

USDA Forest Service

# URBAN FOREST CONNECTIONS

*webinar series*

Second Wednesdays | 1:00 – 2:00 pm ET

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# THE SCIENCE AND FUTURE OF I-TREE

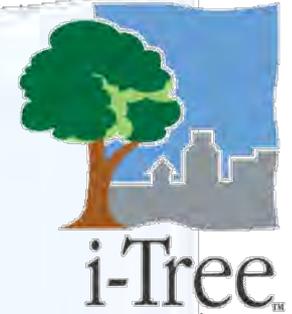


**David Nowak**

*Research Forester*

*USDA Forest Service*

# The Science and Future of i-Tree



*David J. Nowak  
USDA Forest Service  
Syracuse, NY*



i-Tree is a  
Cooperative  
Initiative



# Overview



- 🌳 Introduction and Science (20 minutes)
- 🌳 Q&A (10 minutes)
- 🌳 i-Tree Update (15 minutes)
- 🌳 Q&A (10 minutes)



i-Tree is a  
Cooperative  
Initiative



# What is i-Tree?

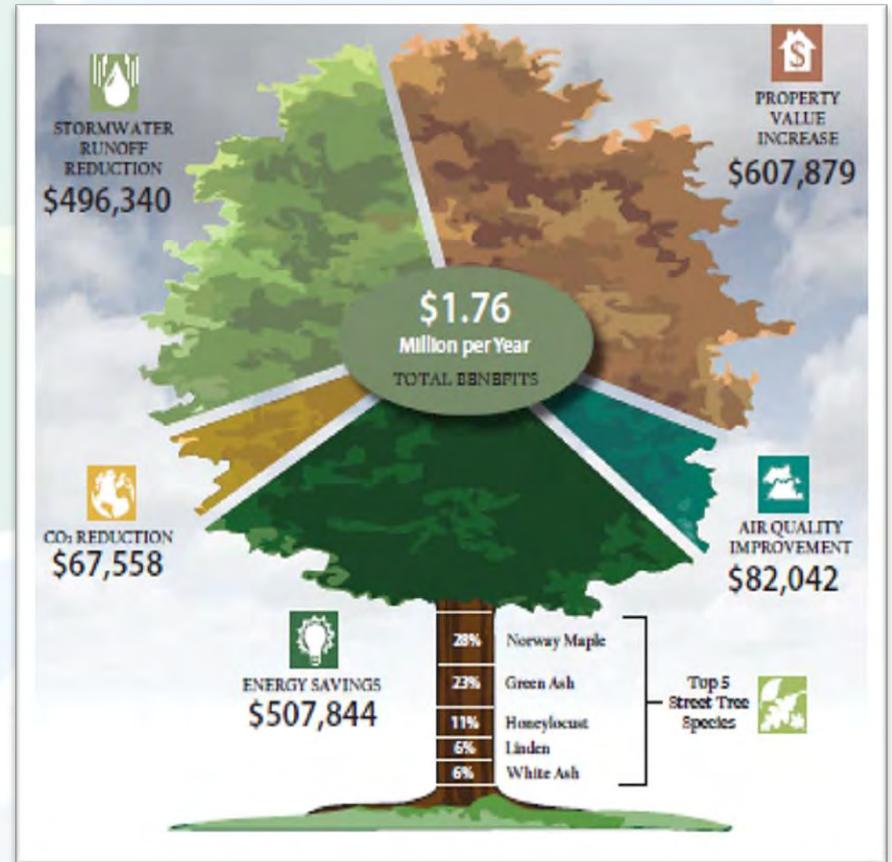


www.itreetools.org



A collaborative public-private partnership and suite of tools that provides:

- Assessment of current and future forest structure and benefits
- Optimal tree planting and design
- Sustainable and resilient forest management
- Public engagement in stewardship



i-Tree is a Cooperative Initiative



# What is i-Tree?



www.itreetools.org



**Purpose: Guide management decisions with best available science and local data**

- ❖ Designed to easily engage managers and general population
- ❖ Data are being used in innovative ways to make a difference:
- ❖ Management plans, advocacy, education, tree planting goals, etc.



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# What is i-Tree?



www.itreetools.org



A series of FREE tools to quantify ecosystem services and values from trees (free support also)

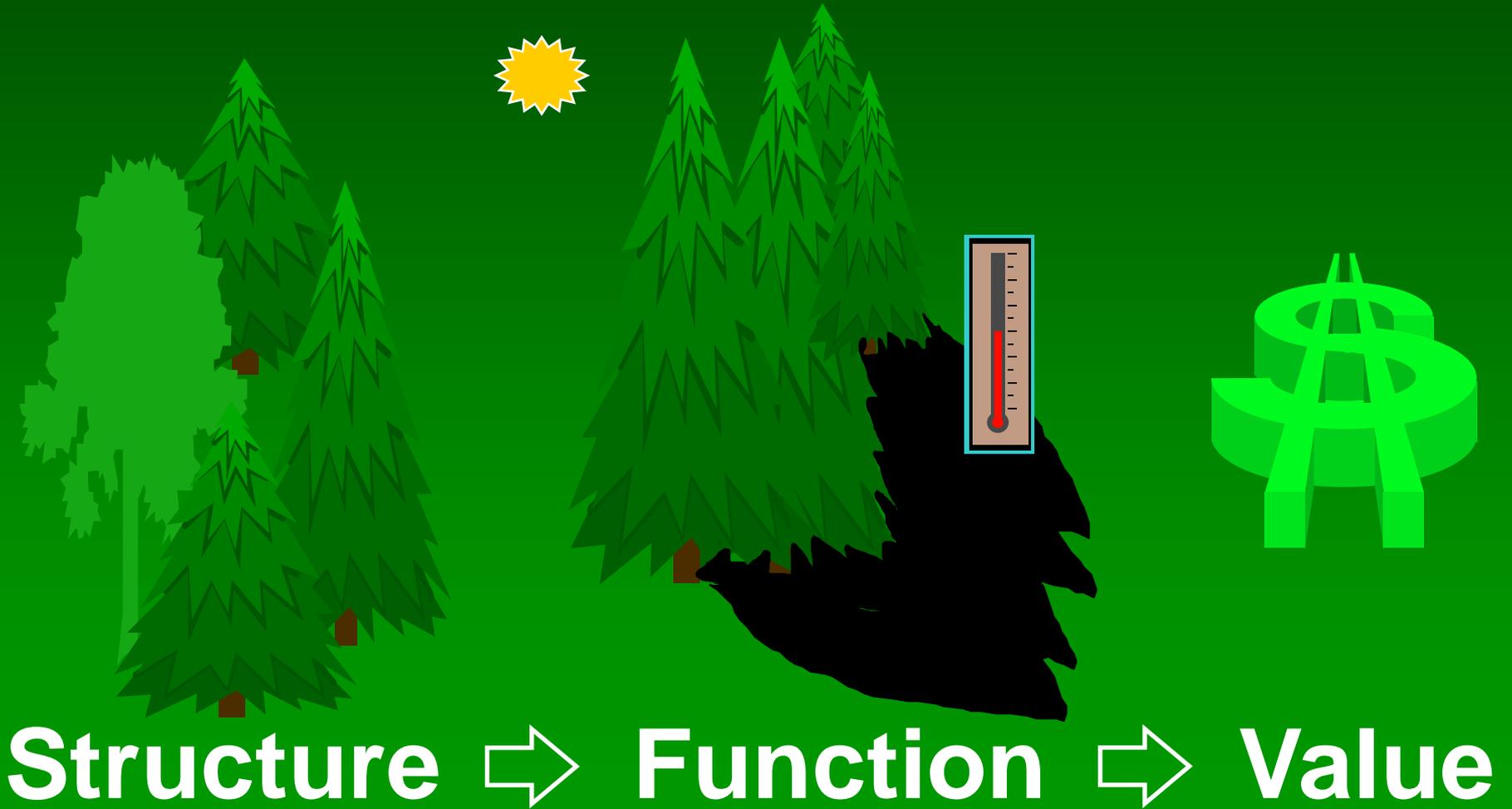


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# Model Framework

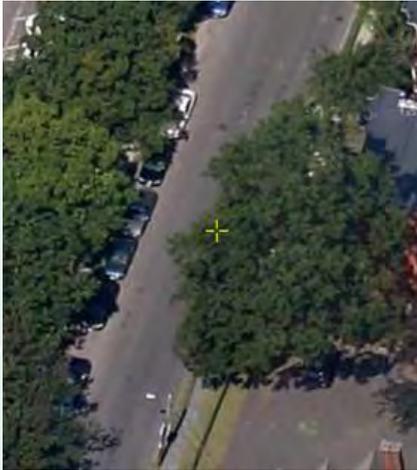


# Population model

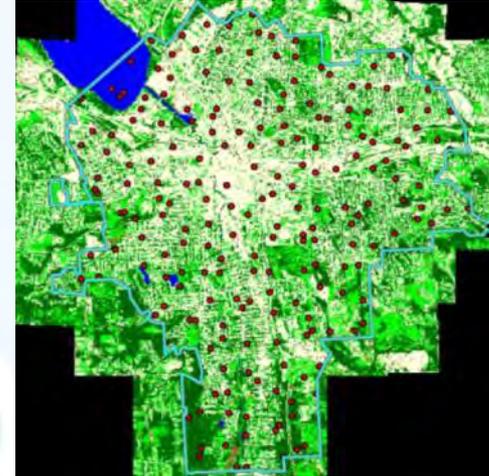
- 🌳 Good at estimating population totals
- 🌳 More discrepancy when predicting individuals
  - 🦋 Issue: predictive equations – tendency to mean
- 🌳 Ease of data collection vs more variables or instrumentation
- 🌳 Uses local environmental data (weather, pollution)
  - 🦋 Area average
  - 🦋 Local variation – NEXRAD, Fused data, Temp model
- 🌳 Structural variables are most important

# Assessing Urban Forest Structure

## Aerial



## Ground-based



# Science - Structure



- 🌳 Structure is critical starting point
- 🌳 Standard sampling statistics
  - 🌿 Inventory vs. sample
- 🌳 Standard error on measured variables
  - 🌿 No. trees, dbh, species counts, height
- 🌳 Standard error – derived variables
  - 🌿 Sampling error, not error of estimation
  - 🌿 Leaf area, leaf biomass, functions



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# Structural References



- Nowak, D.J. 1991. Urban Forest Development and Structure: Analysis of Oakland, California. PhD dissertation. University of California, Berkeley. 232p.
- Nowak, D.J. 1993. Historical vegetation change in Oakland and its implications for urban forest management. *J. Arboric.* 19(5):313-319.
- Nowak, D.J. 1994. Urban forest structure: the state of Chicago's urban forest. In: McPherson, E.G, D.J. Nowak and R.A. Rowntree. *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project.* USDA Forest Service General Technical Report NE-186. pp. 3-18; 140-164.
- Nowak, D.J. 1996. Estimating leaf area and leaf biomass of open-grown urban deciduous trees. *For. Sci.* 42(4):504-507.
- Nowak, D.J., R.A. Rowntree, E.G. McPherson, S.M. Sisinni, E. Kerkmann and J.C. Stevens. 1996. Measuring and analyzing urban tree cover. *Lands. Urban Plann.* 36:49-57.
- Nowak, D.J., J. Pasek, R. Sequeira, D.E. Crane, and V. Mastro. 2001. Potential effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on urban trees in the United States. *J. Econon. Entomol.* 94(1):116-122.
- Nowak, D.J., D.E. Crane, J.C. Stevens, and M. Ibarra. 2002. Brooklyn's Urban Forest. USDA Forest Service Gen. Tech. Rep. NE-290. 107p.
- Myeong, S., D.J. Nowak, P.F. Hopkins, and R.H. Brock. 2003. Urban cover mapping using digital, high-resolution aerial imagery. *Urban Ecosystems.* 5:243-256



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# Structural References (cont.)



- Peper, P.J. and E.G. McPherson. 2003. Evaluation of four methods for estimating leaf area of isolated trees. *Urban Forestry and Urban Greening* 2:19-29
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- Walton, J.T., D.J. Nowak, and E.J. Greenfield. 2008. Assessing urban forest canopy cover using airborne or satellite imagery. *Arboric. Urb. For.* 34(6): 334-340
- Nowak, D.J., J.T. Walton, J.C. Stevens, D.E. Crane, and R.E. Hoehn. 2008. Effect of plot and sample size on timing and precision of urban forest assessments. *Arboric. Urb. For.* 34(6): 386-390
- Woodall, C.W. D.J. Nowak, G.C. Likens, and J.A. Westfall. 2010. Assessing the potential for urban trees to facilitate forest tree migration in the eastern United States. *Forest Ecology and Management*. 259:1447-1454.
- Nowak, D.J. and E. Greenfield. 2010. Evaluating the National Land Cover Database tree canopy and impervious cover estimates across the conterminous United States: A comparison with photo-interpreted estimates. *Environmental Management*. 46: 378-390.
- Nowak, D.J. and E.J. Greenfield. 2012. Tree and impervious cover change in U.S. cities. *Urban Forestry and Urban Greening*. 11:21-30.



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# Structural References (cont.)



- 🌳 Nowak, D.J. and E.J. Greenfield. 2012. Tree and impervious cover in the United States. *Landscape and Urban Planning*. 107: 21– 30
- 🌳 Nowak, D.J. 2012. Contrasting natural regeneration and tree planting in 14 North American cities. *Urban Forestry and Urban Greening*. 11: 374– 382
- 🌳 Nowak, D.J., R.E. Hoehn, A.R. Bodine, E.J. Greenfield, J. O’Neil-Dunne. 2013. Urban Forest Structure, Ecosystem Services and Change in Syracuse, NY. *Urban Ecosystems*. DOI 10.1007/s11252-0
- 🌳 Nock, C.A., A. Paquette, M. Follett, D.J. Nowak and C. Messier. 2013. Effects of urbanization on tree species functional diversity in eastern North America. *Ecosystems* 16: 1487-1497



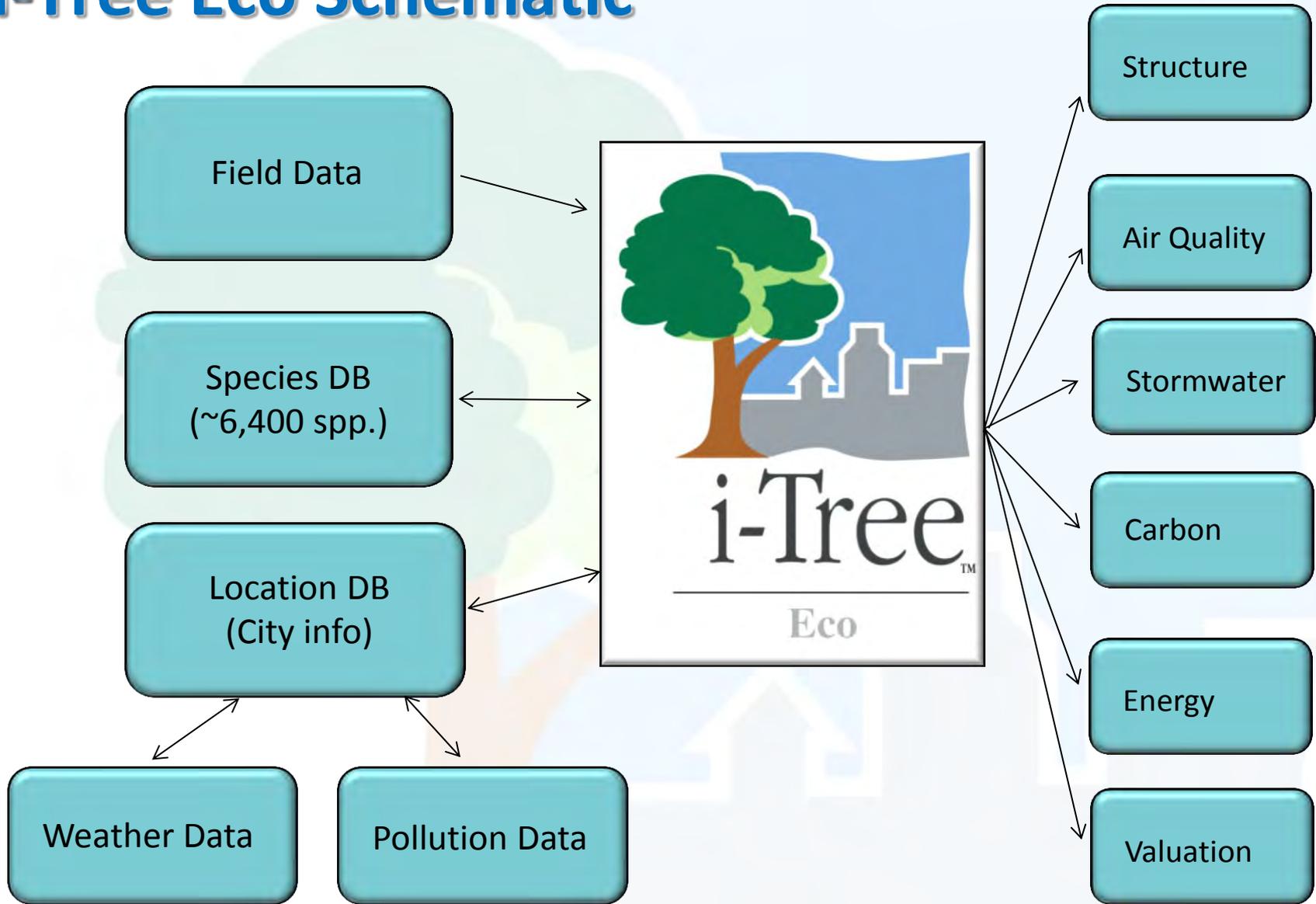
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# i-Tree Calculated Benefits

- Air quality improvement
- Water flow and water quality improvement
- Greenhouse gas reduction
- Building energy use conservation
- Oxygen production
- Health benefits
- Cooler air temperatures
- UV radiation reduction
- Pollen
- Wildlife habitat
- Insect biodiversity
- Products: timber, food, fiber, ethanol

# i-Tree Eco Schematic



i-Tree is a Cooperative Initiative



# Function Process



- 🌳 Determine link between structure and functions
- 🌳 Develop or use algorithms that predict functions based on structural estimates
- 🌳 Quantify impact of function
- 🌳 Peer-reviewed papers on methods
- 🌳 Additional detailed model documentation of methods is on i-Tree web site
- 🌳 Outputs tested against measured variables



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# Air Pollution Removal



- 🌳 Inputs: Daily leaf area; hourly weather and pollution data
- 🌳 Methods: dry deposition modeling (gas exchange)
- 🌳 Certainty: hourly rates in line with measured rates
  - 🌿 Max and min values given (limitation – drought)

- 🌳 Nowak, D.J. 1994. Air pollution removal by Chicago's urban forest. In: McPherson, E.G, D.J. Nowak and R.A. Rowntree. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186. pp. 63-81.
- 🌳 Nowak, D.J., P.J. McHale, M. Ibarra, D. Crane, J. Stevens, and C. Luley. 1998. Modeling the effects of urban vegetation on air pollution. In: Gryning, S.E. and N. Chaumerliac (eds.) Air Pollution Modeling and Its Application XII. Plenum Press, New York. pp. 399-407.
- 🌳 Nowak, D.J., K.L. Civerolo, S.T. Rao, G. Sistla, C.J. Luley, and D.E. Crane. 2000. A modeling study of the impact of urban trees on ozone. Atmos. Environ. 34:1610-1613.
- 🌳 Nowak, D.J., D.E. Crane, J.C. Stevens, and M. Ibarra. 2002. Brooklyn's Urban Forest. USDA Forest Service Gen. Tech. Rep. NE-290. 107p.
- 🌳 Wu, Z. J.R. McBride, D.J. Nowak, J. Yang, and S. Cheng. 2003. Effects of urban forests on air pollution in Hefei City. Journal of Chinese Urban Forestry. 1: 39-43
- 🌳 Nowak, D.J., D.E. Crane and J.C. Stevens. 2006. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening. 4:115-123



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# Pollution References (cont.)



i-Tree

- Escobedo, F.J., J.E. Wagner, D.J. Nowak, C.L. De la Maza, M. Rodriguez, and D.E. Crane. 2008. Analyzing the cost-effectiveness of Santiago de Chile's policy of using urban forests to improve air quality. *J. Environ. Manage.* 86: 148-157
- Escobedo, F. and D.J. Nowak. 2009. Spatial heterogeneity and air pollution removal by an urban forest. *Landscape and Urban Planning.* 90:102-110
- Morani, A., D. Nowak, S. Hirabayashi, and C. Calfapietra. 2011. Tree Planting Locations in New York City to Enhance Pollution Removal Relative to Human Populations. *Environmental Pollution.* 159: 1040-1047
- Hirabayashi, S., C. Kroll, and D. Nowak. 2011. Component-based development and sensitivity analyses of an air pollutant dry deposition model. *Environmental Modeling and Software.* 26:804-816.
- Hirabayashi, S., C.N. Kroll and D.J. Nowak. 2012. Development of a distributed air pollutant dry deposition modeling framework. *Environmental Pollution.* 171: 9-17.
- Nowak, D.J., S. Hirabayashi, A. Bodine and R. Hoehn. 2013. Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. *Environmental Pollution.* 178: 395-402.
- Cabaraban, M.T., C. Kroll, S. Hirabayashi, and D. Nowak. 2013. Modeling of air pollutant removal by dry deposition to urban trees using a WRF/CMAQ/i-Tree Eco coupled system. *Environmental Pollution.* 176: 123-133
- Nowak, D.J. S. Hirabayashi, E. Ellis and E.J. Greenfield. 2014. Tree and forest effects on air quality and human health in the United States. *Environmental Pollution* 193:119-129
- Morani, A., D. Nowak, S. Hirabayashi, G. Guidolotti, M. Medori, V. Muzzini, S. Fares, G. Scarascia Mugnozza, C. Calfapietra. 2014. Comparing modeled ozone deposition with field measurements in a periurban Mediterranean forest. *Environmental Pollution* 195: 202-209



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# Carbon storage and sequestration



- 🌳 Inputs: Species, dbh, condition, location, crown competition
- 🌳 Methods: Allometric biomass equations; growth based on condition, length of growing season, crown competition (adding new equations and wood density conversions)
- 🌳 Certainty: standardized rates in line with FIA rates
  - 🌿 SE based on sampling error
- 🌳 Nowak, D.J. 1991. Urban Forest Development and Structure: Analysis of Oakland, California. PhD dissertation. University of California, Berkeley. 232p.
- 🌳 Nowak, D.J. 1993. Atmospheric carbon reduction by urban trees. *J. Environ. Manage.* 37(3):207-217.



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# Carbon references (cont.)



- Nowak, D.J. 1994. Atmospheric carbon dioxide reduction by Chicago's urban forest. In: McPherson, E.G, D.J. Nowak and R.A. Rowntree. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186. pp. 83-94.
- Nowak, D.J. and D.E. Crane. 2002. Carbon storage and sequestration by urban trees in the USA. Environ. Poll. 116(3):381-389.
- Nowak, D.J., J.C. Stevens, S.M. Sisinni, and C.J. Luley. 2002. Effects of urban tree management and species selection on atmospheric carbon dioxide. J. Arboric. 28(3):113-122.
- Pouyat, R.V., I.D. Yesilonis, and D. Nowak. 2006. Carbon storage by urban soils in the United States. J. Environ. Quality. 35:1566-1575.
- Heath, L.S., J.E. Smith, K.E. Skog, D.J. Nowak, and C.W. Woodall. 2011. Managed forest carbon estimates for the U.S. Greenhouse Gas Inventory, 1990-2008. Journal of Forestry. April/May: 167-173
- Nowak, D.J., E.J. Greenfield, R. Hoehn, and E. LaPoint. 2013. Carbon storage and sequestration by trees in urban and community areas of the United States. Environmental Pollution. 178: 229-236.



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# Oxygen production

- 🌳 Inputs: Species, dbh, condition, location, crown competition
- 🌳 Methods: conversion of carbon sequestration rates
- 🌳 Certainty: same as carbon
  - 🌿 SE based on sampling error
- 🌳 Nowak, D.J., R.H. Hoehn, and D.E. Crane. 2007. Oxygen production by urban trees in the United States. *Arboriculture and Urban Forestry*. 33(3):220-226

# VOC emissions



- 🌳 Inputs: Daily leaf biomass by species; hourly weather data
- 🌳 Methods: EPA BEIS modeling procedures
- 🌳 Certainty: standardized rates in line with BEIS rates

- 🌳 Geron, C.D.; Guenther, A.B.; Pierce, T.E. 1994. An improved model for estimating emissions of volatile organic compounds from forests in the eastern United States. *Journal of Geophysical Research*. 99(D6): 12,773-12,791.
- 🌳 Guenther, A. 1997. Seasonal and spatial variation in natural volatile organic compound emissions. *Ecological Applications*. 7(1): 34-45.
- 🌳 Guenther, A.; Hewitt, C.N.; Erickson, D.; Fall, R.; Geron, C.; Graedel, T.; Harley, P.; Klinger, L.; Lerdau, M.; McKay, W.A.; Pierce, T.; Scholes, B.; Steinbrecher, R.; Tallamraju, R.; Taylor, J.; Zimmerman, P. 1995. A global model of natural volatile organic compound emissions. *Journal of Geophysical Research*. 100 (D5): 8873-8892.
- 🌳 National Oceanic and Atmospheric Administration / U.S. Environmental Protection Agency. 2008. Biogenic Emissions Inventory System (BEIS) Modeling. <http://www.epa.gov/asmdnerl/biogen.html>.



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# Building Energy Conservation

🌳 Inputs: Tree height, condition, distance and direction from building, geographic location

🌳 Methods: Micropas and Shadow Pattern Simulator modeling

🌳 Certainty: unknown

🌳 McPherson, E.G. and J.R. Simpson. 1999. Carbon dioxide reduction through urban forestry: Guidelines for professional and volunteer tree planters. Gen. Tech. Rep. PSW-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p.

# Hydrology – water flow and runoff



- 🌳 Inputs: Daily leaf area; hourly weather data; DEM
- 🌳 Methods: physically based TOPMODEL design
- 🌳 Certainty: model calibrated against stream flow data

- 🌳 Wang, J., T.A. Endreny, and D.J. Nowak. 2008. Mechanistic simulation of urban tree effects in an urban water balance model. *Journal of American Water Resource Association*. 44(1):75-85.
- 🌳 Yang, Y., T. Endreny, and D. Nowak. 2011. iTree-Hydro: snow budget and stormwater pollutant updates for the urban forest hydrology model. *Journal of the American Water Resources Association*. 47(6):1211-1218.
- 🌳 Yang, Y. TA. Endreny, D.J. Nowak. In press. Simulating the effect of flow path roughness to examine how green infrastructure restores urban runoff timing and magnitude. *Urban Forestry & Urban Greening*
- 🌳 Yang, Y., T. Endreny, and D. Nowak. In Press. Simulating the two-peak hydrograph of urban runoff with parallel application of fast and slow advection-diffusion hydrograph models. *Hydrology and Earth System Sciences*



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# Modules in Development



## Air temperature effects

-  Yang Y., T.A. Endreny, and D J. Nowak. 2013. A physically-based local air temperature model. *Journal of Geophysics Research-Atmospheres*. 118: 1–15
-  Heisler, G., A. Ellis, D. Nowak and I. Yesilonis. In press. Modeling and picturing land-cover influences on air-temperature in and near Baltimore, MD. *Theoretical and Applied Climatology*

## Wildlife habitat

-  Lerman, S.B, K.H. Nislow, D.J. Nowak, S. DeStefano, D.I. King and D.T. Jones-Farrand. 2014. Using urban forest assessment tools to model bird habitat potential. *Landscape and Urban Planning*. 122:29-40.

## UV radiation reduction

-  Na, H.R., G.M. Heisler, D.J. Nowak, and R.H. Grant. 2014. Modeling of urban trees' effects on reducing human exposure to UV radiation in Seoul, Korea. *Urban Forestry and Urban Greening* 13:785-792



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# Value Processes



## Structure – CTLA process

-  Nowak, D.J. 1993. Compensatory value of an urban forest: an application of the tree-value formula. *J. Arboric.* 19(3):173-177.
-  Nowak, D.J., D.E. Crane, and J.F. Dwyer. 2002. Compensatory value of urban trees in the United States. *J. Arboric.* 28(4):194-199.

## Pollution removal – BenMAP or externality

-  U.S. Environmental Protection Agency (US EPA). 2012. Environmental Benefits Mapping and Analysis Program (BenMAP). <http://www.epa.gov/air/benmap/>
-  Nowak, D.J., S. Hirabayshi, A. Bodine and R. Hoehn. 2013. Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. *Environmental Pollution.* 178: 395-402.
-  Nowak, D.J. S. Hirabayashi, E. Ellis and E.J. Greenfield. 2014. Tree and forest effects on air quality and human health in the United States. *Environmental Pollution* 193:119-129

## Carbon – social cost of carbon

-  Interagency Working Group on Social Cost of Carbon, United States Government. 2013. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (3% discount rate)

## Energy – average state utility costs



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# Value Processes



## Runoff reduction – average treatment costs

 McPherson et al., Peper et al. and Vargas et al. 16 Regional Community Tree Guides. PSW General Technical Reports.

## Oxygen

 Nowak, D.J., R.H. Hoehn, and D.E. Crane. 2007. Oxygen production by urban trees in the United States. *Arboriculture and Urban Forestry*. 33(3):220-226

## VOC emissions – need to convert to secondary pollutants



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# Model Differences

- 🌳 Field data required
  - 🌿 i-Tree Eco and Design



- 🌳 Average effects per unit tree cover
  - 🌿 State (carbon) or county (pollution removal) averages
  - 🌿 i-Tree Canopy
  - 🌿 i-Tree Landscape
    - 🌿 Entry level program
    - 🌿 Will be coupled to i-Tree Eco



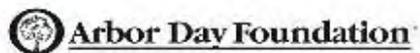
# Questions?



[www.itreetools.org](http://www.itreetools.org)



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# i-Tree Update



- 🌳 Urban FIA
- 🌳 2015 release
  - 🌿 i-Tree Eco
    - 🌿 Forecast
  - 🌿 i-Tree Landscape
- 🌳 Upcoming features



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# Urban FIA (Forest Inventory and Analysis)



- 🌳 Pilot testing protocols since the late 1990's
  - 🌿 State assessments through the early 2000s
- 🌳 2014 Farm Bill – Urban FIA
  - 🌿 Shift to metro areas
- 🌳 Panel system; 200 1/6 acre plot with microplots
- 🌳 Selection based on partnership
  - 🌿 2015 – Austin\*, Baltimore
  - 🌿 2016 – Houston\*, Madison, Milwaukee, St. Louis, Providence, Des Moines
- 🌳 Goal – top 200 metro areas



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# Eco Updates (2015)



**Project Overview**

Enter basic Overview information about your project

Project Info | Location | Data Collector Options

What name would you like to give your new project?

Project Name: Adrian

What name would you like to give your series?

Series Name: Adrian\_2012

Please specify the series year for your project:

Series Year: 2012

Please specify the following inventory information:

Sample Type: Walk Survey

Sample Method: Stratified Random

**Help**

Project Configuration > Define Data Files > Overview > Project Info

The Project Info tab is visible in the active panel on the right. This is the place where you identify many of your most important project settings.

**Steps:**

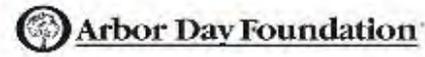
1. Enter a name for your project in the box provided. Your project name gives you a first-hand idea of unique identity. This is also the name that will be used when referring to your study area in your model results. (Available for the desktop version of the software).
2. Enter a series name for your project in the box provided. Again, your series name helps to give your project a unique identity. This series name can be used in the future to reference the data for this project.
3. Enter a series year in the box provided. Then, select the weather and pollution year that you would like to use for your analysis by choosing a year from the drop-down lists. Series year is used to give your project a unique identity. It is recommended that you enter the year of your data collection for this variable.

i-Tree has access to weather and pollution data provided from the U.S. Environmental Protection Agency's (EPA) pollution removal, provided by the Urban Forest in your study area. Weather and pollution data are available for 2005 to 2010.

4. Specify your inventory information by choosing the inventory and sample types from the drop-down lists (see boxes below).

The two types of inventories are plot-based samples or complete inventory.

- A plot-based inventory is a method of data collection that involves established one sample plots within your study area. This type of inventory is most appropriate for large-scale study areas (e.g., city) that would then be collected for all of the trees in your sample plots.
- A complete inventory is a method of data collection that involves collecting data for all of the trees within your study area and is generally more appropriate for small, all discrete areas (e.g., park).



# Eco Updates (2015)



**Project Configuration**

**Basic Overview information about your project**

Project Name: Adrian

Series Name: Adrian\_2012

Series Year: 2012

Sample Type: Walk Survey

Sample Method: Stratified Random

**Help**

Project Configuration > Define Data Files > Overview > Project Info

The Project Info tab is visible in the action panel on the right is the place where you identify many of your most important project settings.

**Steps:**

1. Enter a name for your project in the box provided. Your project name gives you a tree-based project a unique identity. This is also the name that will be used when referring to your study area in your model results. (Available from the beginning of the software).
2. Enter a series name for your project in the box provided. Again, your series name helps to give your project a unique identity. This series name can be used in the future to reference the data for this project.
3. Enter a series year in the box provided. Then, select the weather and pollution year that you would like to use for your analysis by choosing a year from the drop-down lists. Series year is used to give your project a unique identity. It is recommended that you enter the year of your data collection for this variable.

i-Tree tree uses weather and pollution data provided from the U.S. Environmental Protection Agency's (EPA) pollution removal, provided by the Urban forest in your study area. Weather and pollution data are available for 2005 to 2010.

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# Simulating forest growth



## Forecast

Project Variables

Management Scenarios

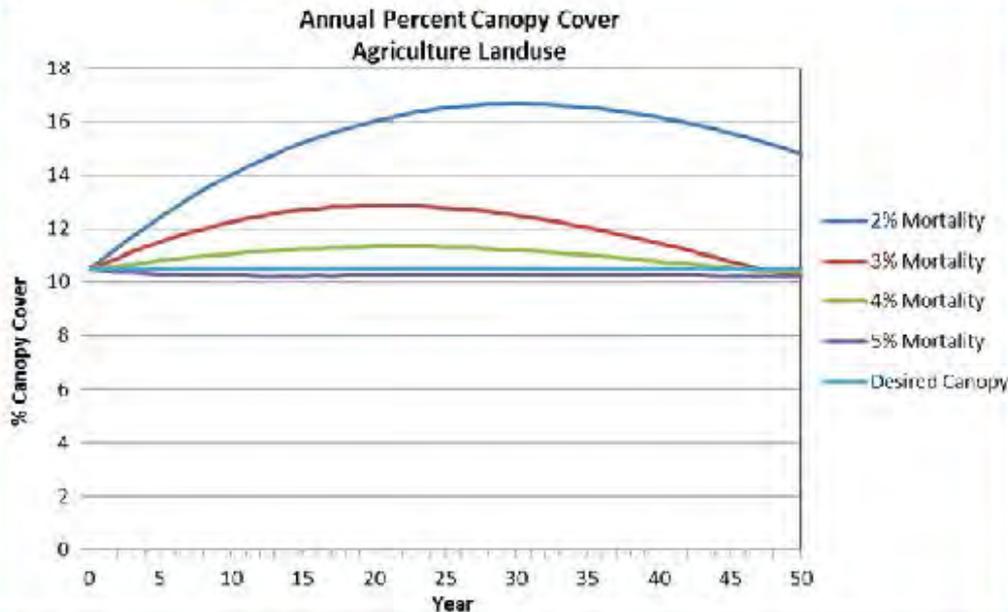
Canned Scenarios

Model Outputs

Help

Total

By Land Use



### Agriculture Land Use - Desired Canopy = 10.5 %

Years	Mortality (%)	Output Canopy (%)	Trees Planted
50	2	14.78	0
50	3	10.25	63,000
50	4	10.37	201,000
50	5	10.2	340,000

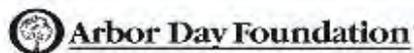
Table

Graph

Next Land Use



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# i-Tree Landscape



- 🌳 National NLCD land cover, tree cover and impervious cover
- 🌳 Local UTC tree and impervious cover (where available)

The screenshot shows the i-Tree Landscape website interface. At the top, there is a navigation bar with the i-Tree logo, the text "i-Tree Landscape v0.5", and links for "Project List" and "Help". On the right side of the navigation bar are "Sign Up" and "Login" buttons. Below the navigation bar is a large heading "Welcome to i-Tree Landscape! v0.5". Underneath this heading is a paragraph of introductory text. To the right of the text is a large i-Tree Landscape logo and a "Get Started" button. Below the text and logo is a horizontal flowchart with five steps: "Get Started", "Explore Place", "See Tree Benefits", "Prioritize Tree Planting", and "Generate Outputs". Each step is represented by a blue dot and a corresponding thumbnail image. The "See Tree Benefits" thumbnail shows a table with air quality data for Ozone and PM2.5 in Washington.

Ozone	
\$	g/m <sup>3</sup> /yr
90122.16	8.59
PM2.5	
\$	g/m <sup>3</sup> /yr
202948.10	0.42

By removing carbon dioxide, trees help mitigate climate change. The shade provided by urban tree canopies can also help tame the urban heat island effect. In addition, trees intercept storm water, which can reduce flooding and improve water quality within their watershed. And, as if more benefits were needed, trees reduce air pollution, such as ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and fine particulate matter-the reduction of which has proven benefits to human health. Trees truly can improve our lives! Click the Get Started button and begin exploring.

Logos of partner organizations are displayed at the bottom of the interface:

- Forest Service UAS (United States Department of Agriculture)
- DAVEY
- Arbor Day Foundation
- SMA (Society of Municipal Arborists)
- ISA (International Society of Arboriculture)
- Casey Trees (Washington DC)
- ESF (Ecological Services Foundation)
- NAASF (Northeastern Area Association of State Foresters)



i-Tree is a Cooperative Initiative



# i-Tree Landscape – Select Area



File Edit View Favorites Tools Help



i-Tree Landscape v.3.3

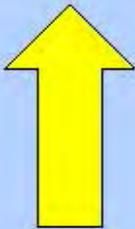
Project List

Help

Sign Up

Login

syracuse ny



Pin or Select

Map Layers

Canopy & Land Layers

Use Maps

Select By

( **ctrl** + **click** ) to select multiple regions.

Process Statistics

Find Locations

Examine Location Data

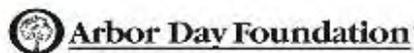
See Tree Benefits

Prioritize Tree Planting

Generate Results



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# i-Tree Landscape – Select Analysis Groups



i-Tree Landscape [Project List](#) [Help](#) [Sign Up](#) [Login](#)

Map Layers

Administrative

- Block Groups
- Places
- Congressional Districts
- Counties
- States

Water

- Lakes
- Rivers

Canopy & Land Layers

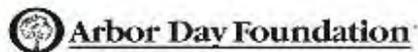
Basic Maps

Select by

(ctrl + click) to select multiple regions.

[Process Statistics](#)

[Find Locations](#) [Examine Location Data](#) [See Tree Benefits](#) [Prioritize Tree Planting](#)



# i-Tree Landscape – View Land Cover (NLCD)



File Edit View Favorites Tools Help



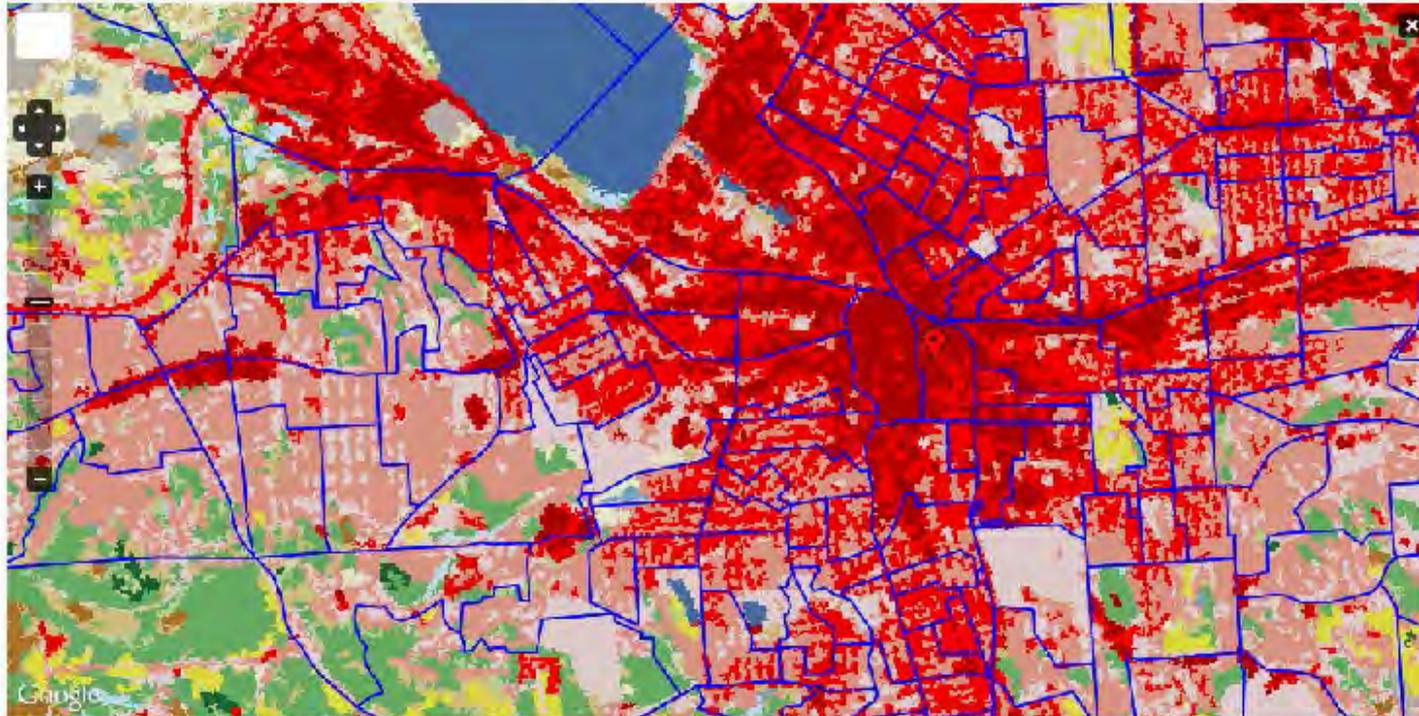
i-Tree Landscape

Project List

Help

Sign Up

Login



Find Locations

Examine Location Data

See Tree Benefits

Prioritize Tree Planting

Full or Select

Map Layers

Administrative

Block Groups

Places

Congressional Districts

Counties

States

Water

Courses

Riparian

Canopy & Land Layers

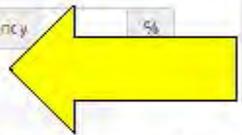
Canopy Cover

Transparency 0 %

Impervious Cover

Transparency %

Land Cover



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Arbor Day Foundation



# i-Tree Landscape



See tree and/or impervious cover

The screenshot displays the i-Tree Landscape web application interface. At the top, there is a navigation bar with 'File', 'Edit', 'View', 'Favorites', 'Tools', and 'Help' menus. The main header includes the 'i-Tree Landscape' logo, 'Project List', and 'Help' links, along with 'Sign Up' and 'Login' buttons. The central part of the interface is a map of Syracuse, NY, showing street grids, green spaces, and water bodies. A red location pin is placed in the city center. To the right of the map is a 'Map Layers' panel with the following sections:

- Pan or Select**: A button for map navigation.
- Map Layers**: A list of layers to toggle on or off.
  - Administrative**: Includes 'Block Groups' (checked), 'Places', 'Congressional Districts', 'Counties', and 'States'.
  - Water**: Includes 'Courses' and 'Riparian'.
  - Canopy & Land Layers**: Includes 'Canopy Cover' (checked) and 'Impervious Cover'. A large yellow arrow points to the 'Canopy Cover' checkbox.

Below the map, there are four main navigation buttons: 'Find Locations', 'Examine Location Data', 'See Tree Benefits', and 'Prioritize Tree Planting'. At the bottom of the interface, there is a row of partner logos: i-Tree, UAS, DAVEY, Arbor Day Foundation, SMA (Society of Municipal Arborists), ISA (International Society of Arboriculture), Casey Trees, and ESF.



i-Tree is a Cooperative Initiative





# i-Tree Landscape – Analyze Areas



File Edit View Favorites Tools Help



i-Tree Landscape

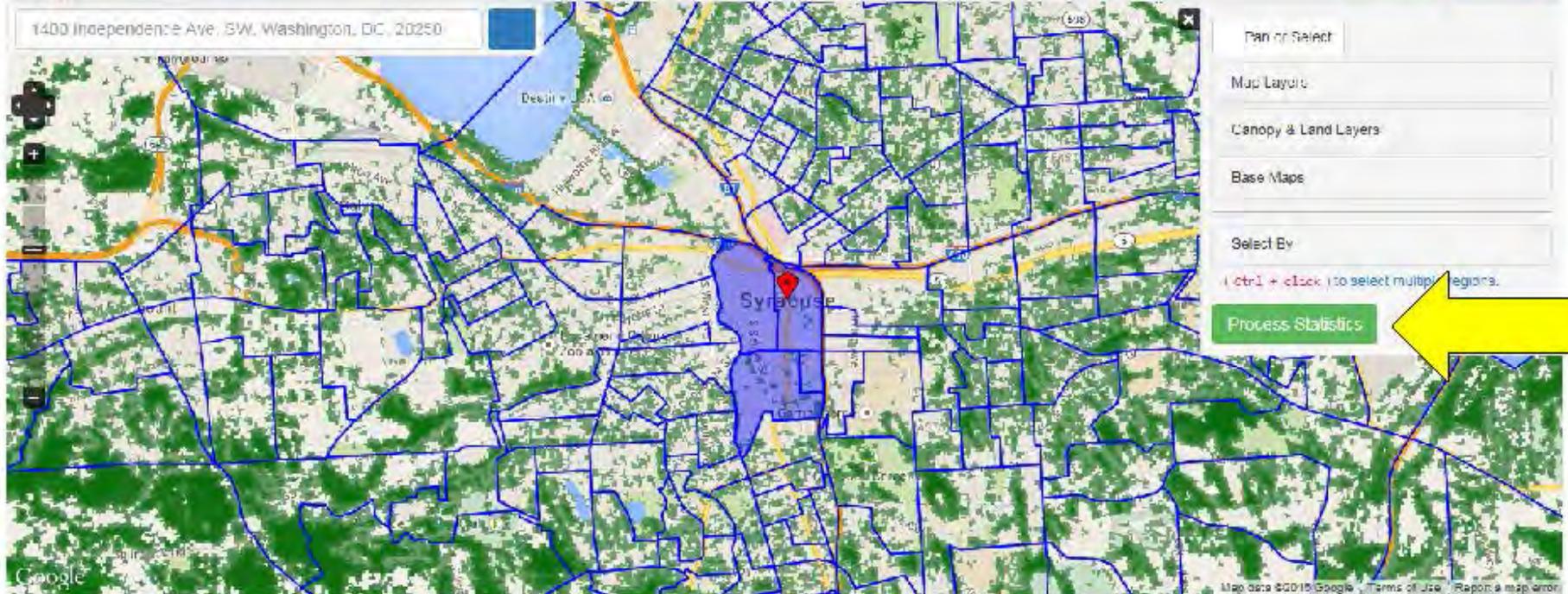
Project List

Help

Sign Up

Login

1400 Independence Ave. SW, Washington, DC, 20250



Find Locations

Examine Location Data

See Tree Benefits

Prioritize Tree Planting

Generate Results

Region	Area (m <sup>2</sup> )	Canopy Area (m <sup>2</sup> )	Canopy Percent	Impervious Area (m <sup>2</sup> )	Impervious Percent
<b>Total</b>	2144727.9	19006.0	0.9	1671000.2	77.9
380670042002	754404.4	14694.7	1.9	492052.1	64.9
3069922021	120510.0	1140.4	0.9	97559.0	50.4

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Initiative

# i-Tree Landscape – Analyze Areas



File Edit View Favorites Tools Help



i-Tree Landscape

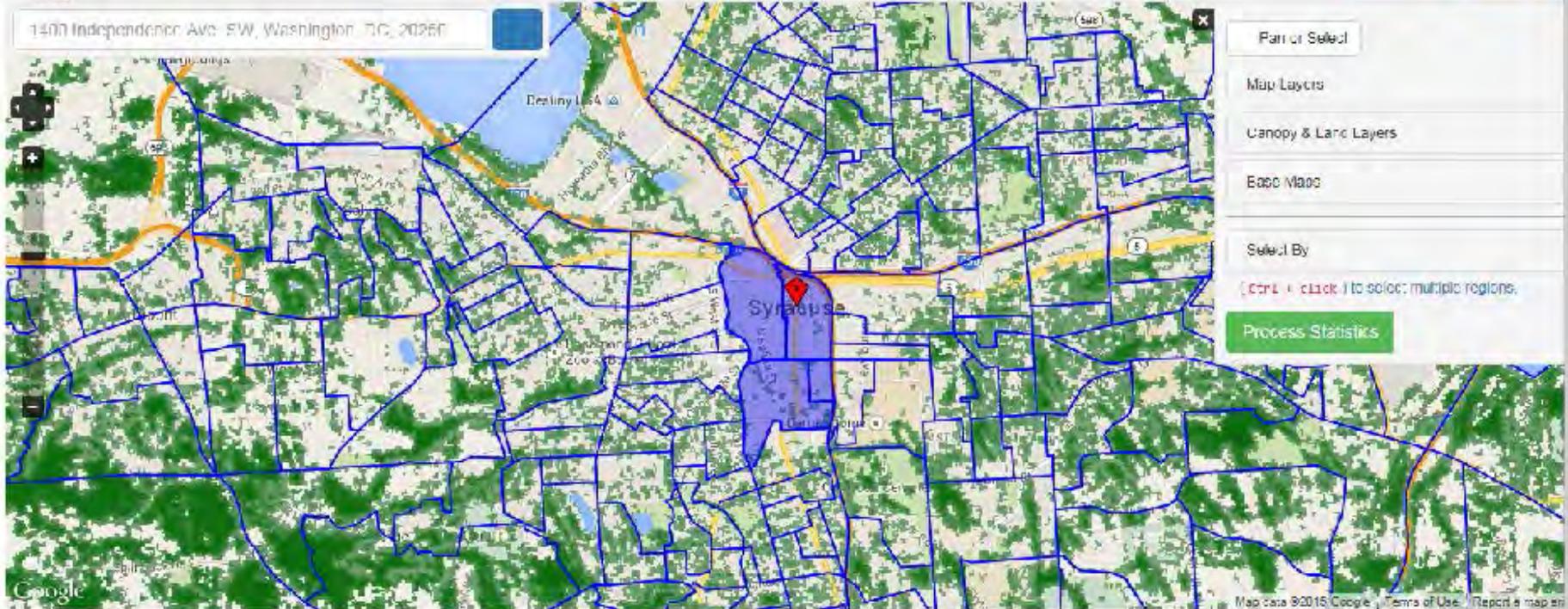
Project List

Help

Sign Up

Login

1400 Independence Ave. SW, Washington, DC, 20260



Full or Select

Map Layers

Canopy & Land Layers

Base Map

Select By

(Ctrl + click) to select multiple regions.

Process Statistics

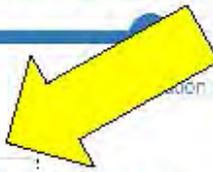
Find Locations

Region Data

See Tree Benefits

Prioritize Tree Planting

Generate Results



Canopy & Impervious **Land Cover** Census Data

Developed Forest Shrubland Herbaceous Planted/Cultivated Barren Wetlands Water

Developed, Open Space

Developed, Low Intensity

Developed, Medium Intensity

Developed, High Intensity

Region is a  
Cooperative  
Initiative

Total

17779.6

%

143935.1

%

627598.5

%

1355414.8

%

# i-Tree Landscape – Analyze Ecosystem Services



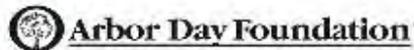
i-Tree Landscape [Project List](#) [Help](#) [Sign Up](#) [Login](#)

1460 Independence Ave. SW, Washington, DC, 20250

Map Layers  
Canopy & Land Layers  
Base Maps  
Select By  
(Ctrl + click) to select multiple regions  
Process Statistics



Carbon		Air Pollution		Hydrology		Carbon Storage		Carbon Sequestration		CO <sub>2</sub> Storage		CO <sub>2</sub> Sequestration	
Region		\$/yr	Tonne	\$/yr	Tonne	\$/yr	Tonne	\$/yr	Tonne	\$/yr	Tonne	\$/yr	Tonne
<b>Total</b>		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
360570142001		194.0	1.4	20.4	0.2	194.0	1.4	20.4	0.2	194.0	1.4	20.4	0.2
360570042001		33.1	0.2	4.0	0.0	33.1	0.2	4.0	0.0	33.1	0.2	4.0	0.1



# i-Tree Landscape



- 🌳 Can change tree cover to see how services change
- 🌳 Specify areas that meet criteria or custom areas
- 🌳 Optimize for planting or protection
- 🌳 Many layers to be added (e.g., soils, temperature, pollution)

i-Tree Landscape v0.3 Project List Help Sign Up Login

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Pan or Select

Map Layers

Canopy & Land Layers

Base Maps

Select By

( Ctrl + click ) to select multiple regions.

Process Statistics

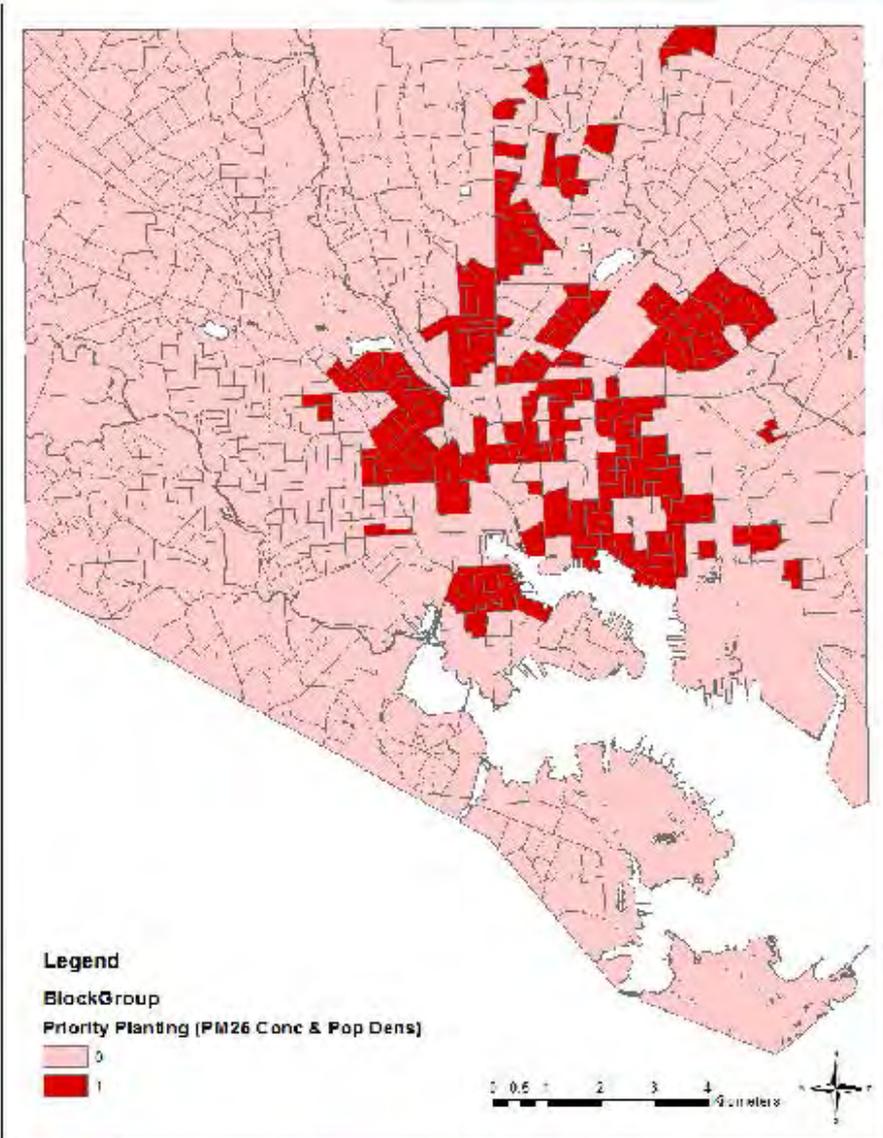
Find Locations Examine Location Data **See Tree Benefits** Prioritize Tree Planting Generate Results



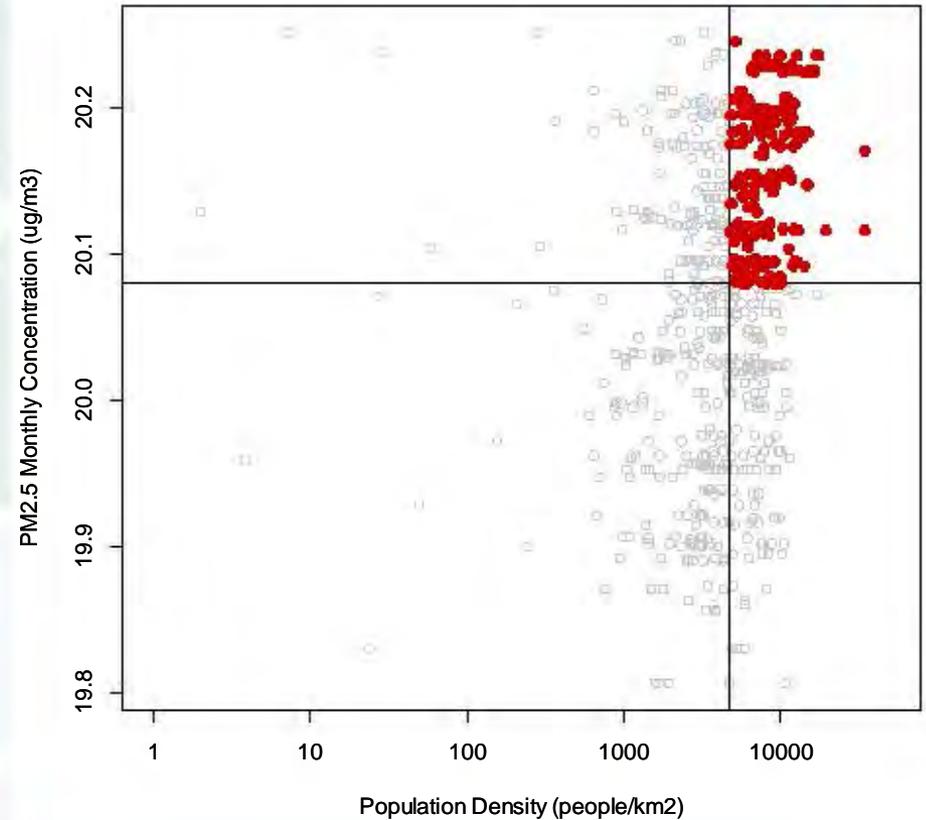
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# Air Pollution (PM<sub>2.5</sub>) - Priority Planting



PM2.5 July Concentration vs. Pop. Density



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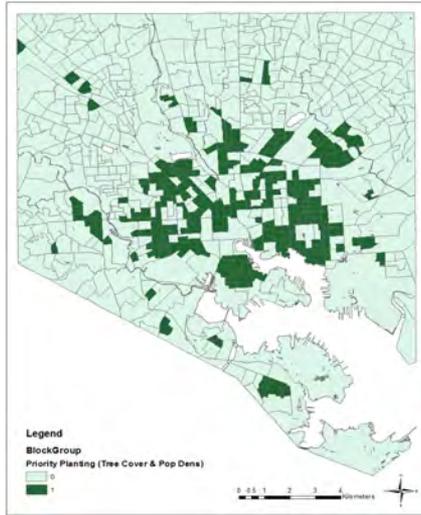
Arbor Day Foundation



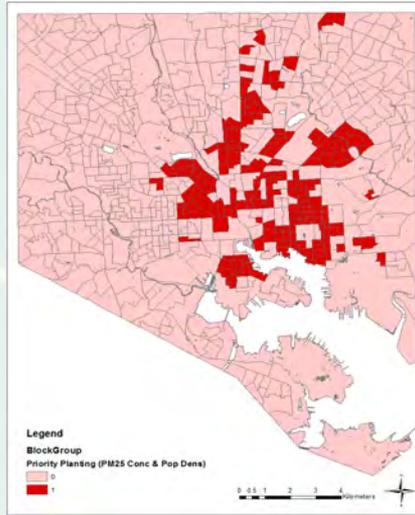
# Priority Planting Block Groups



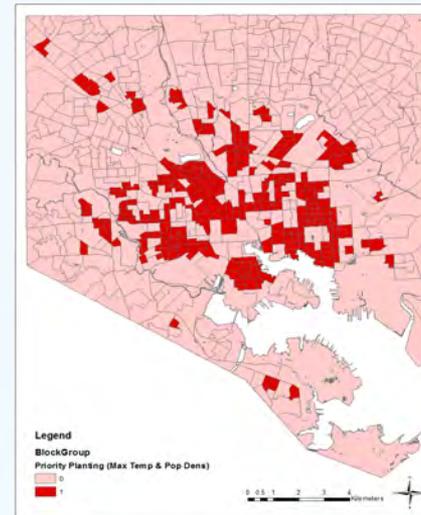
Tree Cover vs. Pop. Dens



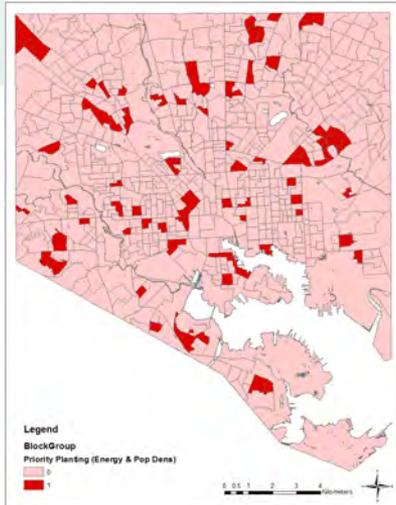
PM<sub>2.5</sub> Conc. vs. Pop. Dens



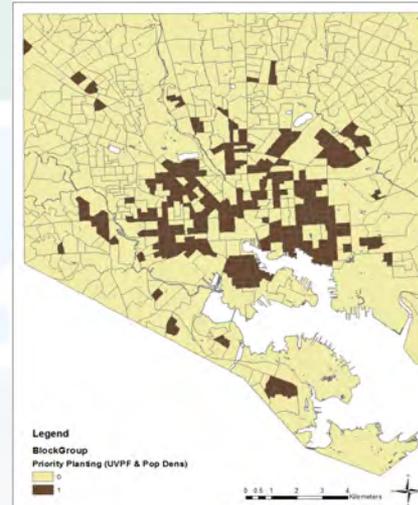
Max. Temp. vs. Pop. Dens



Thermal Comfort vs. Pop. Dens



UVPF vs. Pop. Dens



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# Upcoming Features



- 🌳 Updated carbon equations (FIA, global)
- 🌳 Biodiversity index
- 🌳 Species ratings based on projected climate change
- 🌳 UV reduction and health effects
- 🌳 Air temperature reduction and health effects
- 🌳 Human comfort
- 🌳 Avoided emissions and health effects
- 🌳 Pollen
- 🌳 Nutrient cycling
- 🌳 Urban soils
- 🌳 Product potential
- 🌳 Climate change projections
- 🌳 New map layers in Landscape –links to Design
- 🌳 Drought routines
- 🌳 Grass analyses
- 🌳 Enhanced differentiation by species
- 🌳 Plot re-measurement analyses
- 🌳 Wildlife



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# Improved Mobile Apps



🌳 Accessibility

🌳 Inventory

🌳 Citizen science

🌳 Education



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i-Tree<sup>TM</sup>  
Do you?