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/

- 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, STREET/ 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)

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

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!
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

USDA Forest Service (UFORE) Urban Forest Effects Model
Reforestation More Cost-Effective than Burner and Catalytic Technologies for Ozone Control

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

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 O₃”


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

Quantitative Certainty- Florida

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

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<tr>
<th>vs ECO</th>
<th>vs CTCC</th>
<th>vs STREETS</th>
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<td>520.4</td>
<td>555.6</td>
<td>520.8</td>
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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 assess accuracy*
Quantitative Certainty: Gainesville, FL

Urban Forest – Level CO² 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

- Live oak
- Coconut palm
- Royal palm
- Manilla palm
- Black olive
- Australian pine
- Areca palm
- Bejamin fig
- Bottle palm
- Avocado

Miami-Dade: 229 plots

- Malaleuca
- Button mangrove
- Bejamin fig
- Lancewood
- Live oak
- Black mangrove
- White stopper
- Gumbo limbo
- Royal palm
- West indian
Evaluating ECO Sampling Protocol-Auburn University, USA

- 100% Tree Inventory of 243 ha campus
- Standard ECO measurements
- 3,000 random 400m² plots

To achieve +/-10% error:
- Tree numbers= 258 plots
- Air pollution= 622
- C storage= 870
- C sequestration= 483

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 CO₂ reduction strategies in Miami-Dade

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”*

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

Relevant tools: Storm Damage Assessment


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


“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
<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>• Standardized, accessible</td>
<td>• US- Algorithms</td>
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<td>• Assistance at start up</td>
<td>• Cannot be calibrated</td>
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<td>• Only need to input data</td>
<td>• Snap-shot; 1 point in time</td>
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<td>• Transparent methods</td>
<td>• Little post-project help</td>
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<td>• Science-based results</td>
<td>• Information overload</td>
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<td>• Ecosystem-level view of resource</td>
<td>• Data privacy</td>
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<td>• Information can be used for advocacy</td>
<td>• Certainty depends on data &amp; communicating output</td>
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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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