

Assessing ecosystem services with i-Tree Eco: methods, approaches, and models



Tools for assessing individual trees



MyTree

Are you new to i-Tree? Start with our EASIE... you quickly assess **individual trees** with a m... via your web browser or Android / Apple dev



i-Tree Design

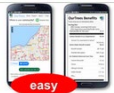
A full-featured web tool with expanded build... forecasting for estimating the benefits of inc... via your web browser



i-Tree Eco

Eco is our flagship tool that accommodates t... or field data evaluation to derive **individual** t... requires installation on a Windows PC

Tree canopy area assessment tools



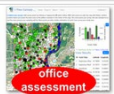
OurTrees

Beta release: Quick **tree canopy** and related i... community within the continental US! via your web browser or Android / Apple dev



i-Tree Landscape

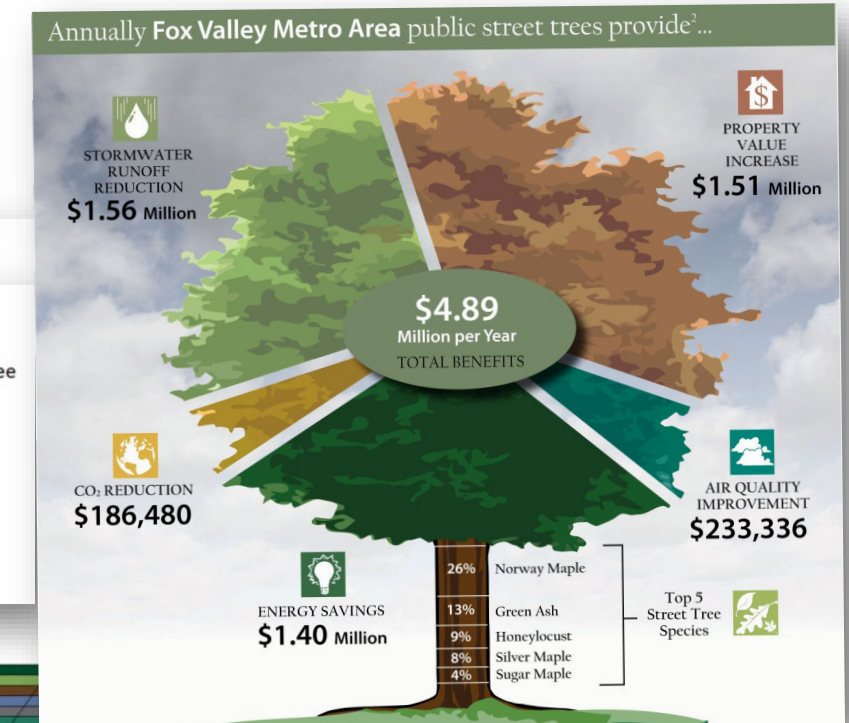
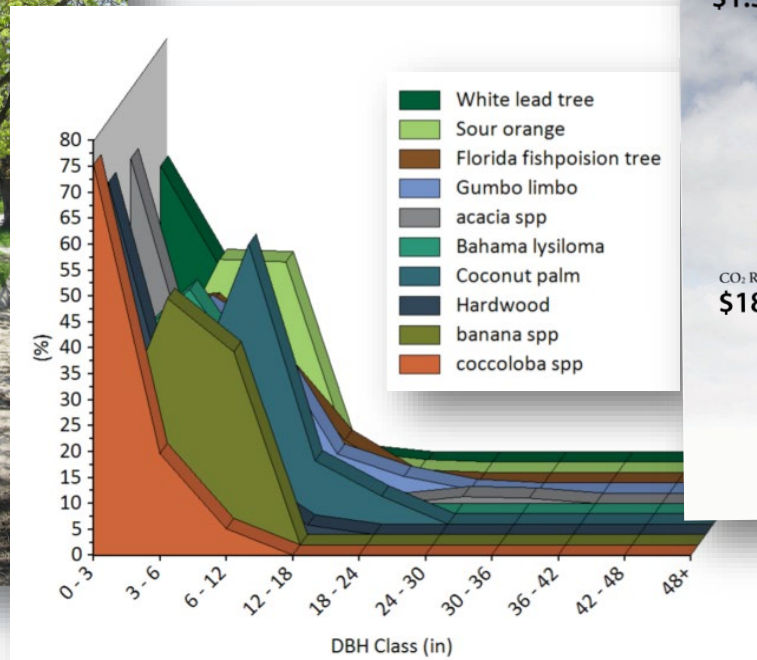
US **tree canopy** and Census maps/data at you... priority planting & protection areas for clima... via your web browser



i-Tree Canopy

From your chair, easily estimate land cover and **tree canopy** plus benefits using random point sampling on aerial imagery. via your web browser

More tools...



Jason Henning
The Davey Institute and
USDA Forest Service, Philadelphia Field Station

Plan for today...

- Introduction to i-Tree
- The core ecosystem services
 - Carbon
 - Air pollution
 - Stormwater
 - Energy

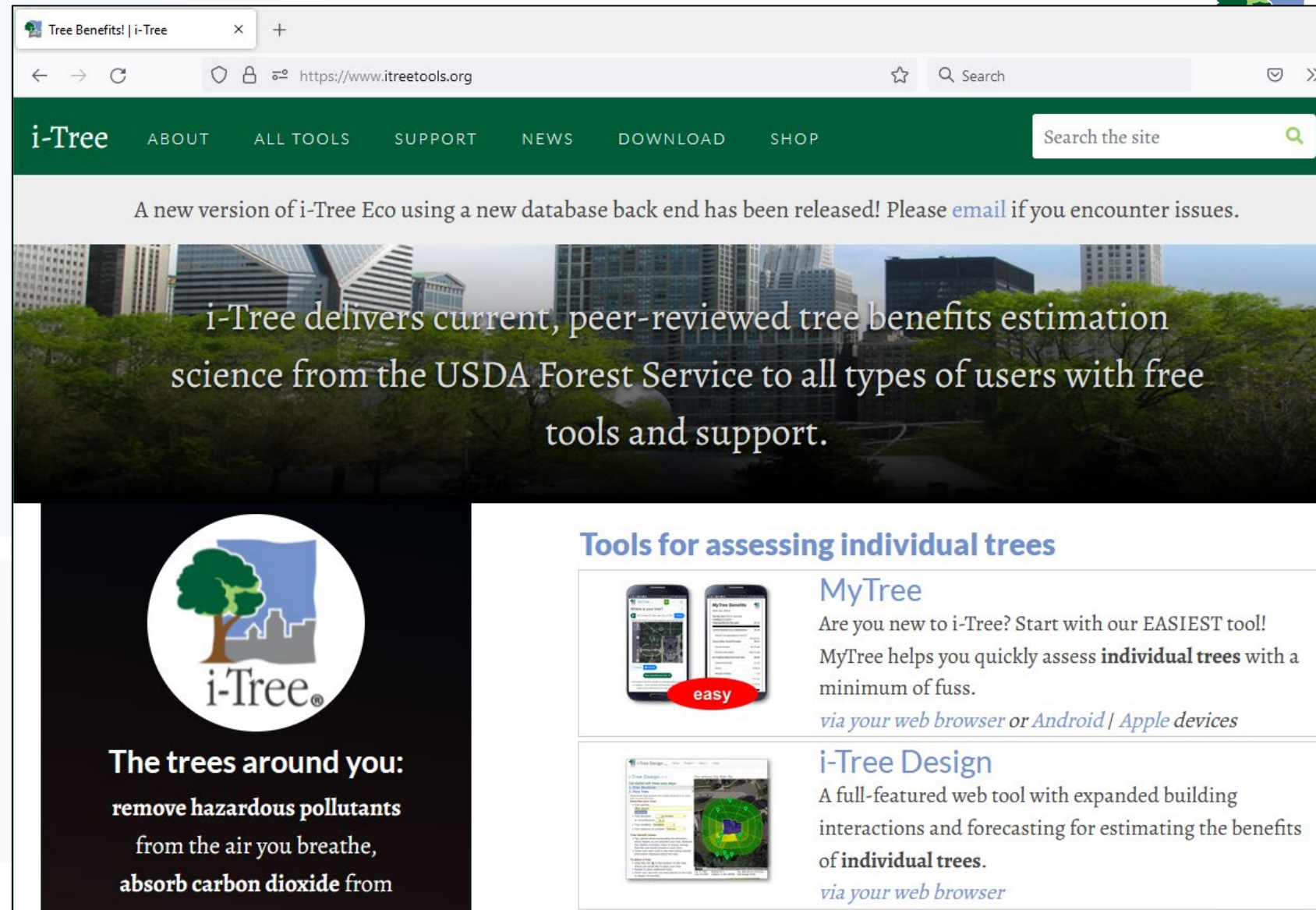


What is i-Tree?

“Putting USFS Urban Forest science into the hands of users”

- Public domain science
- Free tools
- Technical support
- Continuously improved

www.itreetools.org



The screenshot shows the i-Tree website homepage. At the top is a green navigation bar with links: ABOUT, ALL TOOLS, SUPPORT, NEWS, DOWNLOAD, and SHOP. A search bar is on the right. Below the navigation bar is a large banner image of a city skyline with trees in the foreground. Text on the banner reads: "i-Tree delivers current, peer-reviewed tree benefits estimation science from the USDA Forest Service to all types of users with free tools and support." Below the banner, there are two main sections. The left section features the i-Tree logo (a tree and a city skyline) and the text: "The trees around you: remove hazardous pollutants from the air you breathe, absorb carbon dioxide from". The right section is titled "Tools for assessing individual trees" and contains two sub-sections: "MyTree" and "i-Tree Design". "MyTree" is described as the "EASIEST tool!" for quickly assessing individual trees with a minimum of fuss, available via web browser or Android/Apple devices. "i-Tree Design" is described as a full-featured web tool for estimating the benefits of individual trees, available via web browser.

Tree Benefits! | i-Tree


https://www.itreetools.org

i-Tree ABOUT ALL TOOLS SUPPORT NEWS DOWNLOAD SHOP

Search the site


A new version of i-Tree Eco using a new database back end has been released! Please [email](#) if you encounter issues.


i-Tree delivers current, peer-reviewed tree benefits estimation science from the USDA Forest Service to all types of users with free tools and support.

 i-Tree®

The trees around you:
remove hazardous pollutants
from the air you breathe,
absorb carbon dioxide from

Tools for assessing individual trees

 **MyTree**
Are you new to i-Tree? Start with our EASIEST tool!
MyTree helps you quickly assess **individual trees** with a minimum of fuss.
via your web browser or Android / Apple devices

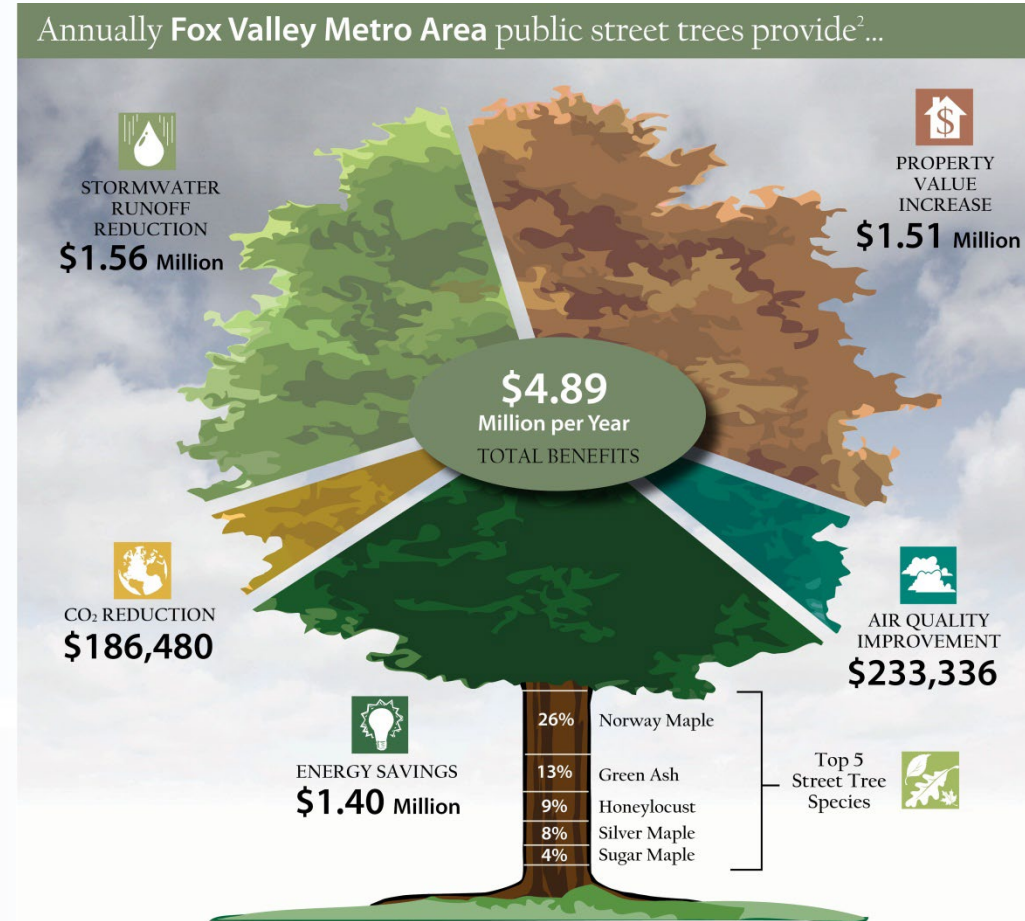
 **i-Tree Design**
A full-featured web tool with expanded building interactions and forecasting for estimating the benefits of **individual trees**.
via your web browser



i-Tree is a
Cooperative
Initiative



i-Tree: Demonstrating Tree Value



Structure → Function → Value

The 2022 i-Tree International Tools



MyTree

MyTree Benefits

Over 20 years.

Horse chestnut, (*Aesculus hippocastanum*)

Serving Size: 45.72 cm. diameter

Condition: Good

Expected over 20 years: \$381.59

Carbon Dioxide Sequestration	\$78.33
CO ₂ equivalent of carbon ¹	1,527.62 kg
Storm Water Mitigation	\$0.04
Runoff Avoided	16.28 L
Rainfall Intercepted	368.04 L
Air Pollution Removal	\$107.17
Carbon Monoxide	0.28 g
Ozone	11.95 g
Nitrogen Dioxide	1.55 g
Sulfur Dioxide	0.76 g
PM _{2.5}	0.61 g
Energy Usage ²	\$179.89
Electricity Savings (A/C)	2,376.13 kWh
Fuel Savings (natural gas, oil)	-12.9 MMBtu
Avoided Energy Emissions	\$16.20
Carbon Dioxide	282.03 kg

i-Tree Canopy

i-Tree Canopy

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 8/31/2022

SatelliteMapWhite

Land Cover

Category	% Covered
Grass/Herbaceous	25%
Impervious Buildings	15%
Impervious Other	22%
Impervious Road	8%
Soil/Bare Ground	3%
Tree/Shrub	47%
Water	2%

i-Tree Eco

i-Tree Eco

[Project: Inventario Merida YUC 1] [Series: Inventario] [Year: 2015] - i-Tree Eco v6.0.27

FileProject ConfigurationDataViewReportsForecastSupport

Project Submit Data Track & Written Composition Benefits Individual Pest Pollution Settings Model Metadata for Processing Retrieve Results Report and Structure - and Costs - Level Results - Analysis - Formatted Reports Charts Notes

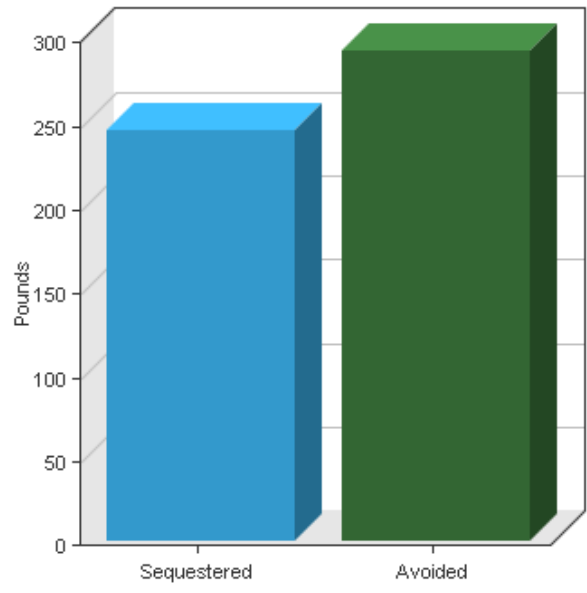
Reports > Formatted Reports > Written Report

I. Tree Characteristics of the Urban Forest

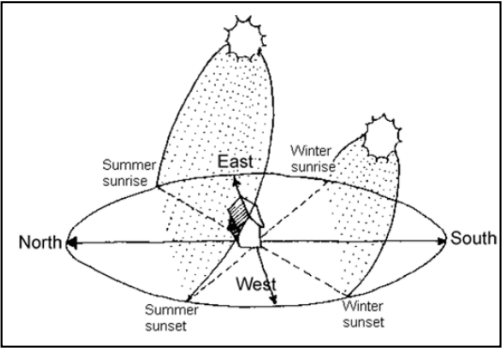
The urban forest of Inventario Merida YUC 1 has an estimated 2,318,000 trees with a tree cover of 21.2 percent. The three most common species are White lead tree (11.9 percent), Sour orange (10.2 percent), and Florida fishpoison tree (7.5 percent).

Species	Percentage
Other	47.7%
White lead tree	11.9%
Sour orange	10.2%
Florida fishpoison tree	7.5%
Gumbo limbo	6.6%
acacia spp	3.9%
Bahama lysiloma	3.1%
Coconut palm	2.4%
Hardwood	2.3%
banana spp	2.2%
coccoloba spp	2.2%

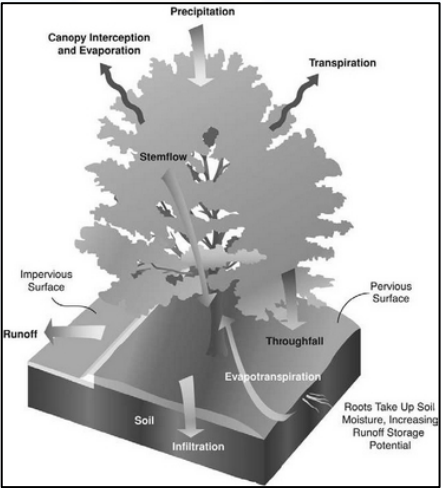
Tree Benefits 101: What does i-Tree Estimate and Why?



Carbon dioxide
Storage and sequestration
of a greenhouse gas

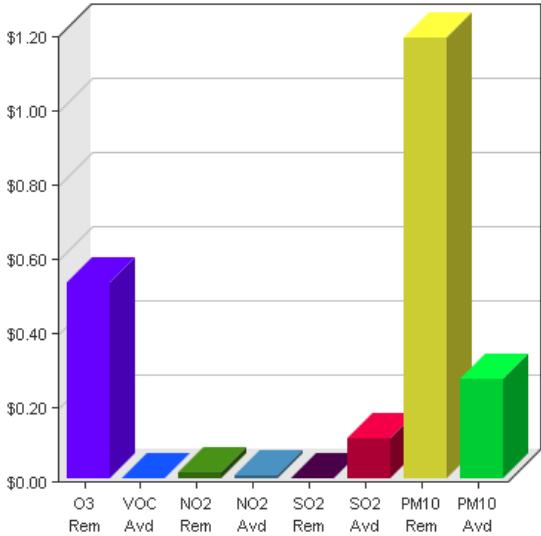


Energy
Tree impacts on
heating and cooling



Stormwater
Avoided runoff,
evaporation, transpiration

Air Quality
Interaction with EPA
criterion pollutants
resulting in improved
health



Carbon Step 1: Measure tree structure



Tree species = Shumard oak
dbh = 18.3 cm



Crown Light Exposure = 4



Crown dieback = 15%
Total tree height = 4.0 m



Carbon Step 1: Measure tree structure

Required:

Tree species = Shumard oak
d.b.h = 18.3 cm



Default:

Crown Light Exposure = 3



Default: Crown dieback = 17%

Modeled: Total tree height = 3.0 m



Carbon Step 2: Current carbon stored in a tree



Biomass Equations

Table 27.—Dry weight biomass equations, by species, used in i-Tree. x = d.b.h. in cm unless otherwise noted; Y= total tree dry weight biomass in kg unless otherwise noted. DHT: x = d.b.h.2 (cm2) x total tree height (m); AGB = aboveground dry weight biomass. These equations were derived from various sources (see Nowak 1994b, Nowak et al. 2002b, and GlobAllomeTree 2017).

Species	Equation form	A	B	C	D	E	F	G	x	Y
<i>Picea abies</i>	$Y=A+Bx+C^2X+D^3x+E^4x+F^5x$	10	-1.3638	0.4216	0.0041	-3E-05	1E-07			
<i>Picea glauca</i>	$Y=e^{(A+B \cdot \ln(X) + (C/2))}$	-1.73798	2.22809	0.05189						
<i>Picea rubens</i>	$Y=A+Bx+C^2X+D^3x+E^4x+F^5x+G^6x$	0.25	-0.3531	0.2983	0.0041	-4E-05	3E-07	-7E-10		
<i>Picea</i> spp.	$Y=e^{(A+B \cdot \ln(X) + (C/2))}$	-1.87821	2.25867	0.04823						
<i>Pinus banksiana</i>	$Y=A+Bx+C^2X+D^3x+E^4x+F^5x+G^6x$	0.21	-0.1925	0.1914	0.0051	-5E-05	3E-07	-9E-10		
<i>Pinus caribaea</i>	$Y=Ax^B$	0.07035	2.56							AGB (kg)
<i>Pinus contorta</i>	$Y=Ax^B$	0.11886	2.2333							

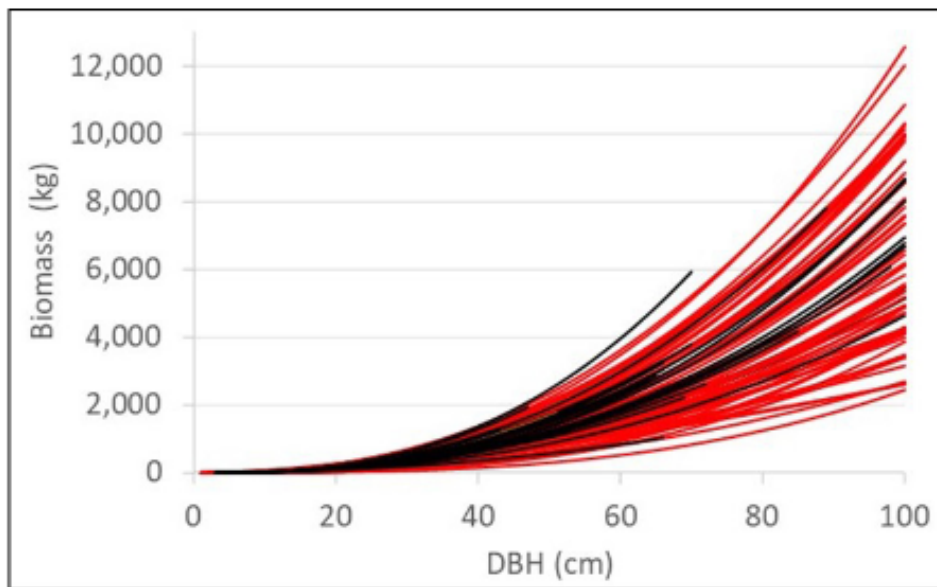


Figure 12.—Estimates of dry weight biomass for numerous species using various equations across a large diameter range. Red lines are i-Tree equation estimates (appendix 10); black lines are estimates from equations from Jenkins et al. (2003). Carbon estimates are one-half of dry weight biomass.

- Estimate tree dry weight biomass from existing species models
- Equations rely on species, dbh, and in some cases height
- Carbon currently stored in the tree is calculated at ½ of biomass

Understanding i-Tree document

<https://www.fs.usda.gov/treearch/pubs/63636>

Carbon Step 3: Estimate annual carbon sequestration



Estimate diameter growth

- Average rate for open grown trees = 0.84 cm/yr
- Adjust for growing season length
- Adjust for species (fast, medium, slow)
- Adjust for available sun based on crown light exposure
- Adjust for tree health based on dieback



Estimate carbon stored after growth

carbon seq. = carbon stored year 2 – carbon stored in year 1

Monetary value from the [US Social Cost of Carbon](#)

Air Pollution Step 1: Estimate tree structure

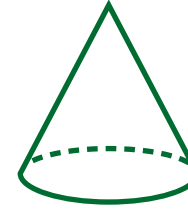
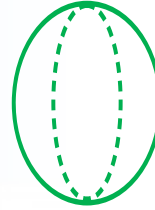
Leaf surface area

1. With at least dbh and species we can predict crown size measurements

$$\text{Red maple height} = e^{(2.6393 + (\ln(\text{DBH}) * 0.5613))}$$

46 cm red maple has an estimate height of 21.3 m

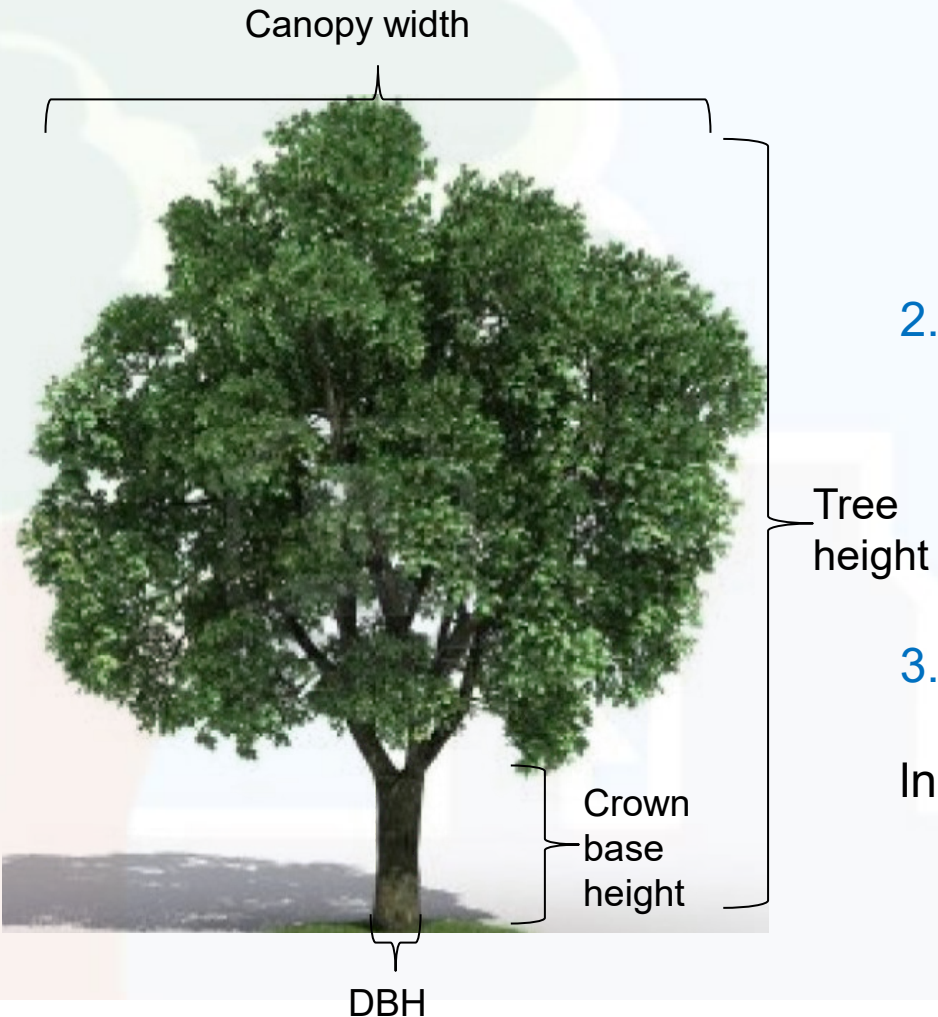
2. With crown size measurements we can estimate crown volume



3. With volume we can estimate leaf surface area

$$\begin{aligned} \ln(\text{leaf area}) = & -4.33 + 0.29 * \text{ht} + \\ & +0.7312 * \text{crown diam} \\ & + 5.72 * \text{species leaf density} \\ & + -0.015 * \text{crown surface area} \end{aligned}$$

Leaf surface area for
our 46 cm red maple =
543 sq m



Air Pollution Step 2: Estimate tree function

Gas exchange - NO_2 , O_3 , SO_2

Deposition - particulate matter ($\text{PM}_{2.5}$) and CO

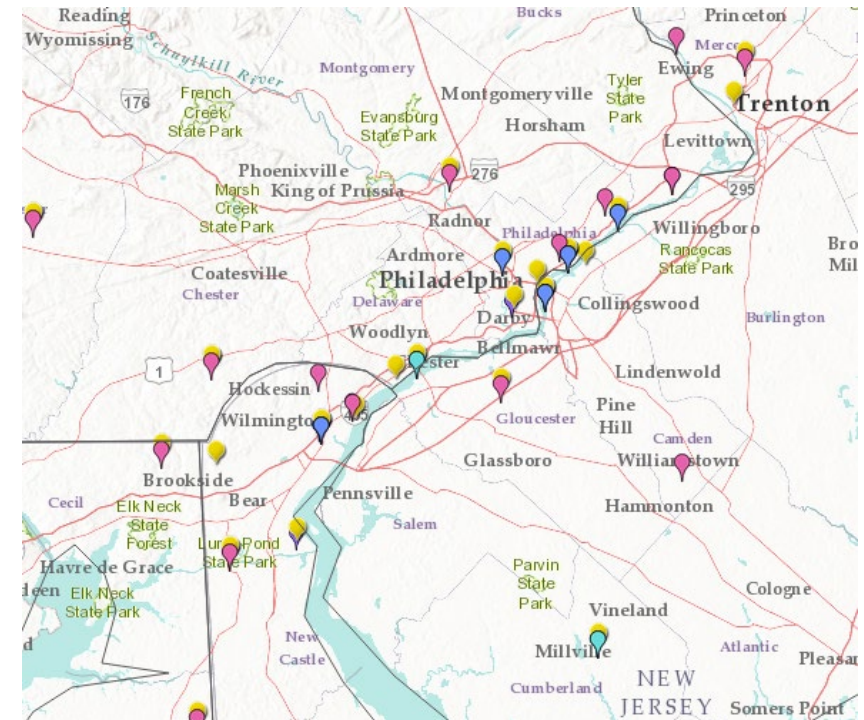
Local hourly weather data:

- windspeed
- sunlight
- rainfall
- humidity

Local hourly pollution data

Tree data

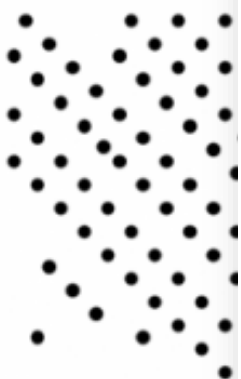
- Leaf area
- Leaf on/off dates
- Deciduous vs. evergreen



Air Pollution Step 3: Estimating value pollution removal value



Benefits M



An air quality
reduces the ni
hospital admis
100

	PM2.5	
	Incidence (Reduction/yr)	Value (\$/yr)
Acute Bronchitis	0.206	18.12
Acute Myocardial Infarction	0.051	4,543.25
Acute Respiratory Symptoms	112.666	11,043.29
Asthma Exacerbation	88.133	7,164.56
Chronic Bronchitis	0.086	24,042.76
Emergency Room Visits	0.134	55.73
Hospital Admissions		
Hospital Admissions, Cardiovascular	0.030	1,164.32
Hospital Admissions, Respiratory	0.026	821.49
Lower Respiratory Symptoms	2.486	129.08
Mortality	0.285	2,214,131.18
School Loss Days		
Upper Respiratory Symptoms	2.048	91.95
Work Loss Days	19.238	3,298.60
Total	225.389	2,266,504.33

data
tion
by age
pollution

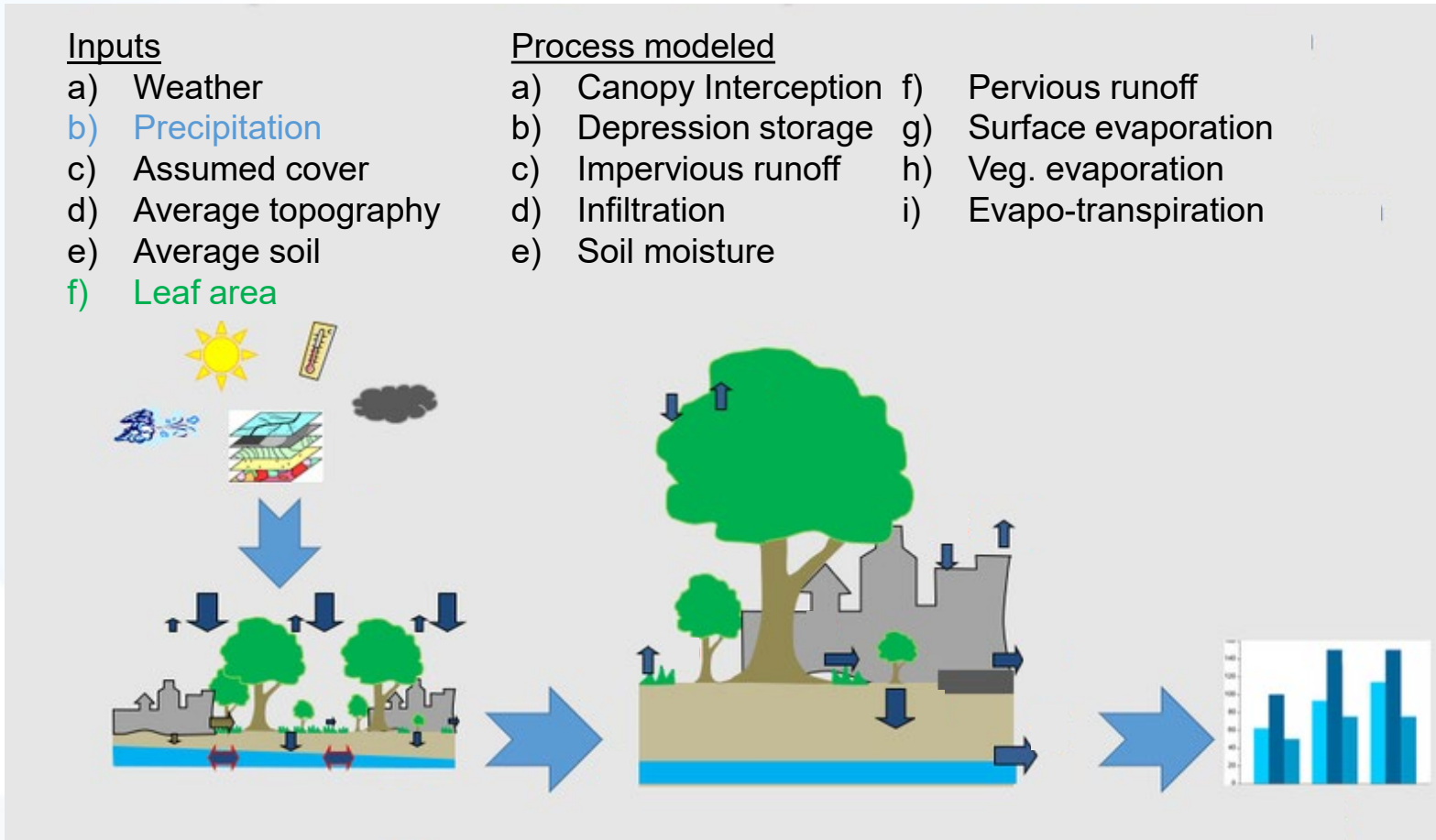
Stormwater



Step 1: Tree/forest structure measurements identical to air pollution to estimate total leaf area

Step 2: Process-based modeling at an hourly time step simulating all hydrology related benefits with and without vegetation

Step 3: Parse benefits to individual trees based on relative leaf area



Energy Step 1: Measure tree structure (within 18 m of house)



Required:

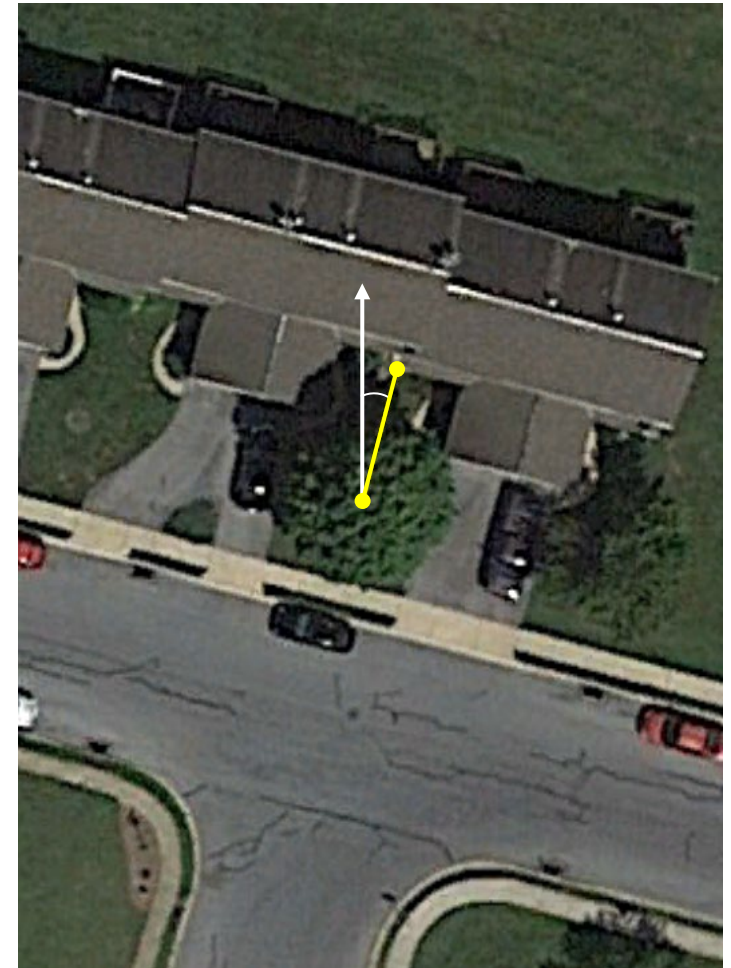
Tree species = Red maple
Total height = 12 m
(can be derived from dbh)

Required or Default:

Crown dieback = 5%
Crown missing = 25%

Required: Distance and direction to building

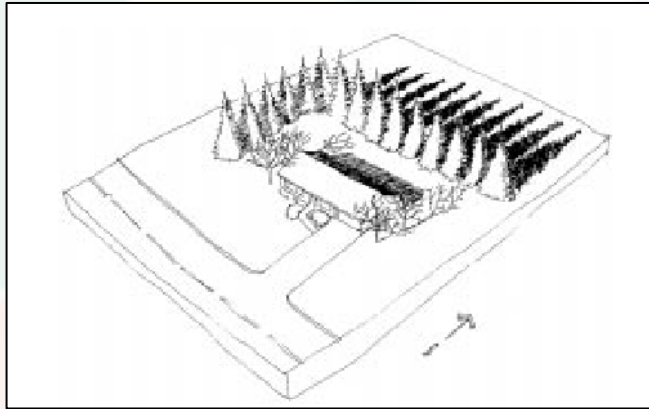
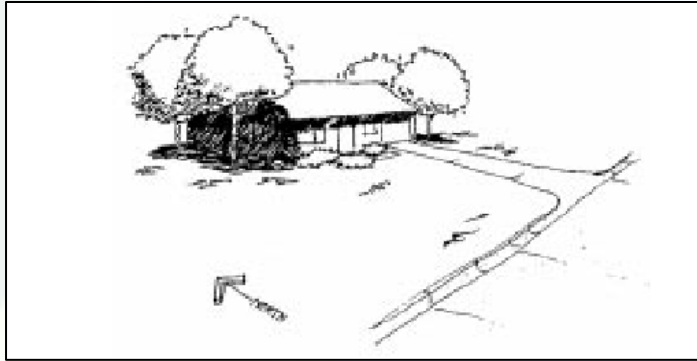
Distance to building = 7.4m
Direction to building = 14 degrees



Energy Step 2: Estimates of function

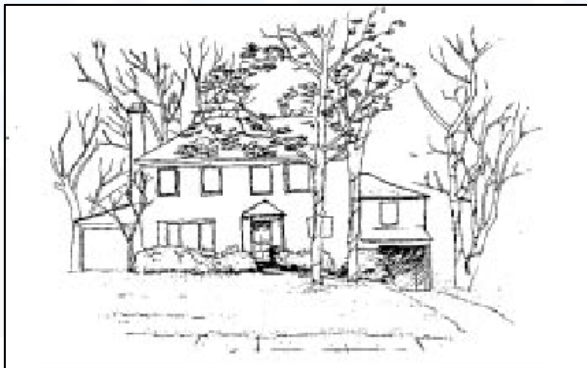


Shade
effects



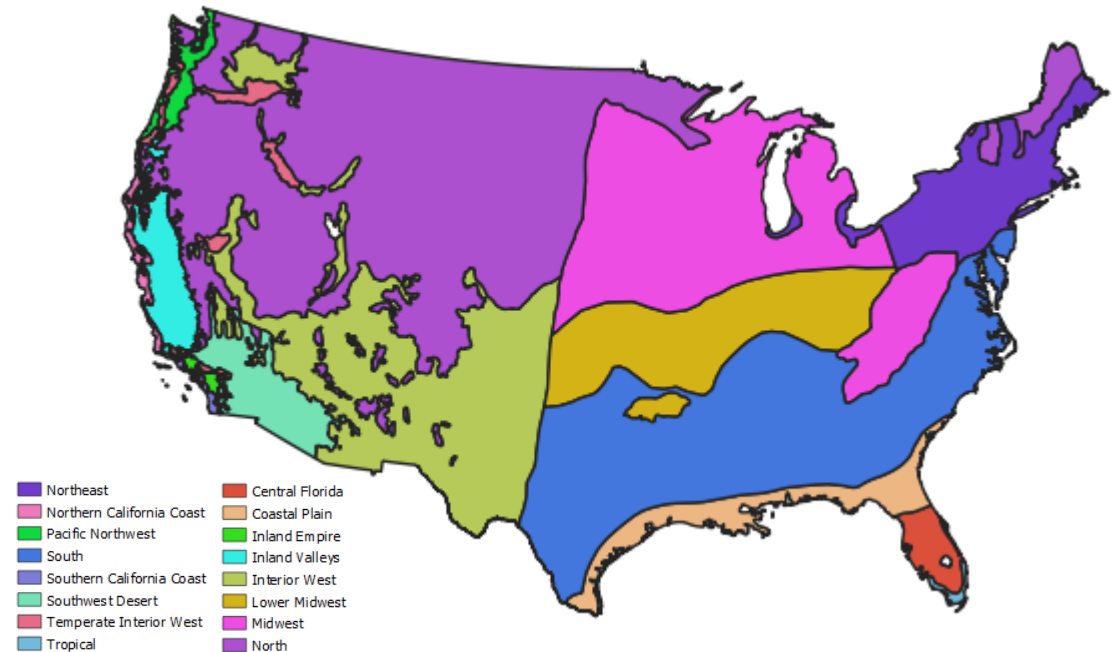
Windbreak
effects

Climate
effects



Influenced by

- climate region
- building vintage
- tree size
- deciduous vs evergreen
- canopy cover
- distance and direction to building



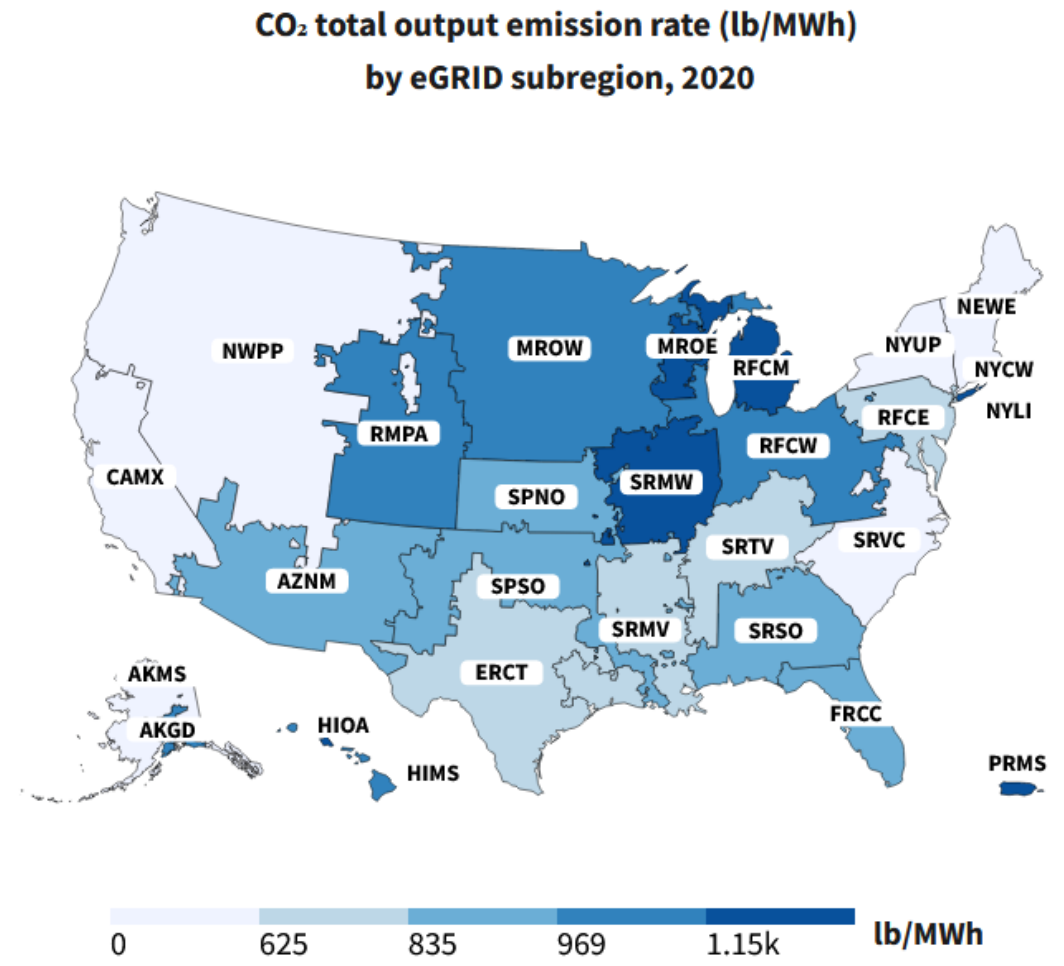
Energy Step 3: Estimate benefits



- Cooling – kwh
- Heating – kwh and therms
- Carbon avoided
- Pollution avoided

State level energy mixes and pollution rates per Therm and kwh from [eGRID](#)

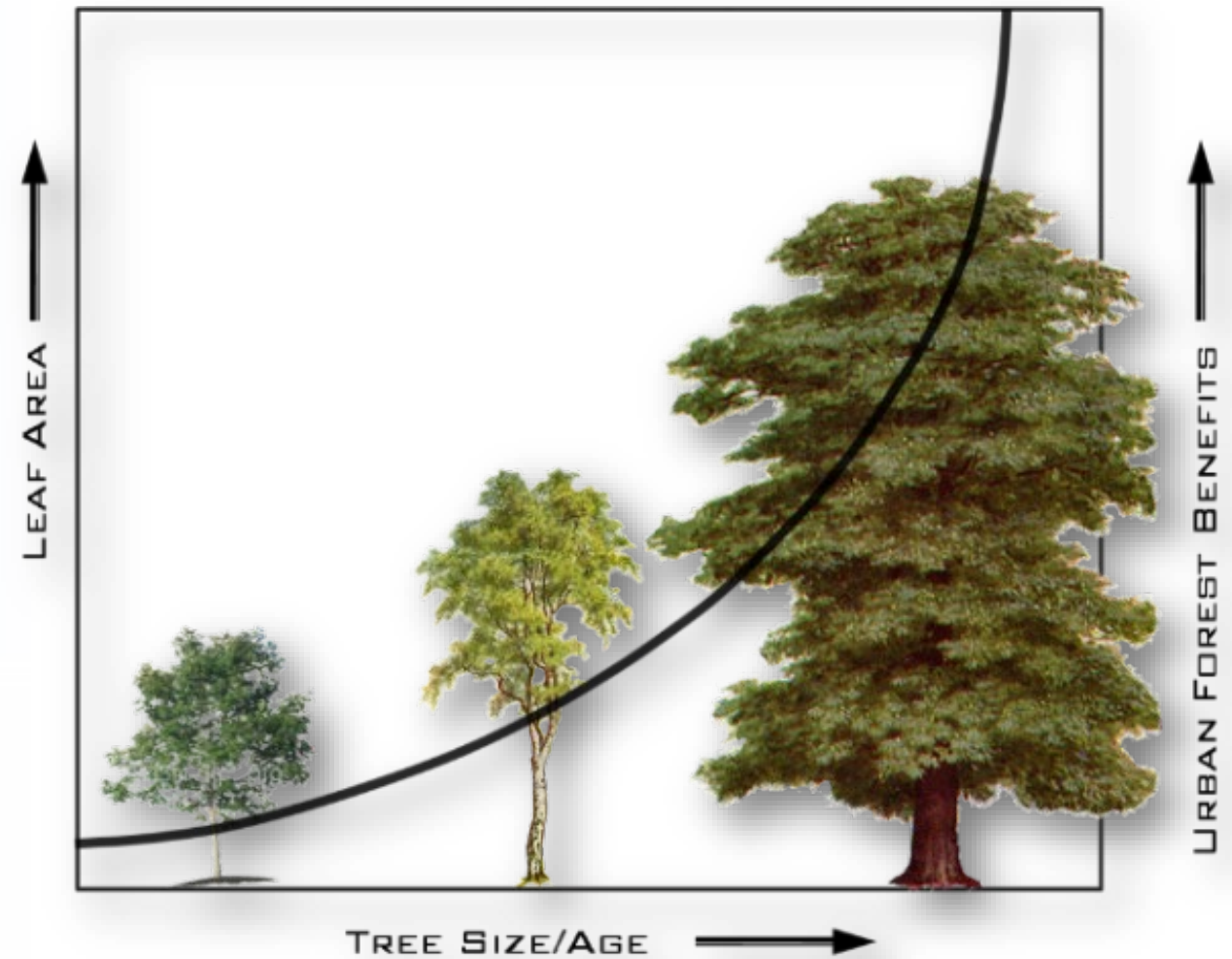
Billing Details		Page 2
Previous Balance	\$145.80	
Payment Received Jun 27, 2011 - Thank You!	-\$145.80	
Balance as of Jul 6, 2011		\$0.00
Charges for - Electric Supplier 1234		
Generation & Transmission Charges		
General Service Rate: ESUP for Jun 3 - Jul 5		
Energy Charge 1429 Kwh@ \$.0949/Kwh	135.61	
Total Electric Supplier 1234 Charges		\$135.61
Charges for - PPL Electric Utilities		
Residential Rate: RS for Jun 3 - Jul 5		
Distribution Charge:		
Customer Charge	8.75	
1,429 kWh at 3.32300000¢ per kWh	47.49	
PA Tax Adj Surcharge at -0.27600000%	-0.16	
Total PPL Electric Utilities Charges		\$56.08
Amount Due By Jul 27, 2011		\$191.69
Account Balance		\$191.69



Key points about the science of i-Tree



- Based on research from dozens of different researchers and over 100 publications
- Research is continuously updated
- Estimates are generally conservative
- International estimates often begin based on US conditions, but customization is possible and recommended



For more information...

[Understanding i-Tree](#)

[i-Tree Methods webpage](#)

[USFS Treesearch archives](#)

www.itreetools.org

info@itreetools.org

jason.henning@davey.com

