academy of Sciences USA1409785111v1-201409785

Models- Simplification of Reality

George E.P. Box

"Essentially, all models are wrong, but some are useful."

"Remember…..the practical question is how wrong do they have to be not to be useful."

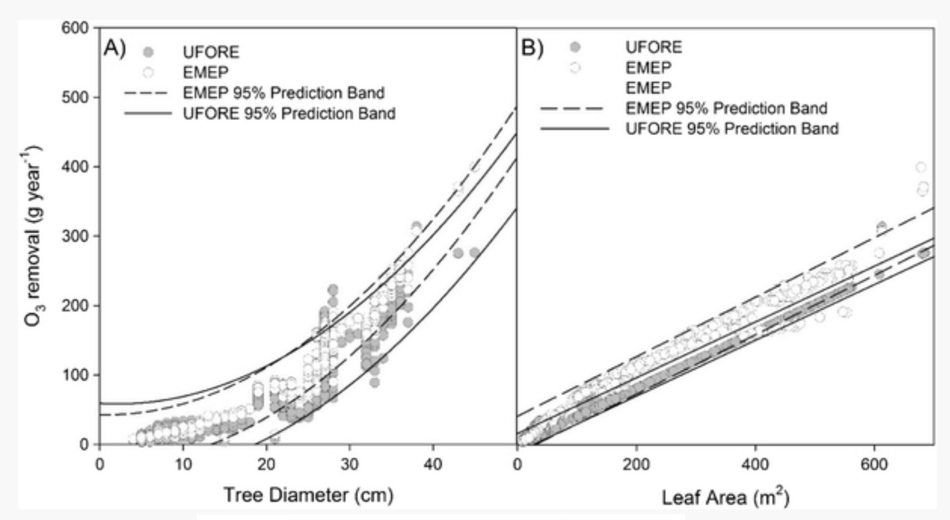
Evaluating ECO/UFORE- Air Pollution

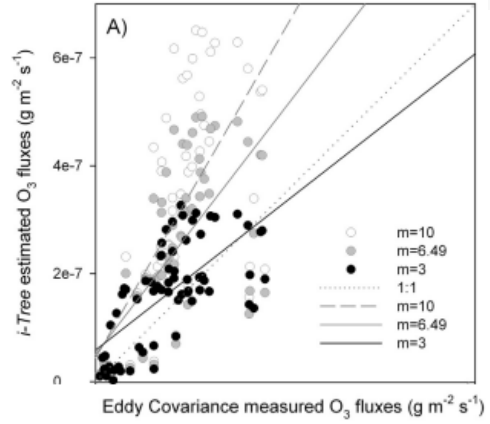
EMEP MSC-W & Eddy Covariance

European Monitoring & Evaluation Programme- Meteorological Synthesizing Centre West

1. Guidolotti et al. (2016) EMEP in Padua, Italy;1776 trees and shrubs (Tilia vulgaris and Celtis australis)
   - "showed a good agreement in the estimates"

2. Morani et al. (2014) used Eddy Covariance Technique to compare with ECO near Rome; 70% Laurus nobilis and Quercus ilex
   - "general agreement between predicted and measured O_3"





Guidolotti, G., Salviato, M. & Calfapietra, C. Environ Sci Pollut Res (2016). doi: 10.1007/s11356-016-7135-x

Morani et al., (2014) Comparing i-Tree modeled ozone deposition with field measurements in a periurban Mediterranean forest. Environ Pollut 195:202–209

Evaluating UFORE- Carbon

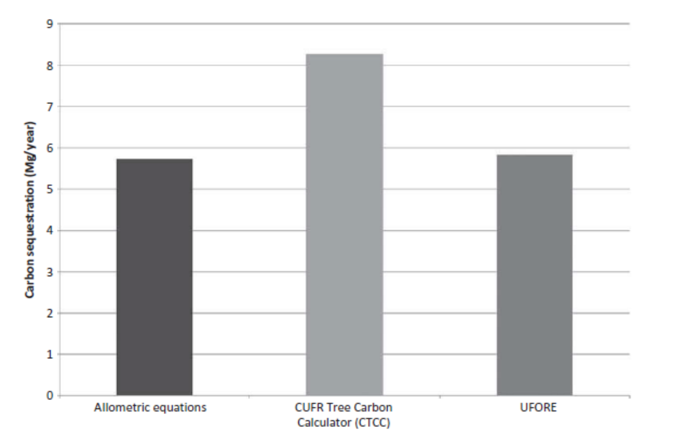
- 475 trees 3 methods, Bolzano Italy:
  1. European allometric equations and re-growth measurements
  2. UFORE (ECO) & Tree Carbon Calculator (CTCC)
- European allometric equations and CTCC / UFORE models were significantly different (P =< 0.0001)

✓ *Different models = different answers; All have +/-*

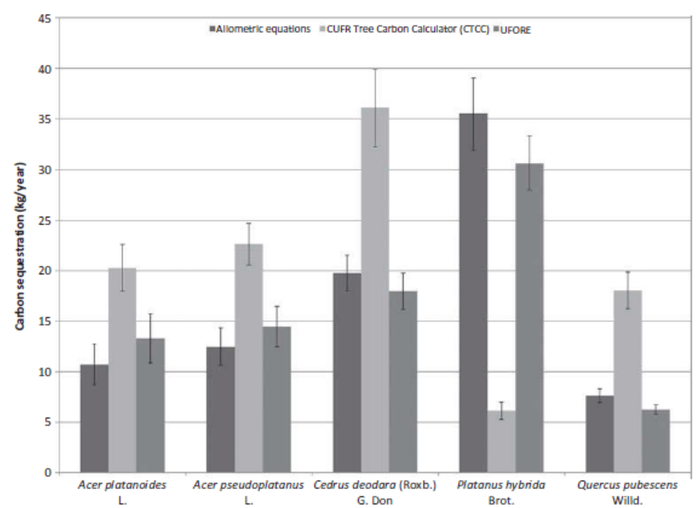
✓ *Certainty and context*

Russo et al (2014) Assessing urban tree carbon storage and sequestration in Bolzano, Italy, International Journal of Biodiversity Science, Ecosystem Services & Management, 10:1, 54-70

International Journal of Biodiversity Science, Ecosystem Services & Management



Annual carbon sequestration (Mg/year) by 475 trees in Bolzano calculated using three different methods.



Quantitative Certainty- Florida

- 9 live, 8 laurel oaks on UF campus; average aboveground dry weight
- (n= 17; DBH range 11-60cm).

	vs ECO	vs CTCC	vs STREETS
	520.4	555.6	520.8
RMS Error:	37%	40%	44%
Prediction:	-15%	2%	11%
	under-pred	over-pred	over-pred

- Destructive Sampling for Individual Tree Allometric Equations Quercus Virginiana, and Q. Laurifolia

RMS Error - Measure used to asses accuracy

Timilsina et al. 2014. Tree biomass, wood waste yield, and carbon storage changes in an urban forest. Landscape and Urban Planning, 127:18-27.

Quantitative Certainty: Gainesville, FL

Urban Forest – Level CO^2 offset estimates using:

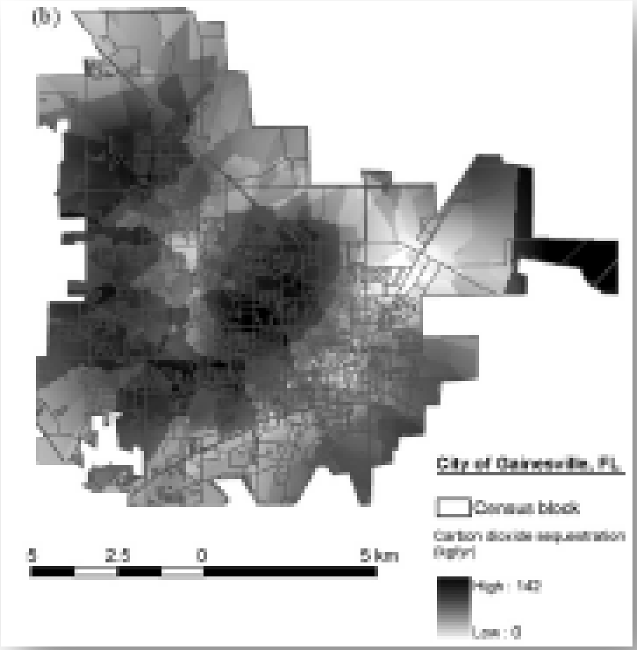
1. Site-specific measurements for growth/mortality rates
2. Local oak & Florida pine allometric equations = **5.6%** vs.

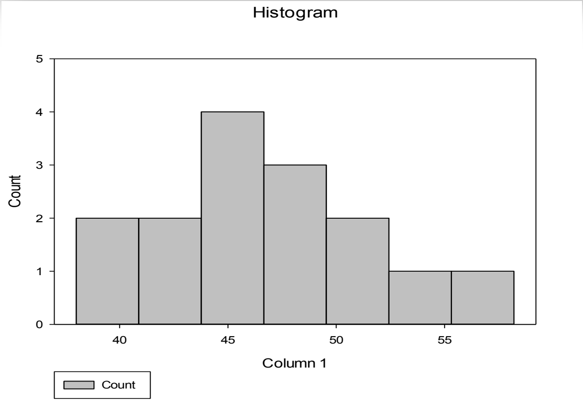
   ECO estimated **2.6%**

i-Tree Canopy:

- 19 last year forestry students:
- Tree Canopy:

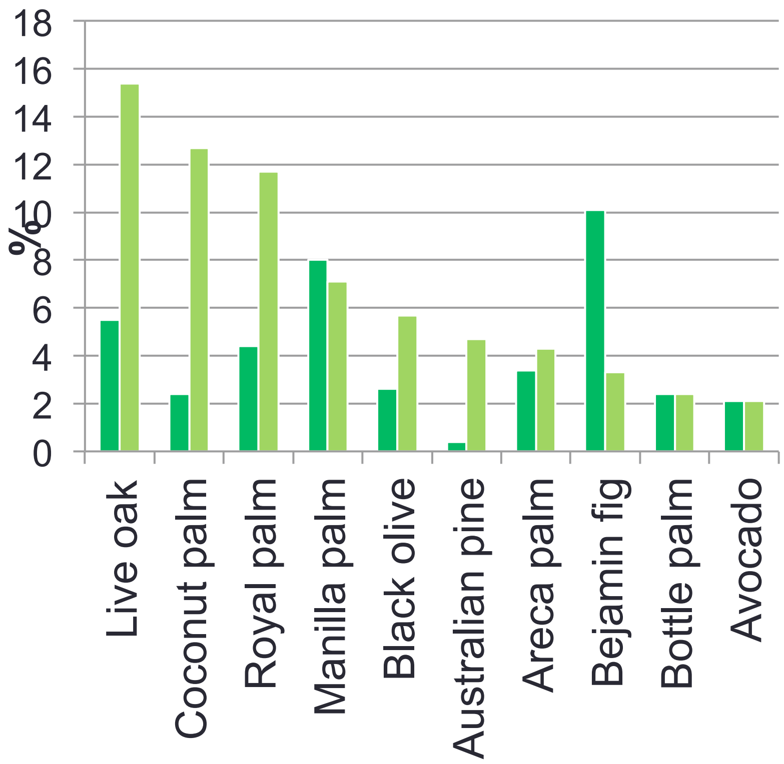
  46.5% (Range = 38-58%)



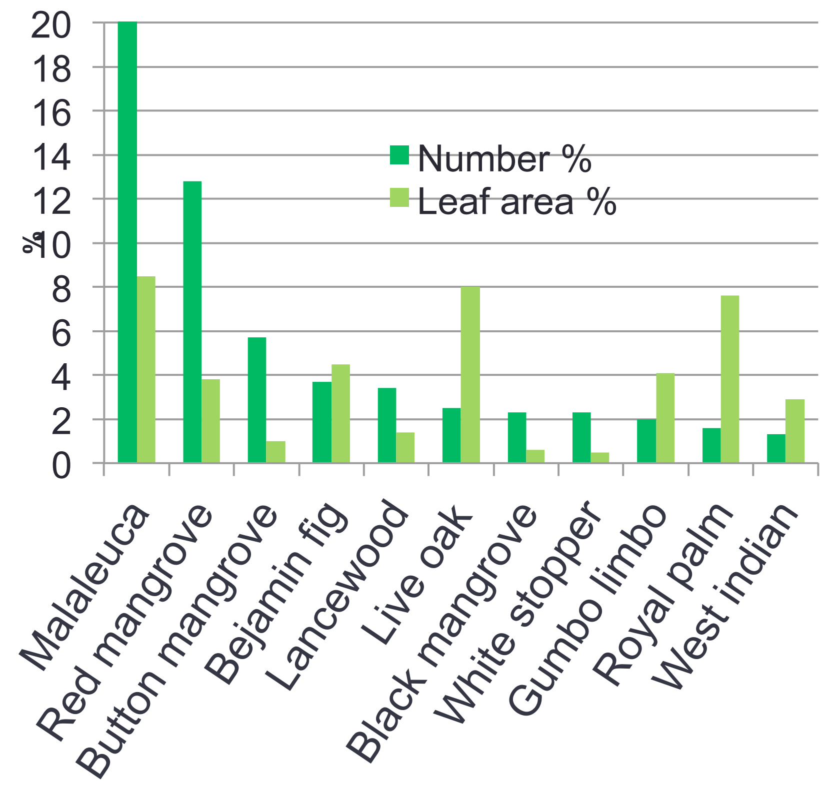


(Un?)Certainty: "The Magic 200 Plots"

Miami-Dade: 197 plots

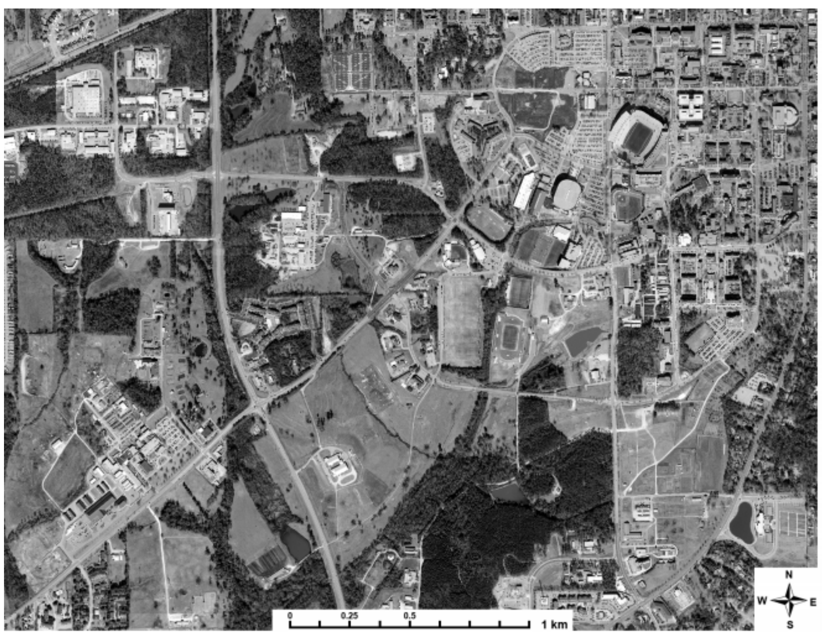


Miami-Dade: 229 plots



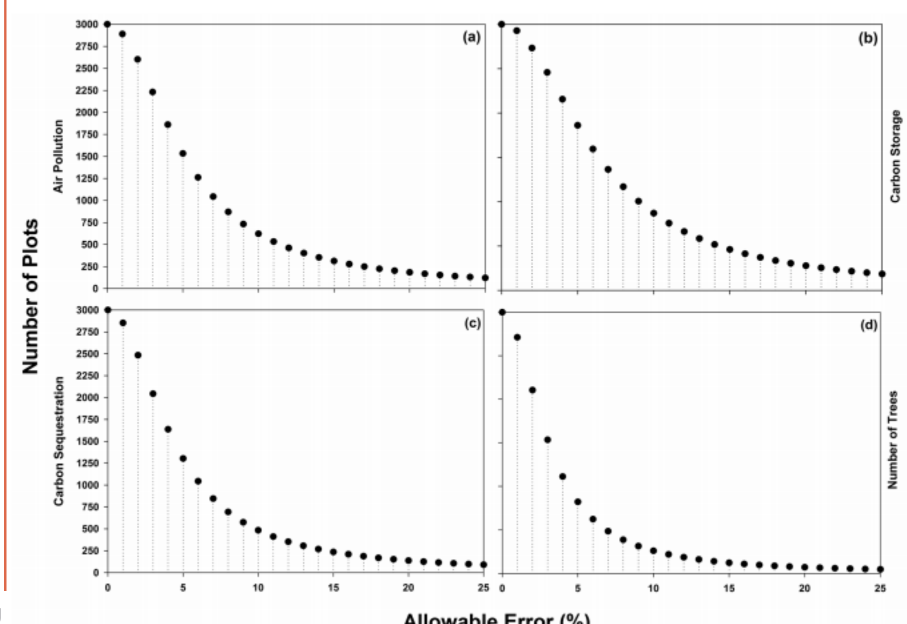
Evaluating ECO Sampling Protocol- Auburn University, USA

- 100% Tree Inventory of 243 ha campus
- Standard ECO measurments
- 3,000 random 400m^2 plots



To achieve +/-10% error:

- Tree numbers= 258 plots
- Air pollution= 622
- C storage= 870
- C sequestration= 483

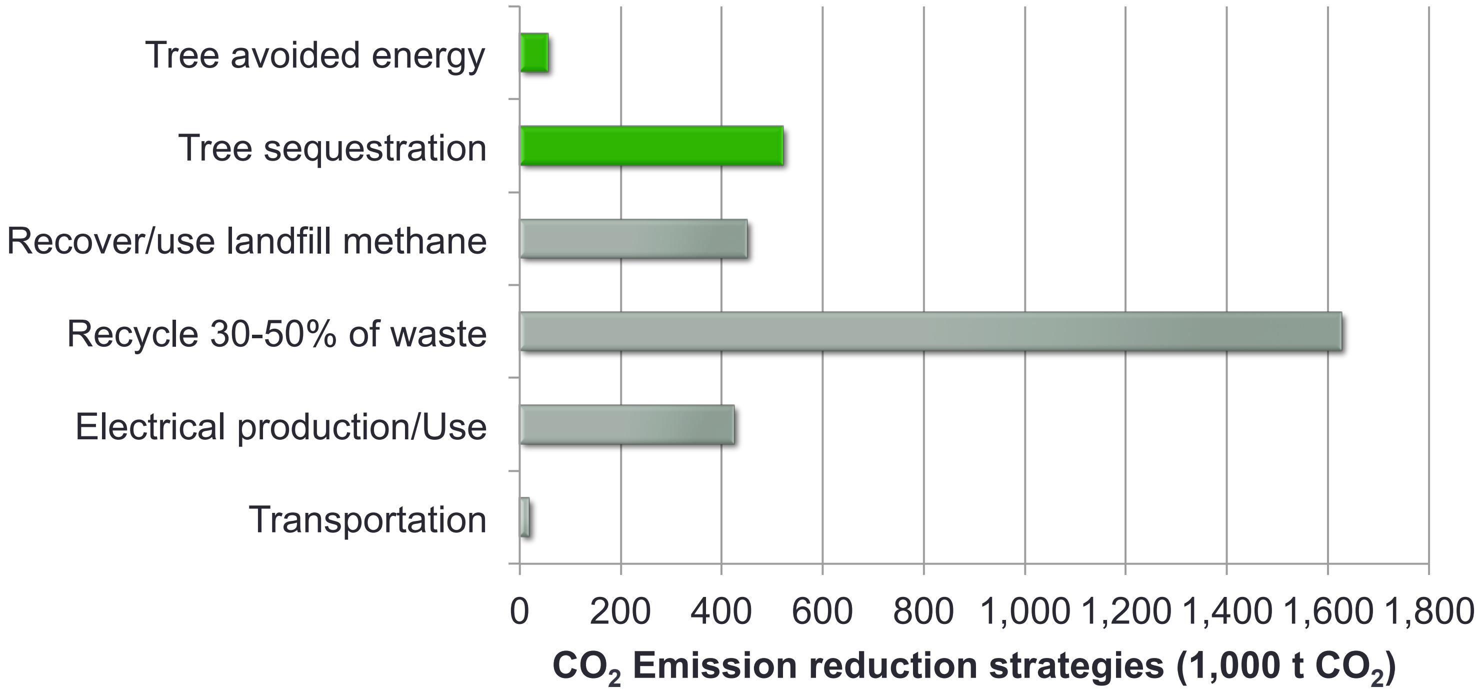


Martin, N., et al. "Evaluation of sampling protocol for i-Tree Eco: A case study in predicting ecosystem services at Auburn University." Arboriculture and urban forestry 39 (2013): 56-61

Lesson- Quantitative AND Political Certainty Will Determine Acceptance

- Results are used if:
  - Decision-makers request project
  - Managers support project
  - Results and methods communicated to key stakeholders
- Results are not used if:
  - Research is the main objective
  - Results not relevant to context
  - Limitations cannot be explained/ defended
- Strong Governance is Key

Lesson- Communicate Relevant Results



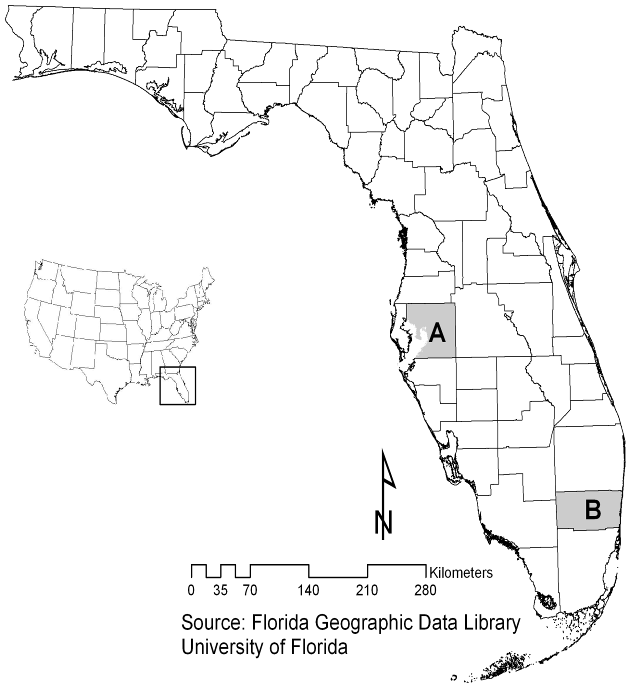
Trees comparable to other CO_2 reduction strategies in Miami-Dade

Escobedo et al 2010. Analyzing the efficacy of subtropical urban forests in offsetting carbon emissions from cities. Environmental Science and Policy, 13:362-372.

What do Floridians "Value" (2008-2010)?

1,219 mail surveys to community leaders

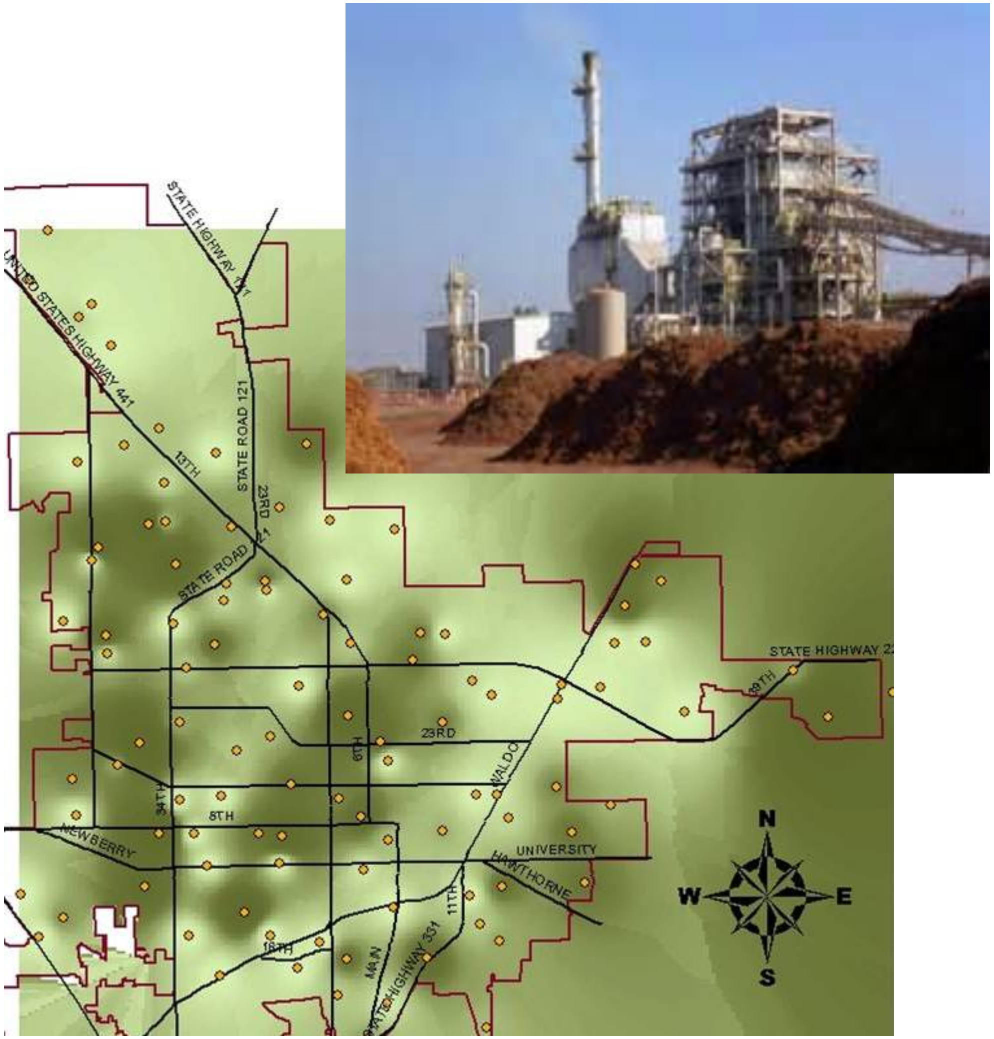
- *Value shade, aesthetics, and property price increases provided by trees*
- *…Do not value damage (hurricane) from urban forests*
- *….No mention of air quality, biogeochemical or hydrological cycles*
- *54% from Hillsborough and 64% from Broward favor increase in urban forests*
- *Tree canopy cover - not significant in supporting "urban forests"*



Wyman, M., Escobedo, F., Stein, T., Orfanedes, M., Northrop, R. 2012. Community leader perceptions towards coastal urban forests and hurricanes in Florida. Southern Journal of Applied Forestry, 36:152-158.

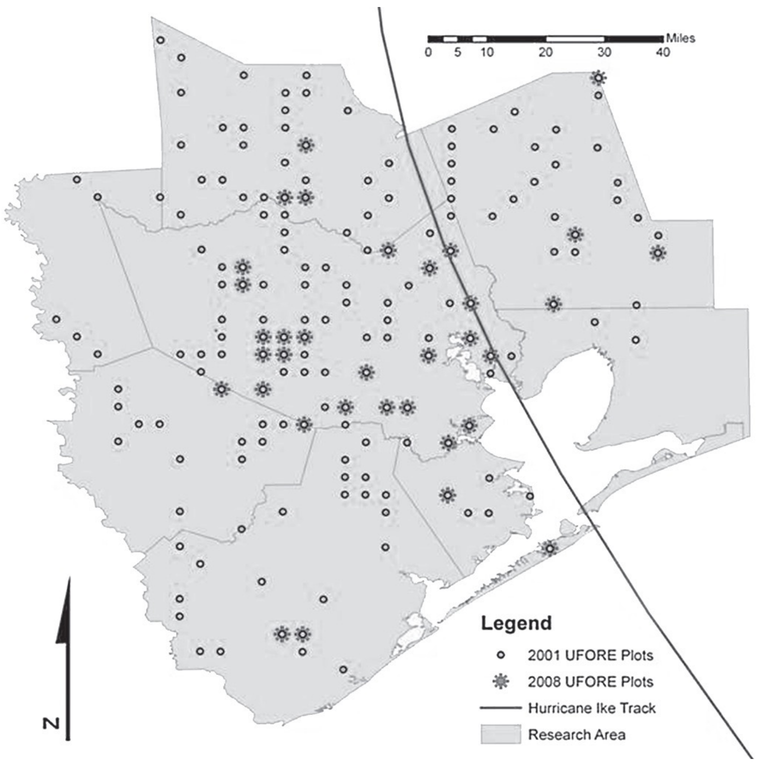
Lesson- Provide Relevant Information: Bioenergy Supply

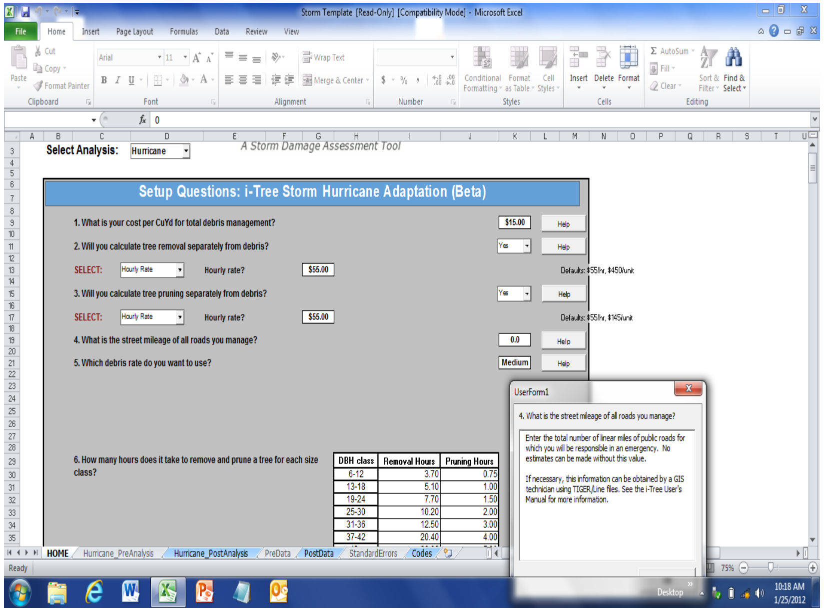
- Biomass change in Gainesville, Florida 2006-2009
  - Permanent Monitoring Plots
- *Pruning-Tree Removal supply was 2 Mg ha^{-1}*
- *5% of a bioenergy plant's annual requirement*



Timilsina, N., Staudhammer, C., Escobedo, F.J., Lawrence, A. 2014. Tree biomass, wood waste yield, and carbon storage changes in an urban forest. Landscape and Urban Planning, 127:18-27

Relevant tools: Storm Damage Assessment

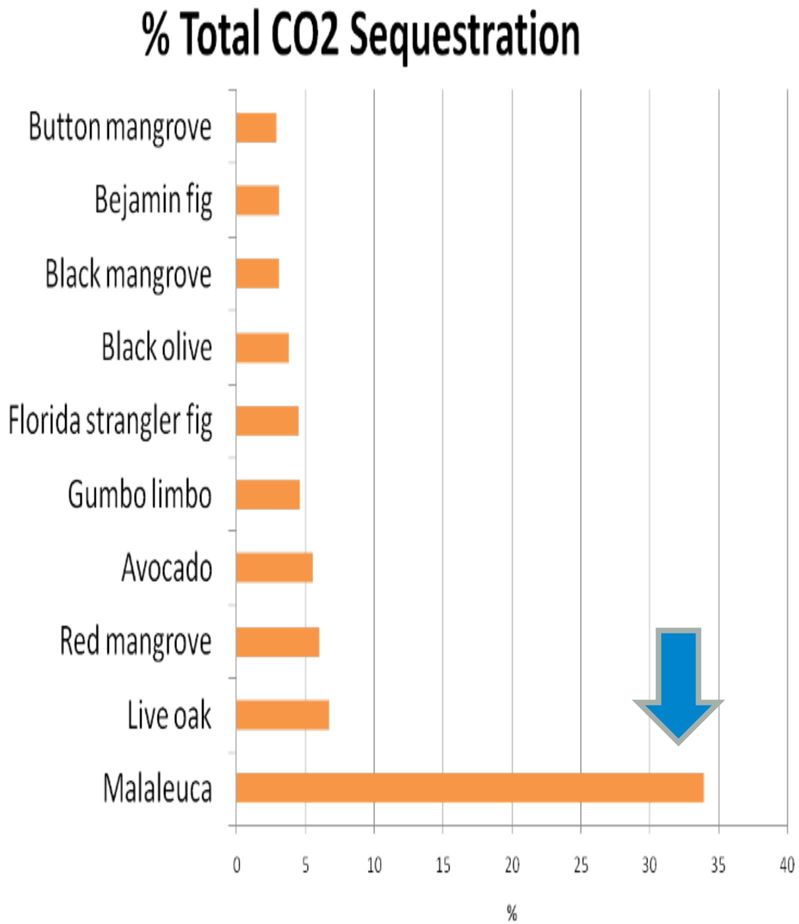


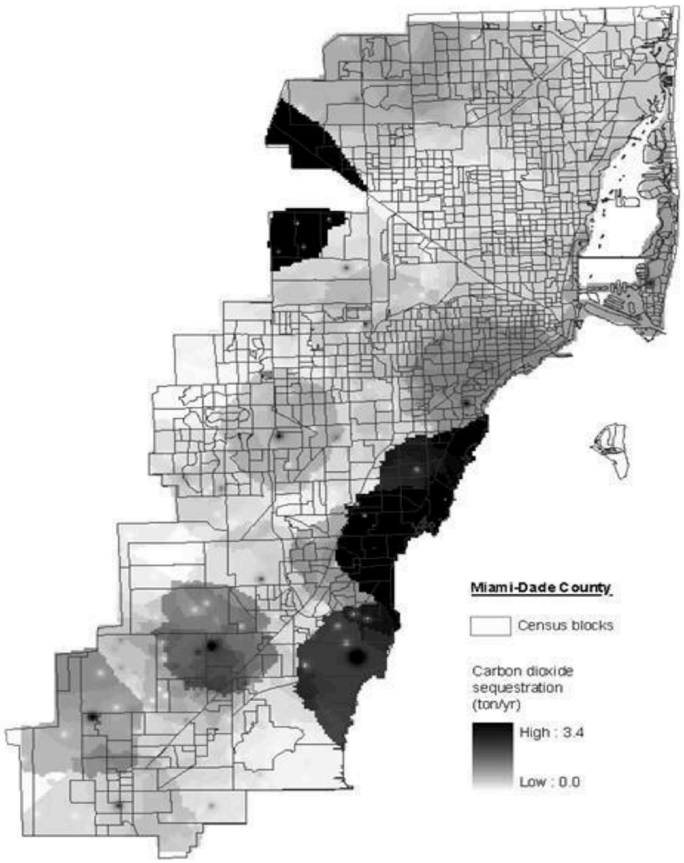


Lawrence A., Escobedo, F., Staudhammer, C., Zipperer, W. 2011. Temporal changes and drivers of growth, in-growth, and mortality in a subtropical urban forest ecosystem. Landscape and Urban Planning. In Revision.

Staudhammer, C., Escobedo, F., Lawrence, A., Duryea, M., Merritt, M., Smith, P. 2011. Rapid assessment of change and hurricane impacts to Houston's urban forest structure. Arboriculture and Urban Forestry, 37:60-66

Lesson- "Urban Forest Ecosystem Approach" will also shed light on previously Unknowns





Szantoi et al 2012. Socioeconomic factors and urban tree cover policies in a subtropical urban forest. GIScience and Remote Sensing, 49:428-449.
Flock, et al. 2011. Environmental justice implications of urban tree cover in Miami-Dade County, Florida. Environmental Justice, 4: 125-134.

“The Model”

Advantages

- Most comprehensive available no-cost model
- Standardized field and data entry protocol
- Transparency and default parameters
- Systems-level analysis
- Can use output “as-is”

Disadvantages

- Cannot access/adjust/calibrate model
- Results take too long (Intl.); Data ownership
- Very resource intensive to collect input data
- Updates not documented
- Top-down approach

Extension

Advantages

- Standardized, accessible
- Assistance at start up
- Only need to input data
- Transparent methods
- Science-based results
- Ecosystem-level view of resource
- Information can be used for advocacy

Disadvantages

- US- Algorithms
- Cannot be calibrated
- Snap-shot; 1 point in time
- Little post-project help
- Information overload
- Data privacy
- Certainty depends on data & communicating output

Conclusion

- First step: Why do you need to use this model!?
  - Models used to understand systems
    - Certainty is also socio-political..

Thank you!

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