Plan for today

1. Setting up your first project
2. Key decisions
3. Putting i-Tree Eco results to work
4. Is i-Tree Eco right for you?
i-Tree Tool Relationships

**Eco**: Tree/Population Ecosystem Services Calculator

**i-Tree Engine/API**: Individual tree benefits and projections

**Cover multipliers**: Structure and benefits per unit area of tree cover

- **MyTree**
- **Planting**
- **Design**
- **Canopy**
- **Landscape**
- **OurTrees**

*i-Tree is a Cooperative Initiative among these partners*
The i-Tree Eco Framework

**Structure**
- Summary of field measurements
- Leaf area
- Condition
- Species distribution
- Diameter distribution

**Function**
- Air quality improvement
- Energy effects
- Carbon storage & sequestration
- Hydrology effects
- Shade ultraviolet effects (UV)
- Foodscape characteristics
- Wildlife suitability – avian focus
- Volatile organic compounds
- Leaf nutrients, wood production, and more

**Value**
- Monetary value
- Equivalent values
- Health outcomes
- Cost Benefit analysis
- Summaries for management
Key Decision 1: What data will you collect?

Minimum Required Tree Data
1. Tree species
2. Diameter at breast height (DBH)

Optional but Recommended Tree Data
3. Total tree height
4. Height to live top
5. Height to crown base
6. Crown width (N-S)
7. Crown width (E-W)
8. % Crown missing
9. % dieback (condition)
10. Crown light exposure (CLE)
11. Land use
From field data to results

**Table 2.—Summary of which directly field-measured characteristics are used to estimate derived variables and ecosystem services.**

<table>
<thead>
<tr>
<th>DIRECT MEASURES</th>
<th>DERIVED VARIABLES</th>
<th>ECOSYSTEM SERVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf Area</td>
<td>Leaf Biomass</td>
</tr>
<tr>
<td>Species</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Diameter at breast height (d.b.h.)</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Total height</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Crown base height</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Crown width</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Crown light exposure</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Percent crown missing</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Crown health (condition/dieback)</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Field land use</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Distance to building</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Direction to building</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Percent tree cover</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Percent shrub cover</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Percent building cover</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Ground cover composition</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Directly field-measured characteristics and derived variables are used to estimate various ecosystem services. D = directly used; I = indirectly used; C = conditionally used.
i-Tree model basics: Inventory data → tree benefits?
Let’s set-up an i-Tree Eco project

Rochester, MN
Street Tree Inventory
Key Decision 2: Sample or complete inventory?

Random sample of plots
- City
- County
- Regional or watershed
- Large scale or forested areas

Complete inventory
- Parks
- Campuses
- Residential properties
- Specimen or single trees
- Only trees of interest
What is a sample and why would you do it?

- A small subset of the items you are interested in
- Easier than measuring the whole thing
- For statistical reasons must be random
- We can estimate how well our sample represents the whole population
- This is how London measures 8.5 million trees
What is a plot?

• By default 37.2 ft in radius, 1/10th acre in area.

• Plot size can be changed

• Tradeoffs between plot size and the number you can measure
### Sample Plots vs. Complete Inventory

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sample</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended area</strong></td>
<td>City or larger</td>
<td>Any</td>
</tr>
<tr>
<td><strong>Number of plots</strong></td>
<td>200 or more</td>
<td>not applicable</td>
</tr>
<tr>
<td><strong>Typical number of trees</strong></td>
<td>&gt;500</td>
<td>Any</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>Numerous permissions usually required</td>
<td>Often no permission required</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>Some loss of accuracy due to sampling error</td>
<td>No sampling error, all trees of interest measured</td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td>Estimates expanded to whole area of interest</td>
<td>Estimates only for measured trees</td>
</tr>
</tbody>
</table>
Key Decision 3: Will you stratify?

Dividing area of interest into categories

- Can be performed by any categories of interest (land use, ownership, political, watershed, etc.)

- Summaries generated by categories of interest

- Perform pre- or post- measurement (sample must be random)

- Can improve statistical accuracy

- Plots or complete inventory
Key Decision 4: How will you enter data? manual, mobile, or import

<table>
<thead>
<tr>
<th>Plot ID</th>
<th>Strata</th>
<th>GPS Coordinates</th>
<th>Date</th>
<th>Crown</th>
<th>Plot Size:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plot Address:

Plot Contact Name: Contact Type or Title:  
Phone #: Email: 
Plot or Access Notes: 

Plot Tree Cover (%) | Shrub Cover (%) | Plantable Space (%) | Percent of Plot Measured (%)  
--- | --- | --- | --- |

Did this Plot have any Trees? (YN): Permanent stake used? (YN):  
Photo ID(s):  

--- Manual data entry:  
Collect on paper then directly enter in the i-Tree Eco interface ---
Data entry: mobile

Web-enabled mobile device

1. Measure and enter your selected field variables

2. Regularly submit data to Davey servers

3. Retrieve data into your i-Tree Eco Project
Data import

<table>
<thead>
<tr>
<th>Zone</th>
<th>Species</th>
<th>Scientific Name</th>
<th>DBH Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>Rocke</td>
<td>Celtis occidentalis</td>
<td>3 Poor</td>
</tr>
<tr>
<td>NW</td>
<td>Maple</td>
<td>Acer platanoides</td>
<td>17 Fair</td>
</tr>
<tr>
<td>NW</td>
<td>Crabapple</td>
<td>Malus</td>
<td>15 Good</td>
</tr>
<tr>
<td>SE</td>
<td>Redbud, Eastern</td>
<td>Cercis canadensis</td>
<td>3 Poor</td>
</tr>
<tr>
<td>SE</td>
<td>Pine</td>
<td>Pinus</td>
<td>15 Poor</td>
</tr>
<tr>
<td>SE</td>
<td>LindenOrnamental</td>
<td>Tilia cordata</td>
<td>28 Good</td>
</tr>
<tr>
<td>SE</td>
<td>Maple</td>
<td>Acer platanoides</td>
<td>0 Poor</td>
</tr>
<tr>
<td>SE</td>
<td>Redbud, Eastern</td>
<td>Cercis canadensis</td>
<td>3 Fair</td>
</tr>
<tr>
<td>SE</td>
<td>Honeylocust</td>
<td>Gleditsia triacanthos</td>
<td>24 Good</td>
</tr>
<tr>
<td>NW</td>
<td>Hawthorn</td>
<td>Crataegus</td>
<td>2 Good</td>
</tr>
<tr>
<td>NW</td>
<td>Crabapple</td>
<td>Malus</td>
<td>0 Poor</td>
</tr>
<tr>
<td>NW</td>
<td>Redbud, Eastern</td>
<td>Cercis canadensis</td>
<td>3 Fair</td>
</tr>
<tr>
<td>NW</td>
<td>AshGreen</td>
<td>Fraxinus pennsylvanica</td>
<td>22 Good</td>
</tr>
<tr>
<td>NE</td>
<td>AshGreen</td>
<td>Fraxinus pennsylvanica</td>
<td>18 Good</td>
</tr>
<tr>
<td>NW</td>
<td>MapleSugar</td>
<td>Acer saccharinum</td>
<td>28 Eying</td>
</tr>
<tr>
<td>NW</td>
<td>MapleNorway</td>
<td>Acer platanoides</td>
<td>9 Good</td>
</tr>
<tr>
<td>NW</td>
<td>MapleSilver</td>
<td>Acer saccharinum</td>
<td>35 Excellent</td>
</tr>
<tr>
<td>SE</td>
<td>Ulmus americana 'princeton'</td>
<td>Ulmus americana 'princeton'</td>
<td>7 Good</td>
</tr>
<tr>
<td>SE</td>
<td>MapleSilver</td>
<td>Acer saccharinum</td>
<td>38 Good</td>
</tr>
<tr>
<td>SE</td>
<td>MapleNorway</td>
<td>Acer platanoides</td>
<td>19 Good</td>
</tr>
<tr>
<td>SW</td>
<td>Crabapple</td>
<td>Malus</td>
<td>7 Eying</td>
</tr>
<tr>
<td>SE</td>
<td>LindenOrnamental</td>
<td>Tilia cordata</td>
<td>15 Good</td>
</tr>
<tr>
<td>NE</td>
<td>Gingo</td>
<td>Gignig bildra</td>
<td>2 Fair</td>
</tr>
<tr>
<td>SE</td>
<td>Honeylocust</td>
<td>Gleditsia triacanthos</td>
<td>5 Poor</td>
</tr>
<tr>
<td>SE</td>
<td>MapleNorway</td>
<td>Acer platanoides</td>
<td>17 Fair</td>
</tr>
<tr>
<td>NE</td>
<td>Rocke</td>
<td>Celtis occidentalis</td>
<td>3 Poor</td>
</tr>
</tbody>
</table>

Steps to Viewing Plot Data:
1. When you click on a record in the plot table, additional plot data will be displayed in the table below it.
2. Use the tools located at the bottom of the action panel to view different plot data in the lower table.
3. Hide the lower table by clicking on the pin button in the upper right-hand corner of the table.
4. Unhide the lower table by clicking on one of the tab at the bottom of the action panel and clicking on the pin button again.

Steps to Manually Add/Edit Data:
1. Click in the box where you would like to enter data and then typing.
2. Use the Tab key on your keyboard or the left and right arrow to move from field to field.
<table>
<thead>
<tr>
<th>Mobile</th>
<th>Manual</th>
<th>Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Useful for citizen science</td>
<td>• Use paper for permanent record</td>
<td>• Ultimate flexibility</td>
</tr>
<tr>
<td>• Multiple people can do data entry</td>
<td>• Fewer potential issues</td>
<td>• Add value to existing inventories</td>
</tr>
<tr>
<td>• Need device, safety, battery</td>
<td>• Single user</td>
<td>• Quick</td>
</tr>
<tr>
<td>• Tedious for plots with lots of trees</td>
<td>• Slow</td>
<td>• Now works for samples or complete inventory</td>
</tr>
</tbody>
</table>
Let’s get some data into i-Tree Eco
Let’s get some data into i-Tree Eco

Mobile data entry

i-Tree Eco structure results

Species Diversity/Composition
Diversity reduces environmental threats, increases resilience

Size/Age Class Distribution
Distribution of age informs sustainability
Appendix VI. Potential Risk of Pests

Fifty-three insects and diseases were analyzed to quantify their potential impact on the urban forest.

<table>
<thead>
<tr>
<th>Code</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Trees at Risk (#)</th>
<th>Value ($ thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>Phyllocnistis populiella</td>
<td>Aspen Leafminer</td>
<td>30</td>
<td>8.94</td>
</tr>
<tr>
<td>ALB</td>
<td>Anoplophora glabripennis</td>
<td>Asian Longhorned Beetle</td>
<td>5,080</td>
<td>6,037.13</td>
</tr>
<tr>
<td>ARCA</td>
<td>Neodolithia populina</td>
<td>Aspen Running Canker</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>ARD</td>
<td>Armillaria spp.</td>
<td>Armillaria Root Disease</td>
<td>4</td>
<td>2.86</td>
</tr>
<tr>
<td>BBD</td>
<td>Neoneotelia faginata</td>
<td>Beech Bark Disease</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>BC</td>
<td>Sirococcus clavigignenti</td>
<td>Butternut Canker</td>
<td>145</td>
<td>273.64</td>
</tr>
<tr>
<td>BLD</td>
<td>Litylenchus crenatae mccannii</td>
<td>Beech Leaf Disease</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>BM</td>
<td>Euproctis chrysorrhoea</td>
<td>Browntail Moth</td>
<td>891</td>
<td>335.73</td>
</tr>
<tr>
<td>BOB</td>
<td>Tubakia iowensis</td>
<td>Bur Oak Blight</td>
<td>105</td>
<td>291.08</td>
</tr>
<tr>
<td>BSRD</td>
<td>Leptographium wageneri</td>
<td>Black Stain Root Disease</td>
<td>4</td>
<td>2.86</td>
</tr>
<tr>
<td>BWA</td>
<td>Adelges piceae</td>
<td>Balsam Woolly Adelgid</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>CB</td>
<td>Cryphonectria parasitica</td>
<td>Chestnut Blight</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>DA</td>
<td>Discula destructiva</td>
<td>Dogwood Anthracnose</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Carbon Storage

- Norway maple
- Honeylocust
- Sugar maple
- Silver maple
- Eastern cottonwood
- Green ash
- American elm
- Black walnut
- Spruce spp.
- Bur oak
i-Tree Eco tree function

Rochester Inventory Data

**Silver maples**
- Tree count: 247
- Leaf area: 33 acres

**Honeylocusts**
- Tree count: 623
- Leaf area: 40 acres
i-TREE Eco detailed results

Hourly Ozone Concentration

Hourly Precipitation

Hourly Ozone Reduction by Trees
## Air Quality Health Impacts and Values by Trees

**Location:** Rochester, Olmsted, Minnesota, United States of America  
**Project:** Rochester Street Trees, Series: 1, Year: 2023  
**Generated:** 4/18/2023

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>NO2 ($/yr)</th>
<th>O3 ($/yr)</th>
<th>PM2.5 ($/yr)</th>
<th>SO2 ($/yr)</th>
<th>All ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Bronchitis</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Acute Myocardial</td>
<td></td>
<td>13.31</td>
<td></td>
<td></td>
<td>13.31</td>
</tr>
<tr>
<td>Acute Respiratory</td>
<td>0.99</td>
<td>77.97</td>
<td>28.87</td>
<td>0.17</td>
<td>108</td>
</tr>
<tr>
<td>Asthma Exacerbiation</td>
<td>39.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.41</td>
</tr>
<tr>
<td>Emergency Room Visits</td>
<td>0.10</td>
<td>0.13</td>
<td>0.10</td>
<td>0.05</td>
<td>0.38</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>21.86</td>
<td>31.31</td>
<td></td>
<td>4.49</td>
<td>57.66</td>
</tr>
<tr>
<td>Hospital Admissions,</td>
<td></td>
<td></td>
<td></td>
<td>3.16</td>
<td>3.16</td>
</tr>
<tr>
<td>Hospital Admissions,</td>
<td></td>
<td></td>
<td></td>
<td>2.24</td>
<td>2.24</td>
</tr>
<tr>
<td>Lower Respiratory</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td>Mortality</td>
<td></td>
<td>3153.14</td>
<td>5791.25</td>
<td></td>
<td>8944.39</td>
</tr>
<tr>
<td>School Loss Days</td>
<td></td>
<td></td>
<td>38.07</td>
<td></td>
<td>38.07</td>
</tr>
<tr>
<td>Upper Respiratory</td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td></td>
<td></td>
<td></td>
<td>8.95</td>
<td>8.95</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62.10</strong></td>
<td><strong>3300.62</strong></td>
<td><strong>5939.98</strong></td>
<td><strong>8.41</strong></td>
<td><strong>9311.11</strong></td>
</tr>
</tbody>
</table>
Leaf Area of Trees Over Time

- Northwest
- Northeast
- Southwest
- Southeast

Year

Leaf Area (ac)

- 550
- 500
- 450
- 400
- 350
- 300
- 250
- 200
- 150
- 100
- 50
- 0
"These six trees store 14,291 lbs of carbon and continue to sequester 470 lbs of carbon each year. For comparison, the 1,316 small trees between 1-4 inches DBH in this study store a combined total of 16,567 lbs of carbon."

From Corey Bassett, [https://www.itreetools.org/documents/352/UPenn_iTreeEcoInventory.pdf](https://www.itreetools.org/documents/352/UPenn_iTreeEcoInventory.pdf)
i-Tree Eco: Power of stratification

City owned parkland is **9%** of the city

Trees on city owned parkland account for **40%** of carbon storage and sequestration

<table>
<thead>
<tr>
<th>Feature</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trees</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Tree Cover</td>
<td>64%</td>
</tr>
<tr>
<td>Carbon Storage</td>
<td>273,000 tons ($19.4 million)</td>
</tr>
<tr>
<td>Pollution Removal</td>
<td>179 tons/yr ($6.6 million/yr)</td>
</tr>
</tbody>
</table>
### Ash Trees:
City stands to lose 7.1% of its forest and millions in benefits to emerald ash borer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Units</th>
<th>% of Total City</th>
<th>Species Group Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>206,996</td>
<td>number</td>
<td>7.1</td>
<td>3</td>
</tr>
<tr>
<td>Density</td>
<td>2.3</td>
<td>trees/acre</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Carbon stored</td>
<td>35,742</td>
<td>tons</td>
<td>5.1</td>
<td>7</td>
</tr>
<tr>
<td>Carbon sequestered</td>
<td>1,025</td>
<td>tons/year</td>
<td>3.8</td>
<td>11</td>
</tr>
<tr>
<td>Net carbon sequestered</td>
<td>935</td>
<td>tons/year</td>
<td>4.0</td>
<td>10</td>
</tr>
<tr>
<td>Leaf area</td>
<td>4,818</td>
<td>acres</td>
<td>5.2</td>
<td>7</td>
</tr>
<tr>
<td>Leaf biomass</td>
<td>1,936</td>
<td>tons</td>
<td>6.3</td>
<td>3</td>
</tr>
<tr>
<td>Trees, diameter 1-3 in.</td>
<td>111,777</td>
<td>number</td>
<td>54.0(^a)</td>
<td>2</td>
</tr>
<tr>
<td>Trees, diameter &gt;18 in.</td>
<td>10,557</td>
<td>number</td>
<td>5.1(^a)</td>
<td>12</td>
</tr>
</tbody>
</table>

\(^a\) Percent of all ash trees
Tree Size Matters. Large mature shade trees have the most leaf area and provide the greatest benefits. While trees 30" or greater in diameter make up only 8% of the population - their canopies make up 27% of the neighborhood’s leaf area. A comparison of the benefits of an 11” diameter Dogwood tree and a 30” diameter Maple tree growing in the neighborhood shows that the Maple provides nearly 8 times the ecosystem benefits as the Dogwood.

To maximize the benefits Abington’s tree canopy provides - we should focus our private property efforts on preserving our existing large trees and planting species that will grow to be large shade trees to replace those we have lost or will lose in the future.

https://storymaps.arcgis.com/stories/ed7e547aeaed454ea5dd44c4b1be08c0
i-Tree Eco: Advantages

- **Local Modeling** – Eco uses available local hourly weather & pollution data and other local characteristics for modeling

- **Dynamic model** – constantly improved with new science, new international locations, new reports and functions

- **Flexible** data collection and project design maximize user base.

- The **Eco import** option is a great way to assess existing tree inventory data quickly
i-Tree Eco: Advantages

- **Options to improve** the model. e.g. users can submit new species, hourly rainfall data, biomass equations *(i-Tree Database)*

- **Flexible results** – Eco reports by species, strata, and individual tree to help with strategic decision making.
Use i-Tree Eco ...

... when you have existing data.
... when you have resources for a large-scale project.
... if you can make good use of the wealth of results.
... to support management.
... when interested in a plot-based sample.
... for centralized project management.

Try another i-Tree tool ...

... when working with students or the public.
... to show that trees have benefits.
... when time is limited.
... to start conversations on trees and tree benefits.
... when you are interested in canopy cover.
... for priority planning.

i-Tree Eco is flexible
Test your decisions with a pilot project!

A pilot project is a small project designed using the set-up you are considering for a larger project.

• Test assumptions and methods
• Evaluate challenges and limitations
• Can be expanded to become your target project