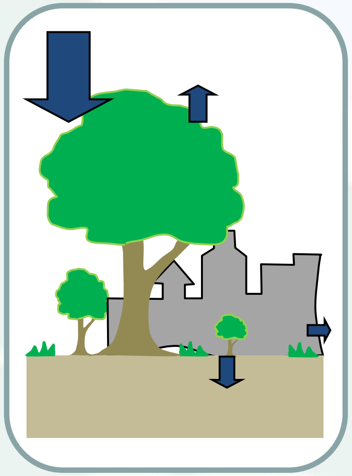


i-Tree Tools and i-Tree Hydro

Robbie Coville

The Davey Tree Expert Company

Dr. Ted Endreny

SUNY College of Environmental Science and Forestry

i-Tree is a Cooperative Initiative among these partners

Outline

- Intro to the i-Tree Suite
- i-Tree and hydrology
- i-Tree Hydro
  - Overview of methods, inputs, and outputs
  - Project setup: step-by-step demo
  - A look at outputs and a couple of use-cases
  - Optional: preview of what's new in Hydro v6.0 beta
- Where to find more info: support, videos, reports
- Wrap-up discussion, Q&A, and *how can i-Tree help DEP?*

What is i-Tree?

www.itreetools.org

i-Tree

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

i-Tree Eco

i-Tree Hydro

i-Tree Landscape

i-Tree Canopy

i-Tree Design

i-Tree Species

i-Tree is a Cooperative Initiative among these partners

DAVEY

Arbor Day Foundation

ISA

Casey Trees

ESF State University of New York College of Environmental Science and Forestry

NAASF

EPA United States Environmental Protection Agency

How do the tools differ?

General categories:

- **Top-down**
- **Bottom-up**
- **Specialized utilities**

i-Tree Eco

i-Tree Hydro

Install on Desktop PC

i-Tree Landscape

i-Tree Canopy

i-Tree Design

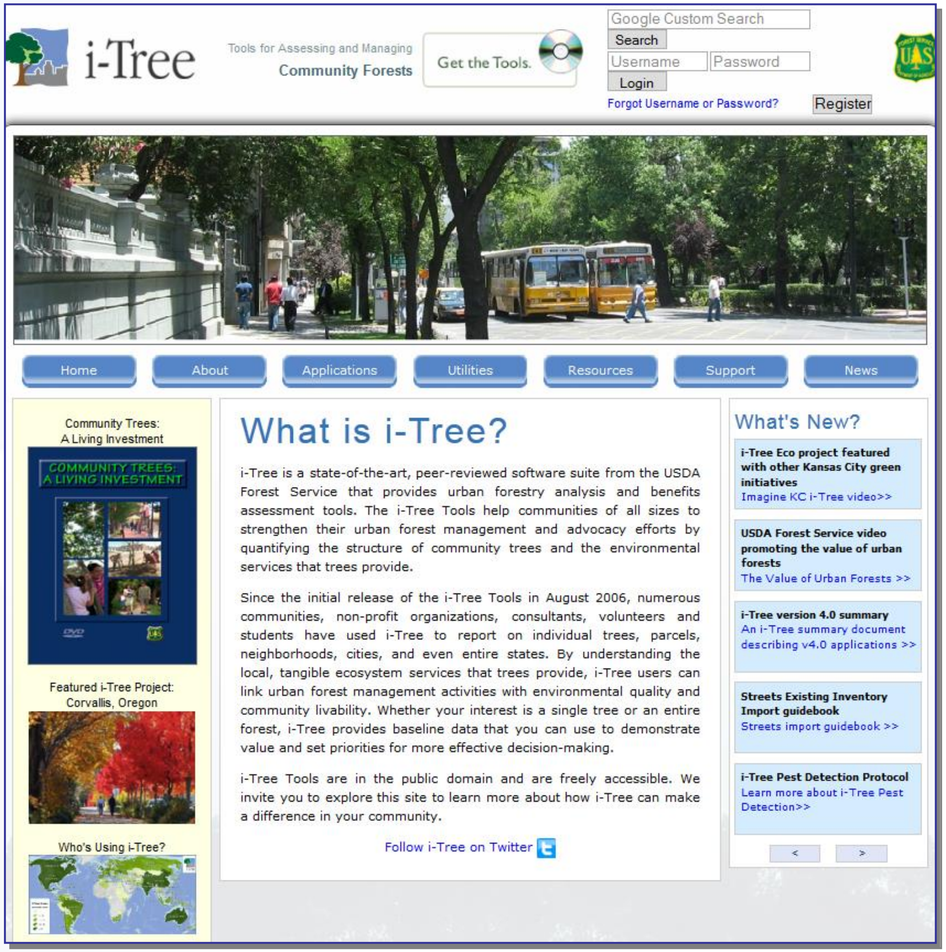
i-Tree Species

Use in a Web Browser

i-Tree…

"Putting USFS Urban Forest science into the hands of users"

- Public Domain Software
- Based on peer-reviewed research
- Technical support
- Continuously improved

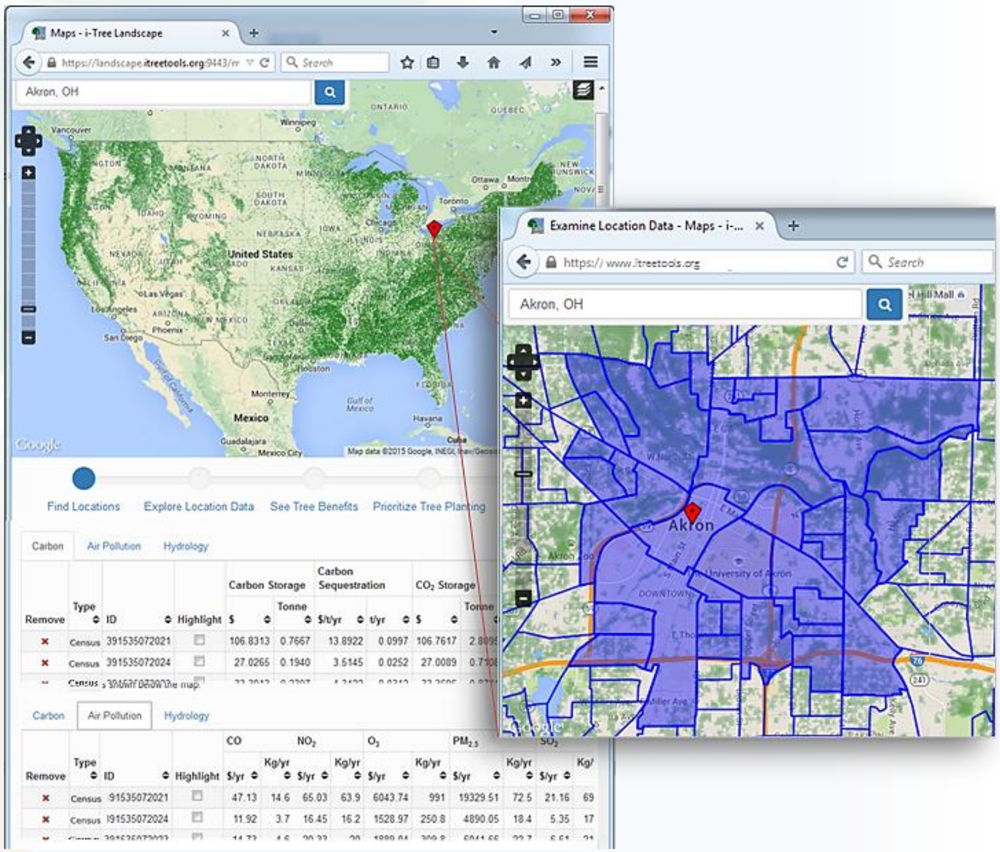


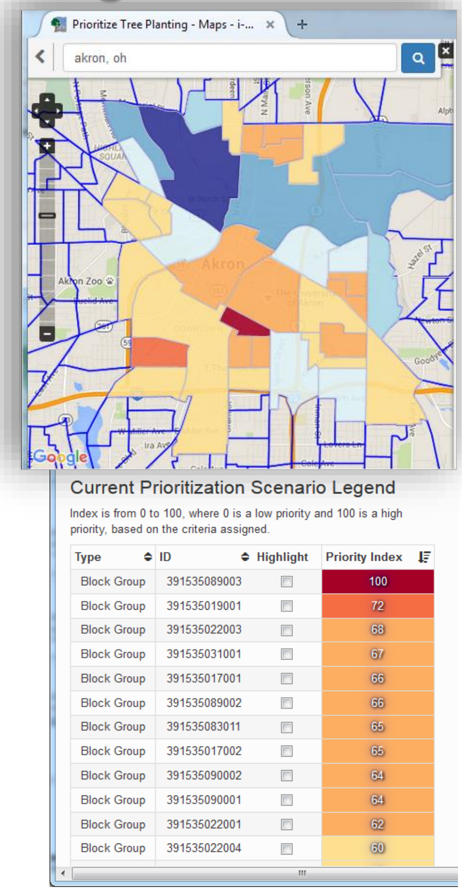
www.itreetools.org

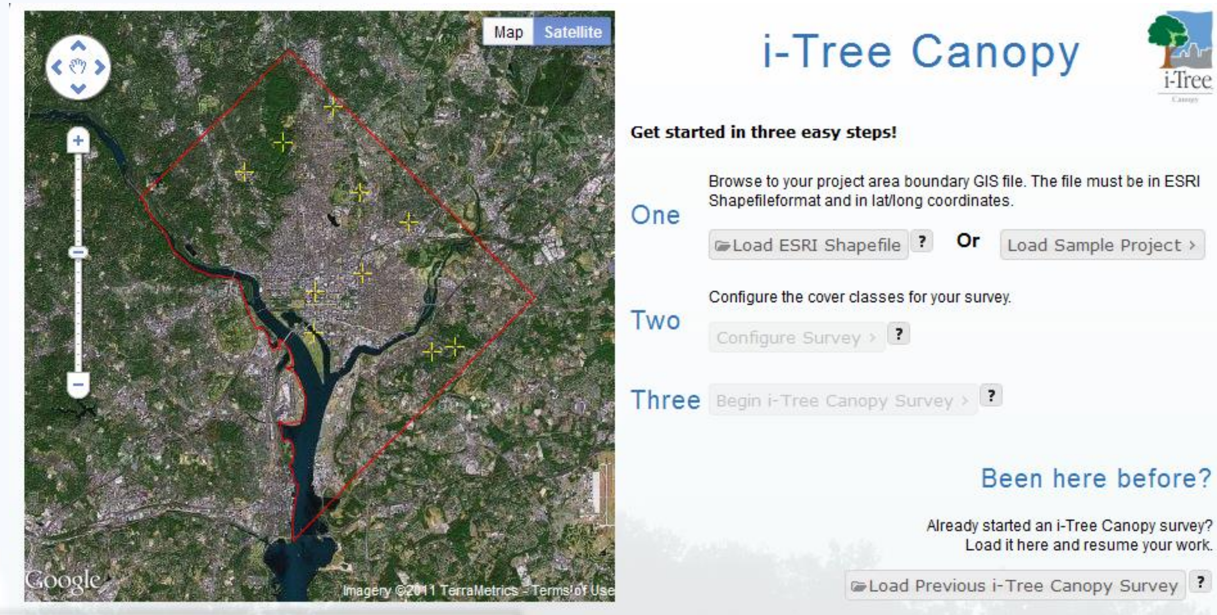
i-Tree is a Cooperative Initiative among these partners

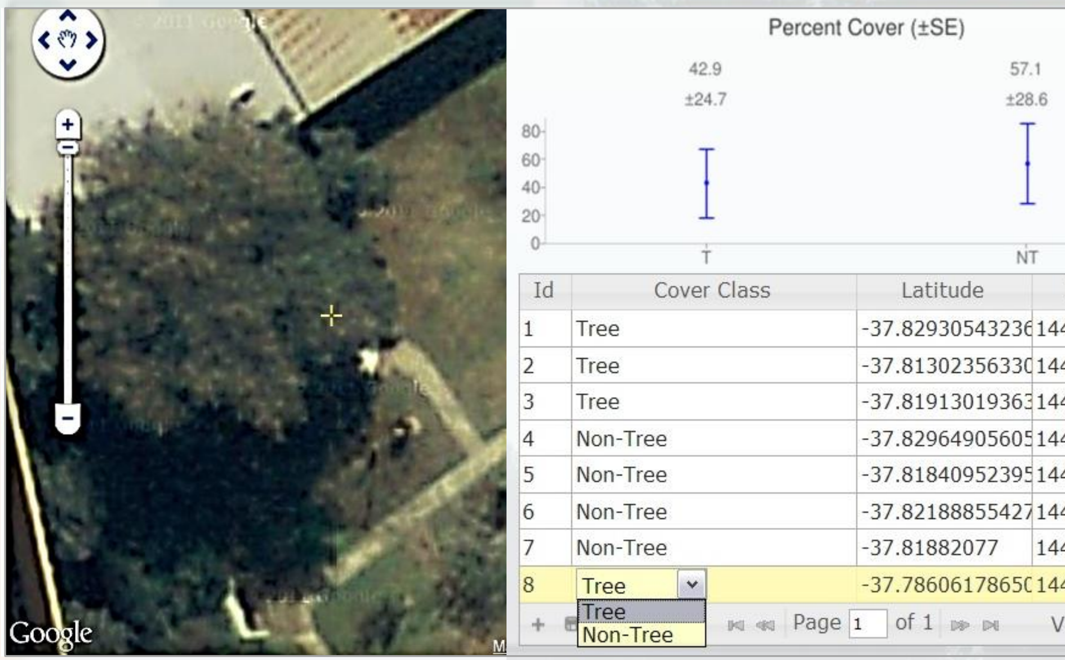
i-Tree Landscape

- National data sets
- Explore & compare states, counties, watersheds, block groups
- Estimate tree services and prioritize management areas









Determines
% tree cover

Easy & Fast

World-wide

Web-based

i-Tree is a Cooperative Initiative among these partners

i-Tree Species

Selector - i-Tree Species
https://species.itreetools.org/selector/

i-Tree Species | Home | Project | Menu | i-Tree

Report

Report Type

- (•) Top 10% ( ) All

Save Report

Top 10% of Species for Selected Functions

Location: Indianapolis city (balance), Marion, Indiana, United States of America

Constraints:

- Minimum Height: None
- Maximum Height: 50

Air Pollutant Removal (0-10 Importance):

- Overall: 0

Other Functions (0-10 Importance):

- Low VOC: 8
- Carbon Storage: 4
- Wind Reduction: 0
- Air Temperature Reduction: 5
- UV Radiation Reduction: 4
- Building Energy Reduction: 0
- Streamflow Reduction: 0
- Low Allergenicity: 0

Generated: 11/11/2016

S = Sensitive I = Intermediate S/I = Indeterminate

Species				Sensitivity			Pest Risk
Scientific Name	Common Name	Hardiness Zone	Invasive	Ozone (O3)	Nitrogen Dioxide (NO2)	Sulfur Dioxide (SO2)	Possible Pests
SEQUOIA SEMPERVIRENS	COAST REDWOOD	7-10					
LIRIODENDRON TULIPIFERA	TULIP TREE	5-9		S			
ULMUS AMERICANA	AMERICAN ELM	3-9			I/S		Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth
ULMUS GLABRA	WYCH ELM	4-7					Asian Longhorned Beetle, Dutch Elm Disease
MAGNOLIA GRANDIFLORA	SOUTHERN MAGNOLIA	7-10					
TILIA AMERICANA	AMERICAN BASSWOOD	4-9		I	I		Gypsy Moth, Winter Moth
TSUGA HETEROPHYLLA	WESTERN HEMLOCK	6-7			I		Southern Pine Beetle, Western Spruce Budworm
TSUGA MERTENSIANA	MOUNTAIN HEMLOCK	5-7					Fir Engraver, Southern Pine Beetle, Western Spruce Budworm

Air Pollutant Removal (0-10 importance)

Rank each of the following environmental services from 0 to 10 on how important these tree services are to you. 0 = not important; 10 = highly important.

Pollutant Removal

(•) Overall ( ) Specific

Overall Rate ?

7

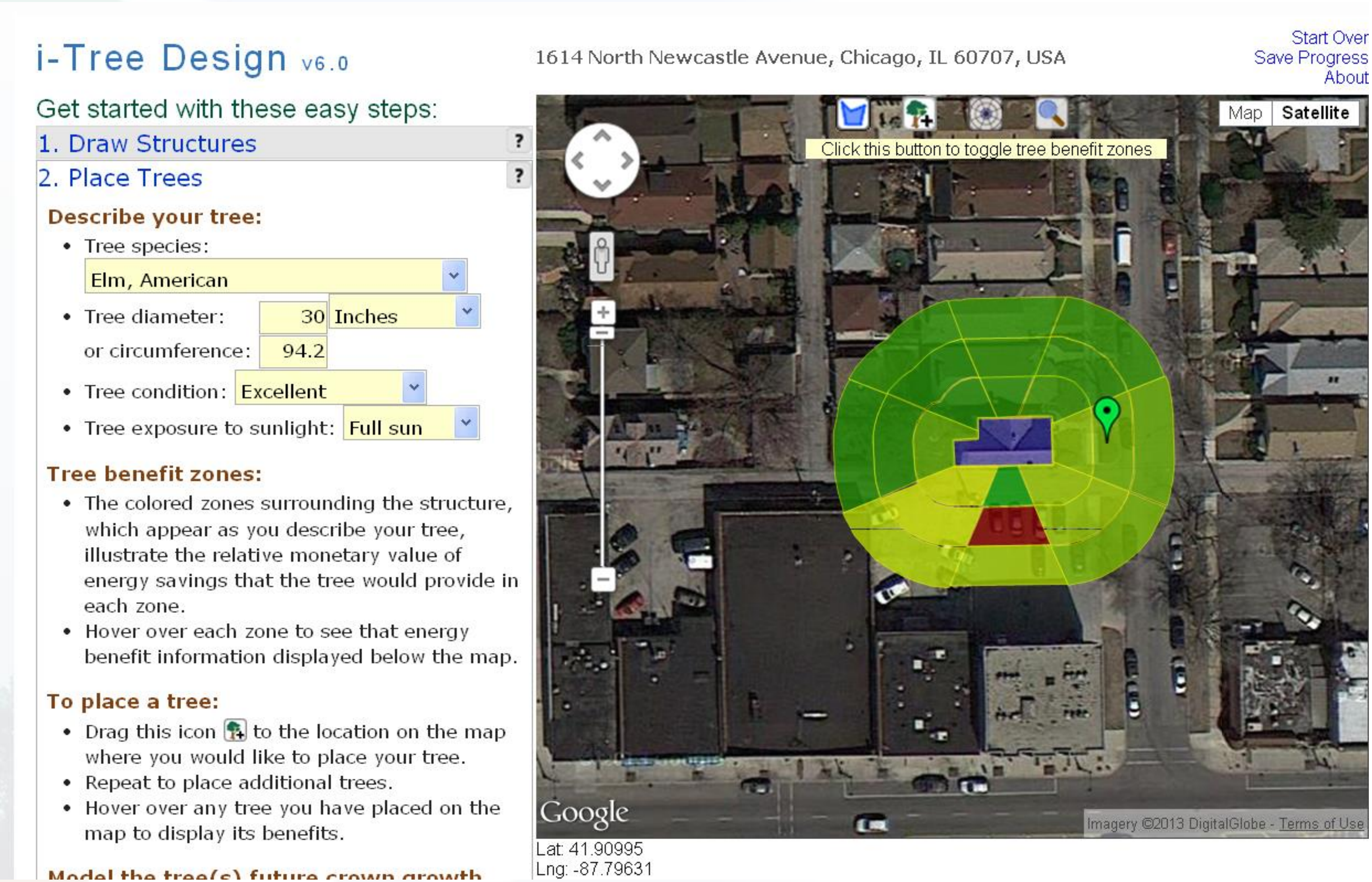
- Select Overall to consider the overall air pollutant removal impact of any tree (weights five pollutants based on the estimated effect of each pollutant).
- If you wish to rank the pollutants individually, select Specific to see a list of five pollutants.
- Ranking sliders: 10 is most important while choosing 0 means the pollutant will not be considered during species selection.

Other Functions (0-10 importance)

Loc VOC Emissions ? 0
Carbon Storage ? 4
Wind Reduction ? 0
Air Temperature Reduction ? 0
UV Radiation Reduction ? 0
Building Energy Reduction ? 2
Streamflow Reduction ? 9
Low Allergenicity ? 0

- Select species criteria
  - Structure
  - Services
- Lists top species that meet your criteria

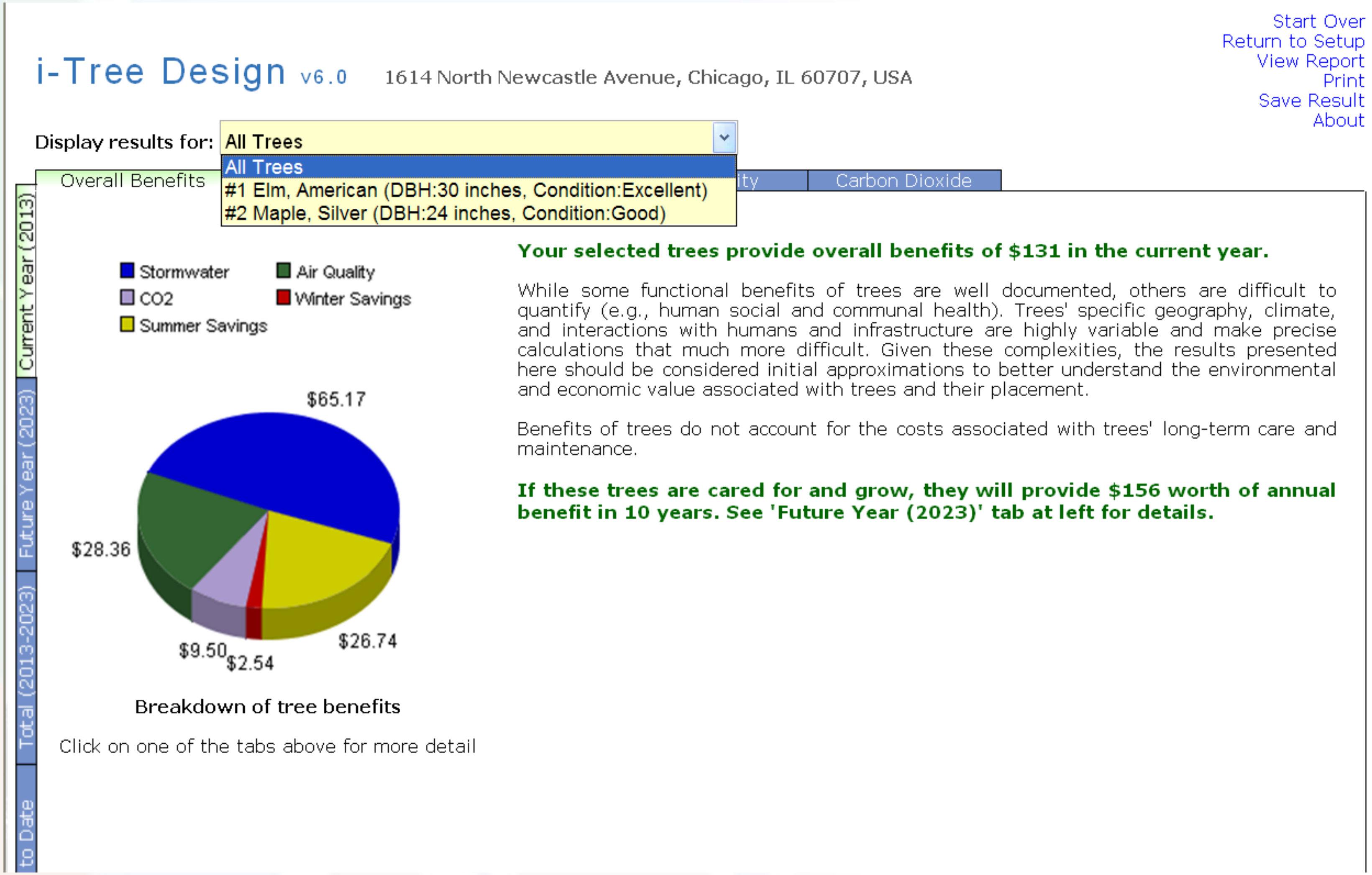
i-Tree



i-Tree Design

- Place trees on Google Maps imagery
- Outline structures

i-Tree is a Cooperative Initiative among these partners



- Rapid estimate & forecast of tree benefits
- Stormwater, CO_2, energy (heating/cooling), air quality

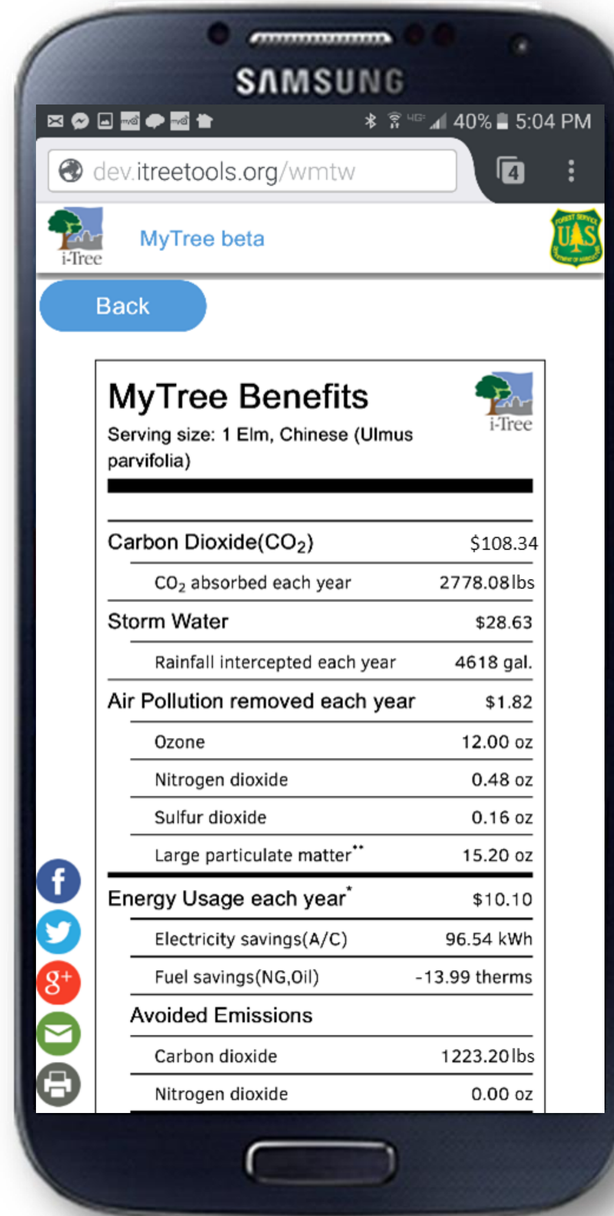
i-Tree Design

i-Tree is a Cooperative Initiative among these partners

MyTree *beta*

- i-Tree on the go!
  - Running on the i-Tree Design engine

www.itreetools.org/MyTree



i-Tree Eco: Quantifies Tree and Forest Resources

www.itreetools.org

Structure

- Number of trees, species distribution, canopy cover, species diversity, etc.

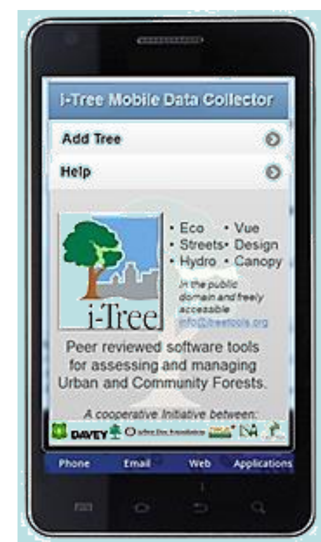
Functions / Ecosystem Services

- Energy use
- Air pollution (w/ health impacts)
- UV
- Carbon
- Biogenic VOC emissions
- Avoided runoff & hydrology
- Wildlife

Management needs

- Pest risk
- Tree health
- Exotic/invasive spp.

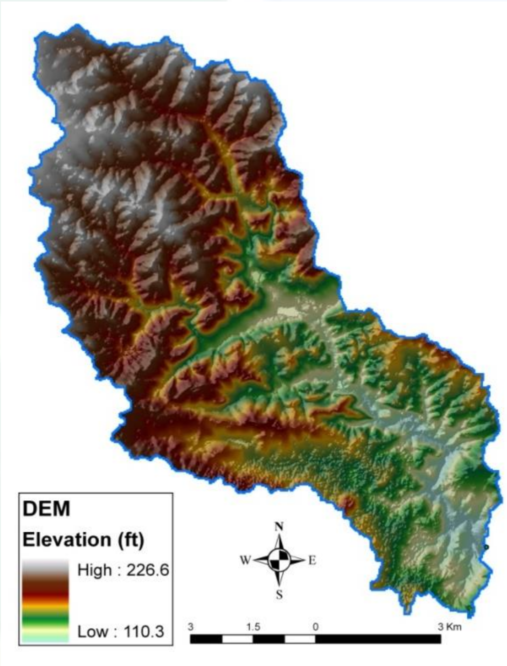
$ Value



i-Tree is a Cooperative Initiative among these partners

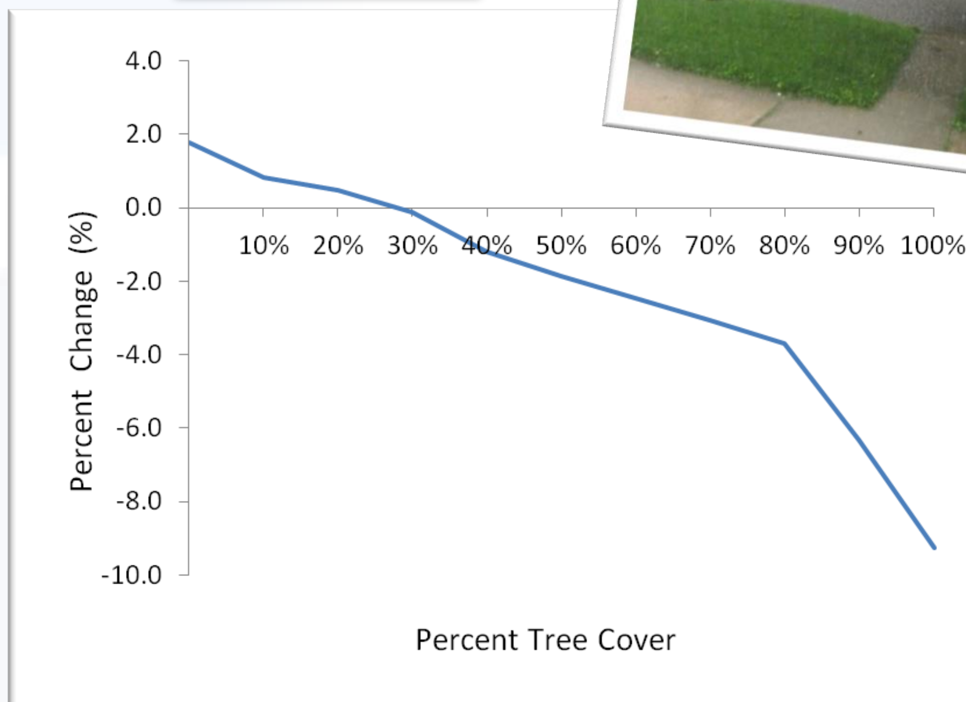
i-Tree Hydro

Gwynns Falls Watershed, Baltimore



www.itreetools.org

Hydro



Quantifies effects of:

- Tree cover
- Impervious cover

on:

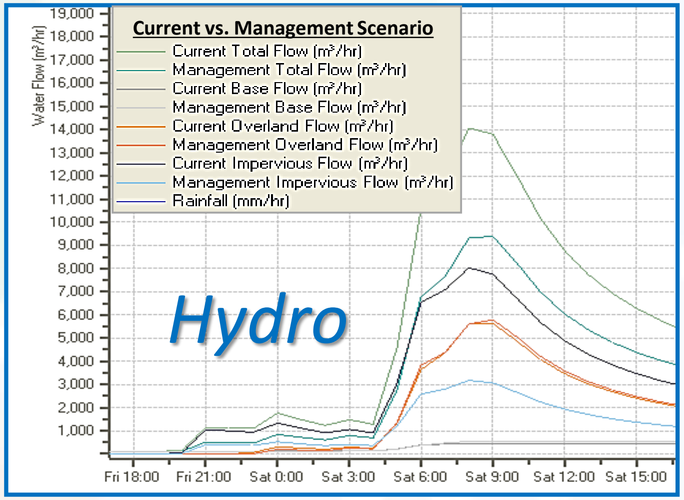
- Hourly stream flow
- Water quality

i-Tree is a Cooperative Initiative among these partners

i-Tree Tools for Stormwater

Hydro

- Input % land cover
- Estimates hourly changes in streamflow and water quality
- Engine for Eco's hydrology estimates

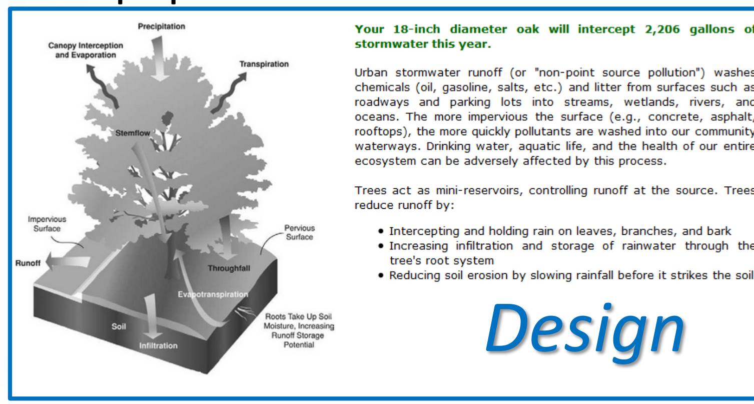


Eco

- Input big or small plots or inventory
- Estimates runoff avoided, interception, transpiration
- Runs on simplified Hydro engine

Landscape

- Examine & compare watersheds
- Forest-to-Faucet dataset shows area's importance to drinking water reservoirs
- Combine tree data with US Census population data

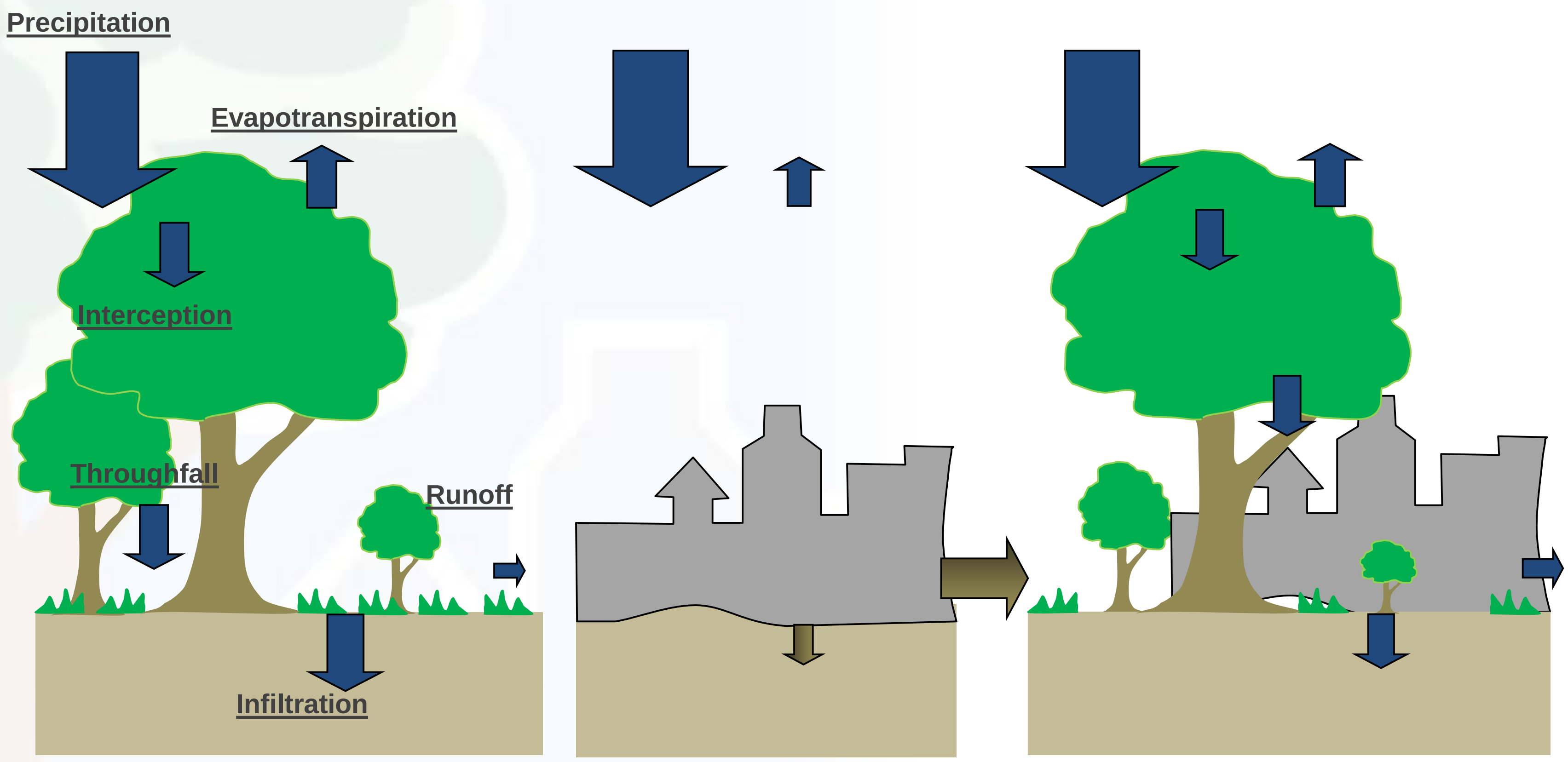


Design & MyTree

- User-friendly, quick & easy
- Estimates tree interception, soon to be updated to include Eco's estimates of Avoided Runoff

Zooming in on i-Tree Hydro

Simulating How Land Cover Changes Affect Water Quantity & Quality



i-Tree Hydro

- Model Background

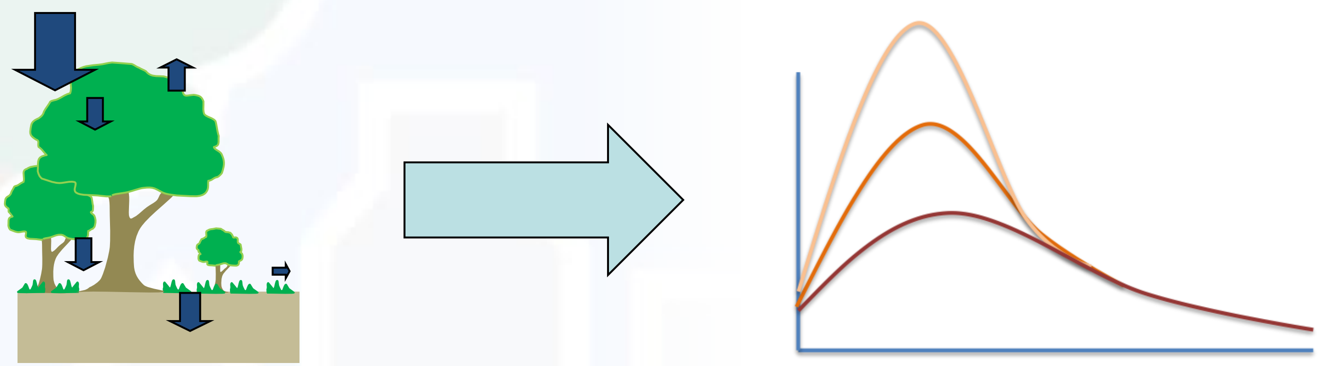
  - Origins from discussions between Dr. Ted Endreny (SUNY-ESF) and Dr. David Nowak (USFS - NRS)

  - Wanted to replace curve number based runoff models with a processed based hydrological model

St. Elizabeth Hosp. D.C. 2006-2011
Casey Trees

Rainfall-runoff Model

- Rainfall – runoff model
  - Transformation of rainfall into runoff
    - Effective precip -> Infiltration -> runoff generation
    - Runoff partitioning
      - baseflow, overland flow, shallow subsurface flow, etc.

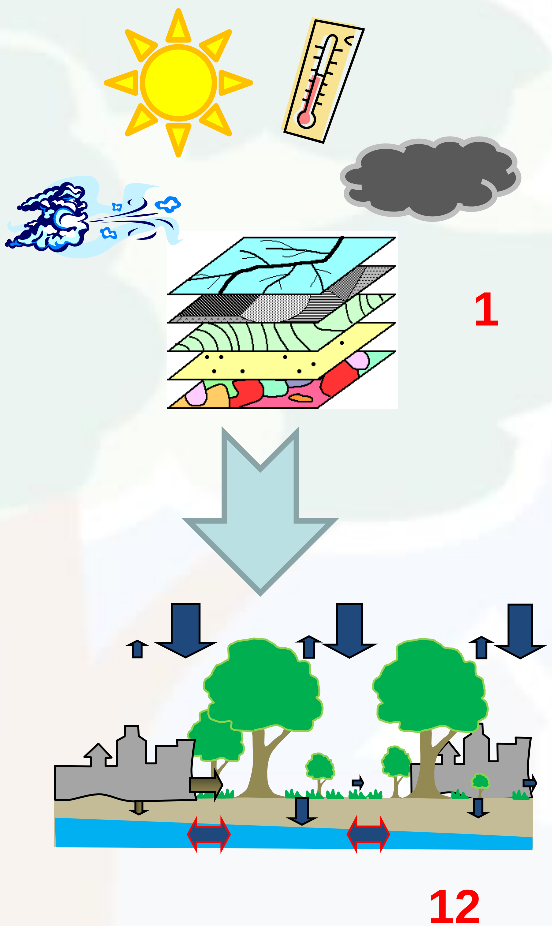


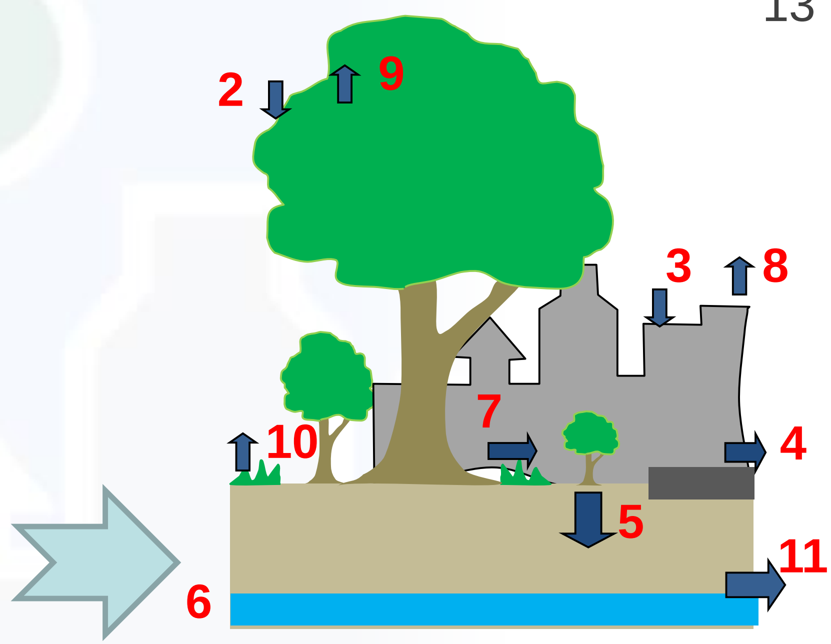
  - Routing of runoff through watershed / to the outlet
    - Building of the hydrograph, timing of flow arrival

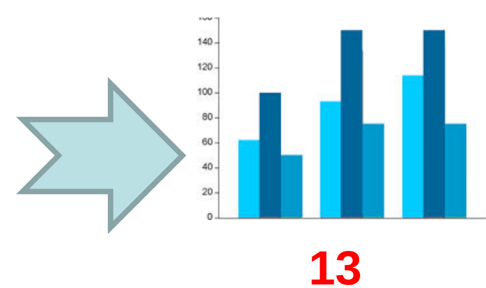
Modeled Hydrologic Processes

i-Tree

1 Inputs
2 Canopy Interception
3 Depression Storage
4 Impervious Runoff
5 Infiltration
6 Soil Moisture
7 Pervious Runoff
8 Surface Evaporation
9 Veg Evaporation
10 Evapotranspiration
11 Subsurface Runoff
12 Spatial Distribution
13 Outputs







i-Tree is a Cooperative Initiative among these partners

Snapshot of All Inputs

i-Tree

- Location (State, County, Place)
- Topography (DEM or preloaded topographic index), typically of 30 or 10 m resolution
- Precipitation data
- Other weather and climate data (windspeed, solar radiation, etc.)
- **Land cover data**, from iTree Canopy, Ground Surveys, etc.
- Hydrology parameters

Snapshot of All Outputs

- For each time step (1 hour for these simulations):
  - Canopy interception
  - Depression storage
  - Infiltration
  - Evapotranspiration
  - Surface (pervious, impervious) and subsurface (base flow) flow
  - Channel discharge (total flow)
  - Water quality (EMC)

Model Inputs

- Landcover
  - 5 main cover classes
    - Bare Soil
    - Shrub/Grass/Herbaceous (SV)
    - Impervious Surface
    - Tree Cover over Impervious Area
    - Tree Cover over Pervious Area
  - In the future: green infrastructure
    - Tree Pits
    - Rain Gardens
    - Green Roofs
    - Porous Pavement
    - Rain Barrels
    - ?

Model Inputs

- Canopy Properties
  - Leaf Area Index (LAI) – One sided leaf area per square meter of canopy
    - Tree LAI + Tree bark BAI
    - Shrub/ Herbaceaous LAI + Bark BAI
    - Deciduous vs. Coniferous makeup
  - Leaf On/Off days
- Hydrological Parameters
  - Defaults provide baseline for comparative analysis
  - Autocalibration offers localized parameterization

Source: Aguilar, M.A. et al., 2010

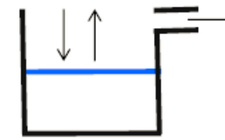
Model Processes

- Interception
  - f(Tree%, Shrub%, Herb.%, LAI, etc.)
    - Open space vs. canopy cover, LAI, leaf on/off days, etc.

- Depression storage
  - f(Landcover type, Depression depth)
    - Pervious vs. impervious – different depression storage maxes

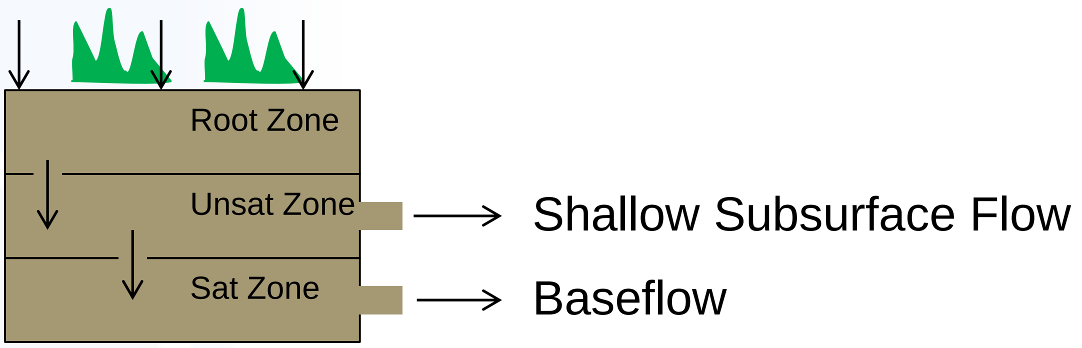
Model Processes

- Surface runoff – pervious and impervious
  - f(Depression storage, Infiltration process, Soil moisture status)
    - Depression storage filled? Saturated soil? Rainfall intensity greater than infiltration rate?
    - Model user sets ratio of infiltration to saturation excess soils



Model Processes

- Infiltration
  - f(K_{sat}, Rainfall intensity, Infiltration process)
  - Infiltration excess – Modified Green-Ampt routine
  - Saturation excess – unconstrained flow into rootzone

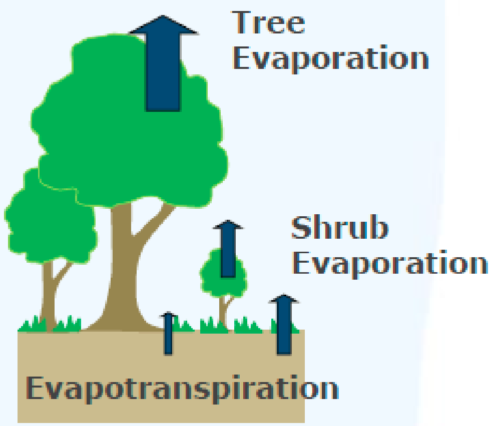


- Soil Moisture
  - Upper Soil zone → Unsaturated zone → Saturated zone
  - f(Infiltrated water, ET, Intra-zone flow rates, Baseflow generation, etc.)

Model Processes

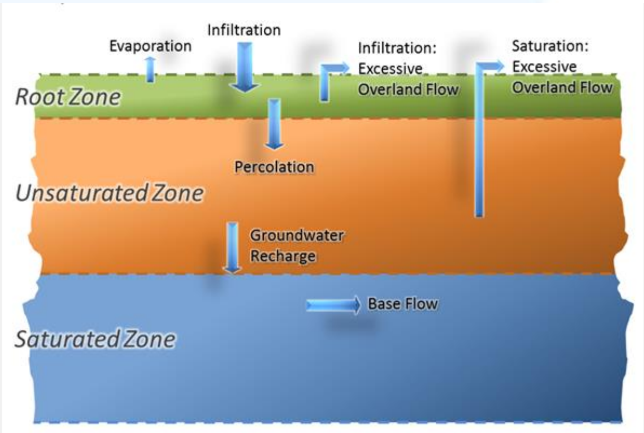
i-Tree

- Evaporation and ET
  - Tree > Shrub > ET
  - Potential Rates
    - Penman-Montieth
    - Evap - f(temp, net radiation, wind speed, etc.)
    - ET - f(temp,…, soil + canopy resistances)
  - Actual Rates
    - f(water availability, Storage/Rootzone depth, LAI, etc.)



Model Processes

- Subsurface flow
  - f(K_{sat}, Average soil moisture deficit, Recession rate)



- Streamflow Prediction
  - Baseflow – f(Subsurface flow)
    - Specific discharge
  - Overland runoff – f(Pervious and Impervious flow)
    - Per landcover percentage/area

Model Calibration

i-Tree

Calibration

- Method:
  - Determining optimal model parameter set
    - Optimization algorithm - PEST
  - Repeated model runs
    - Comparing predicted and observed values
  - Maximize goodness of fit metrics

- Problems:
  - Equifinality – Different parameter sets, same optimum
  - Disagreement between field data and model parameters

Model Calibration

Parameter Calibration Results

Daily Model Calibration Results

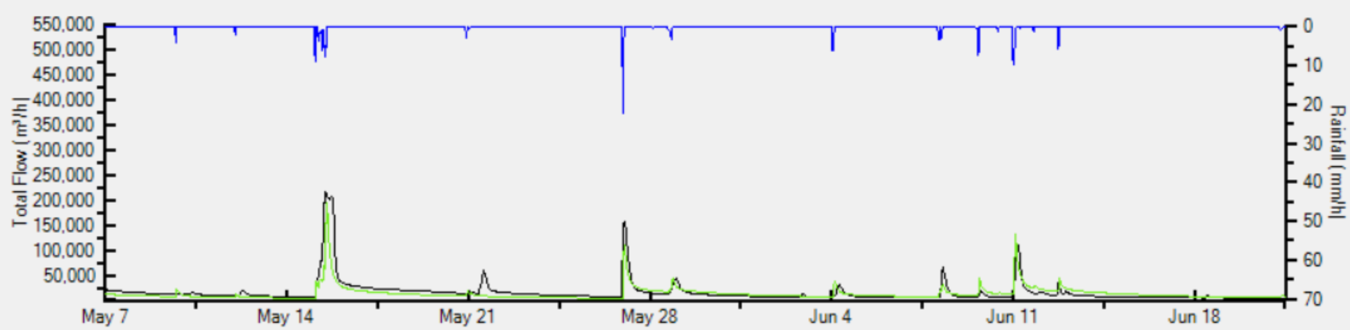
Enabled	Name	Volumetric Efficiency	CRF1 - Peak Flow Fit	CRF2 - Baseflow Fit	CRF3 - Overall Fit	Color
☑	Observed Discharge	N/A	N/A	N/A	N/A	
☑	Rainfall	N/A	N/A	N/A	N/A	
☐	Suggested Default Values	0.368219	0.113362	0.182292	0.00354765	
☑	AutoCalibrated Parameters	0.504397	0.683245	0.358546	0.571221	

The CRF1 , CRF2, and CRF3 values are a measure of how well the estimated flow matches the flow observed at the gaging station. With a very good fit, these CRF values will approach 1.0. The full range for all values is anywhere from negative infinity to 1.0, so negative values are not necessarily "bad." Typically, "good" values range from 0.3 to 0.7, but higher values are better. A value of 0.0 means the model is no better than just using the observed average value to represent the observed data . In short, the calibration process is to maximize the NSE (CRF1) value.

Show Graph

Export JPG

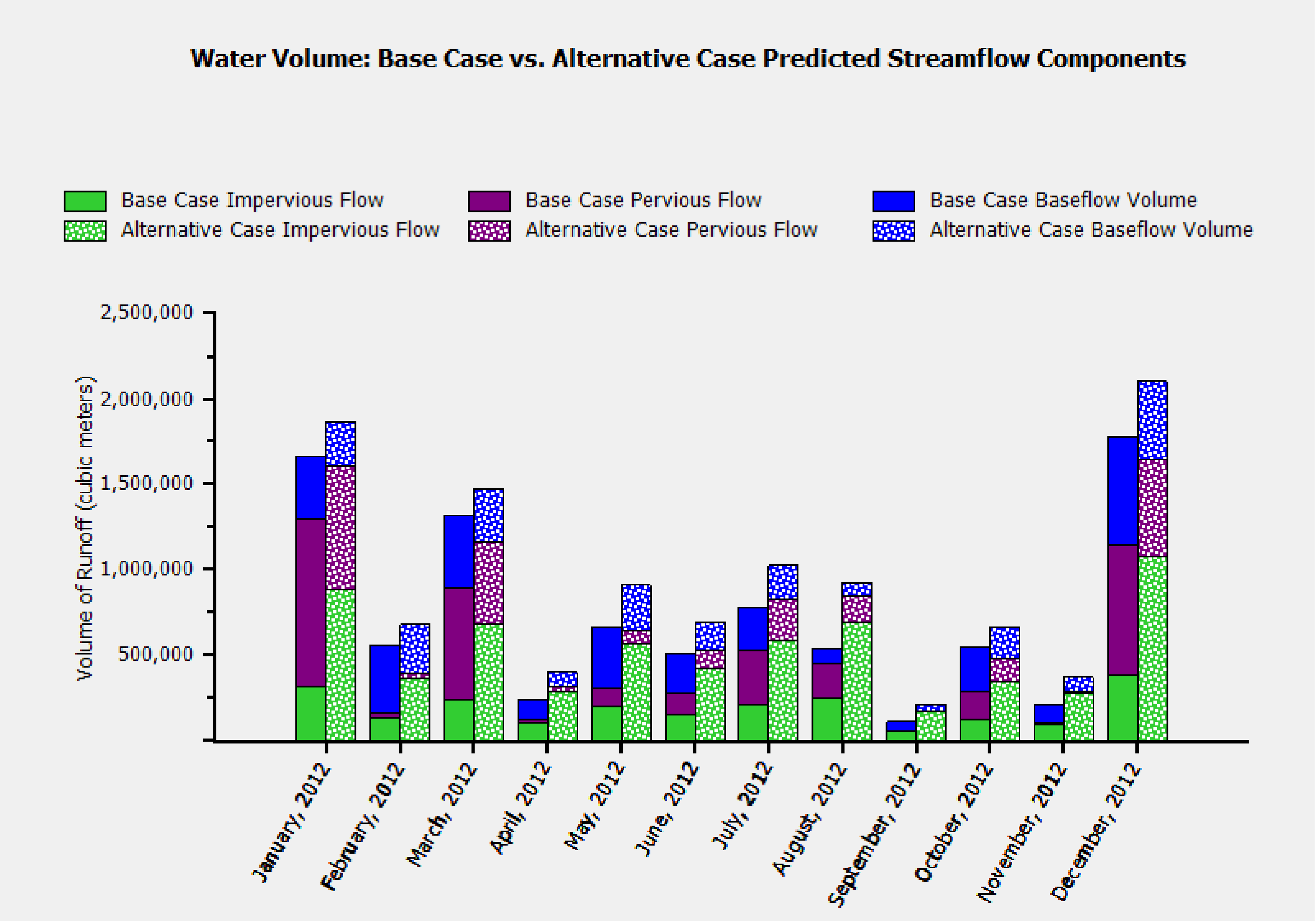
Calibration Comparison



OK

Outputs

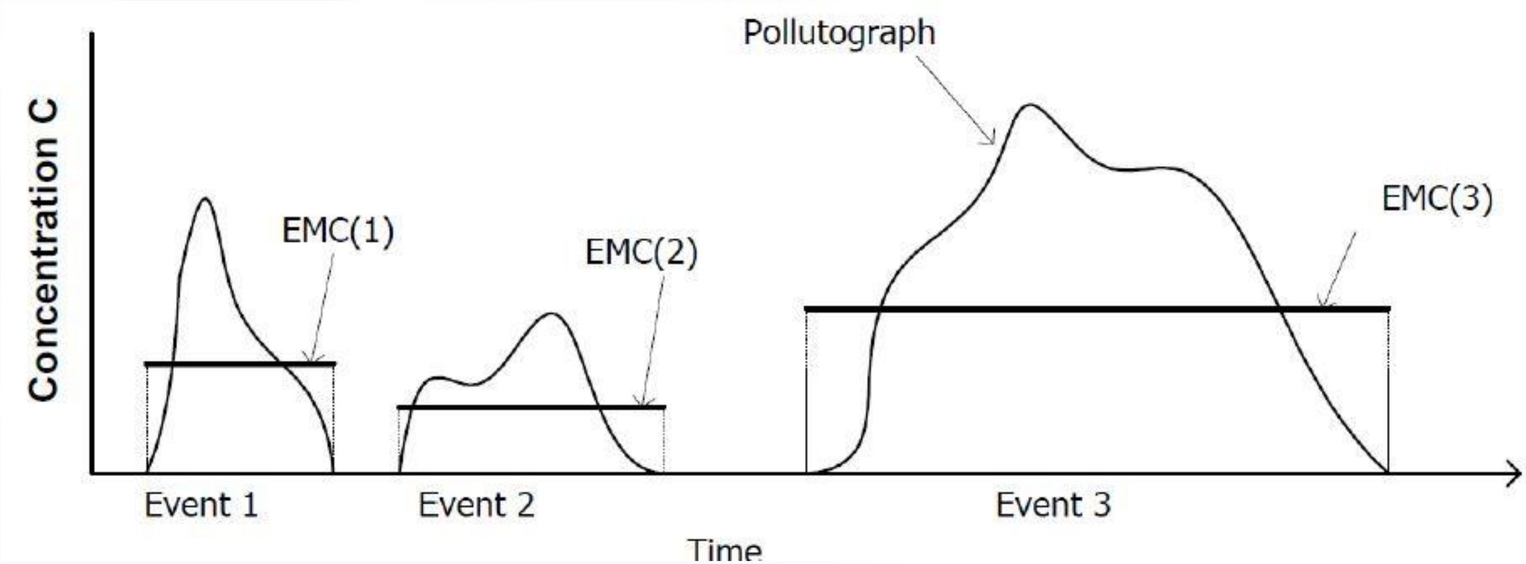
- Water Quantity Outputs
  - Predicted streamflow vs. observed (if available)



Outputs

Water Quality Outputs

- Pollution – Loading estimates
  - Total pollutant mass
  - Based on EMC values – from EPA's NURP data
    - Currently using national avg, changing to localized HUC-8 and land cover specific EMC values to distinguish changes in concentration based on location and cover type



i-Tree Hydro

Introduction to Project Setup

i-Tree is a Cooperative Initiative

i-Tree Hydro: An Introduction

- Model interfaces
- Model inputs
- Model outputs

i-Tree Hydro: Model interface

i-Tree Hydro

File Steps Outputs Help

Welcome to i-Tree Hydro!

What is Hydro?
How to Run i-Tree Hydro
About the Sample Project
New Project Steps

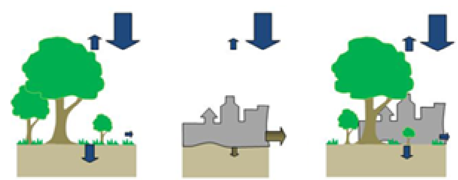
General References:

i-Tree Hydro webpage
Hydrologic Cycle
Soil Profile
User's Manual

What is Hydro?

i-Tree Hydro is a simulation tool that analyzes how land cover influences the volume and quality of runoff. It can analyze historical or future hydrological events and allow the user to contrast runoff volume and quality from existing land cover (referred to as the Base Case) with runoff from the Alternative Case land cover. The i-Tree Hydro model differs from other i-Tree products in the following ways:

- The model simulation area is loaded into the program either as a digital elevation model (DEM) file or as a topographic index (TI) file. It is not hand-delineated in the program by the user. If the user is interested in a watershed, they can load a DEM or TI file. If the user is interested in a city or parcel that is not defined by a single watershed they load a TI file.
- The model simulation can be run in calibration mode or non-calibration mode. For calibration runs the user loads observed streamflow data from a gauging station and the model will identify the optimal hydrological parameters to fit the observed streamflow data. Observed streamflow data are provided for thousands of watershed areas. For non-calibration runs the user can use previously calibrated parameters or independently set the land cover and hydrological parameter values by adjusting the default values that the model provides.



Current Project:

No project loaded.

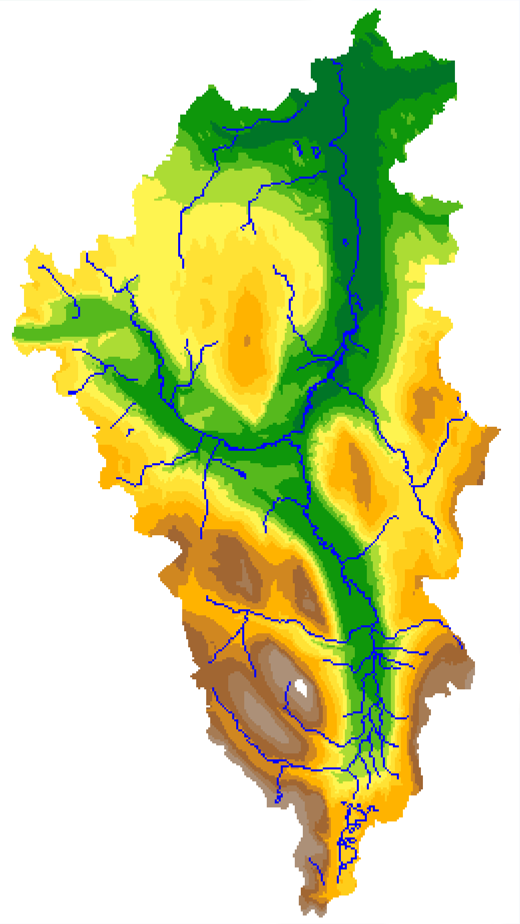
i-Tree Hydro

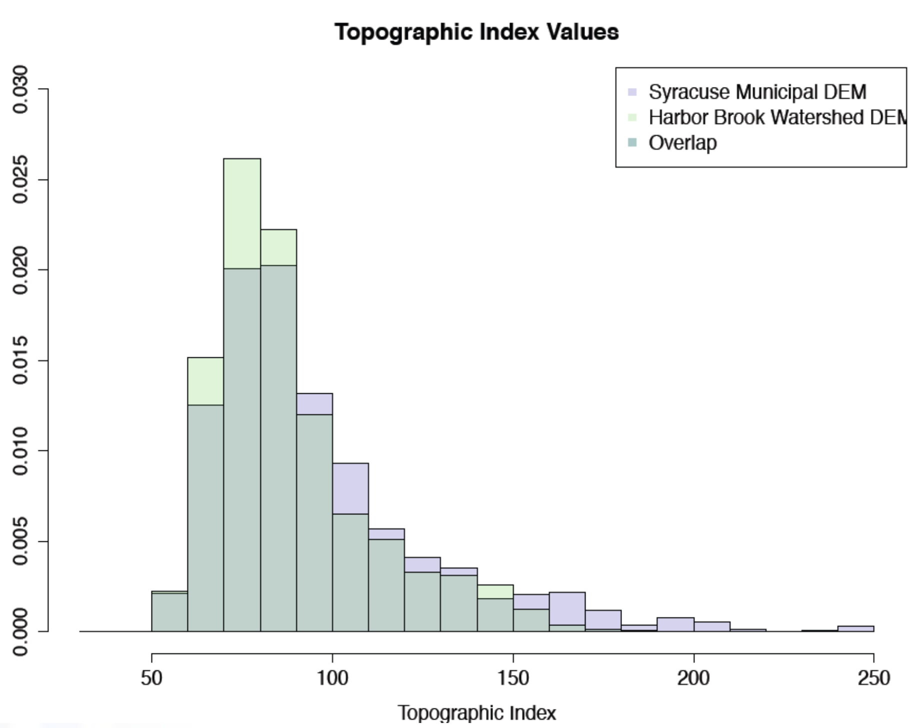
i-Tree

- **Step 1**
- Topographic
- Project Location
- Basic WS Info
- Streamflow
- Weather

i-Tree Hydro: DEM vs Topographic Index Option

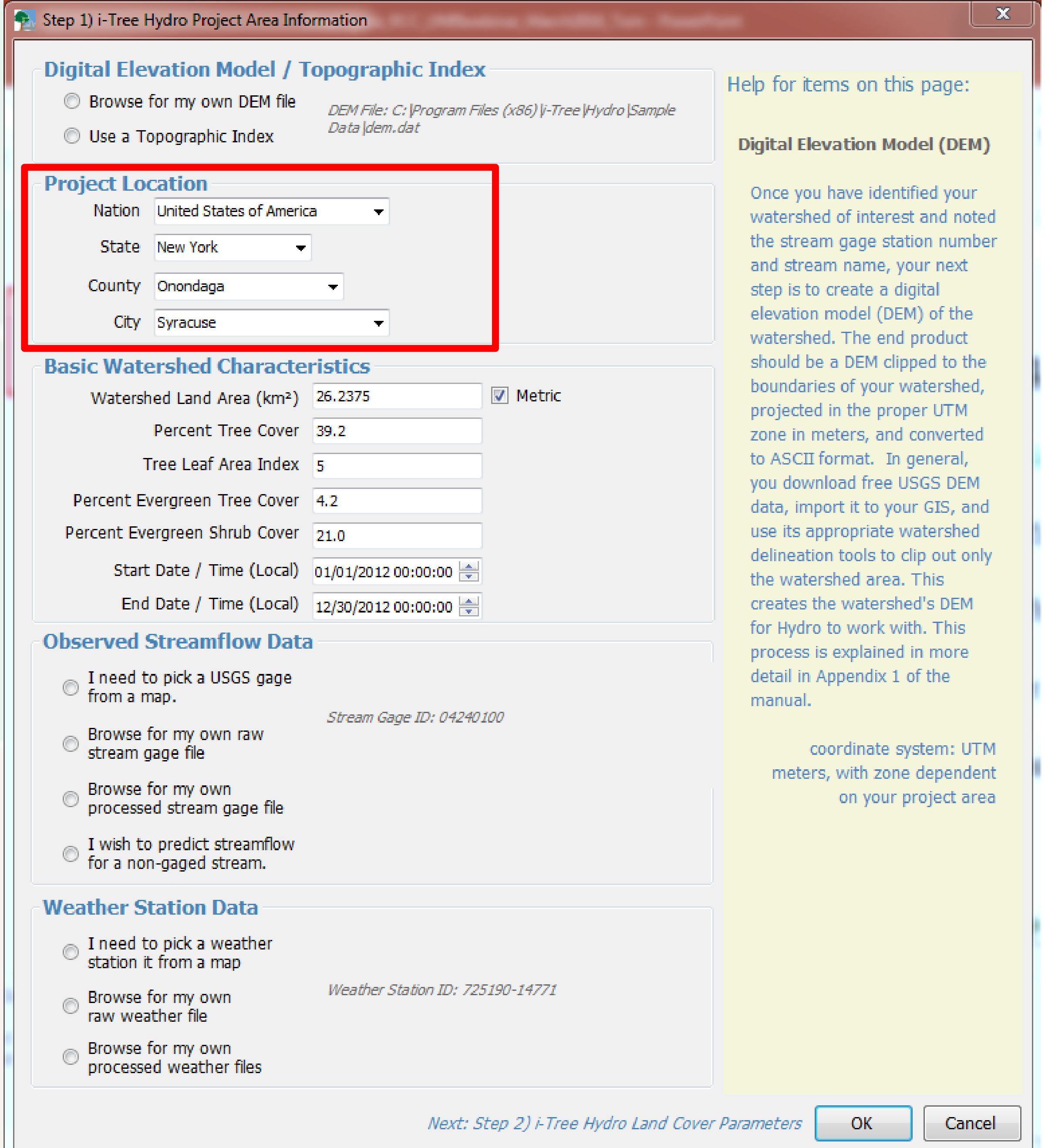
i-Tree





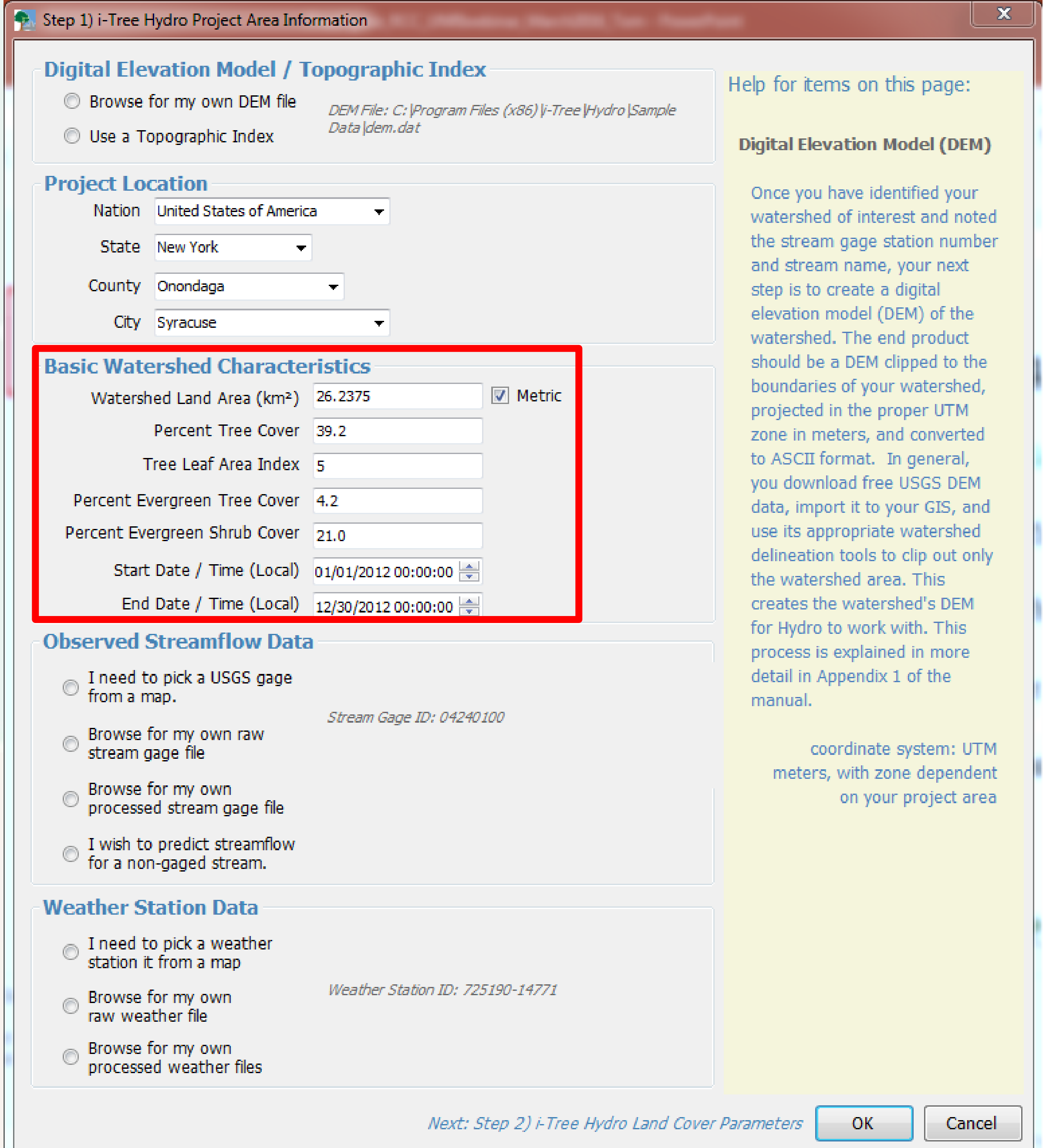
Digital Elevation Model (DEM)

Topographic Index from DEM



i-Tree

- **Step 1**
- Topographic
- Project Location
- Basic WS Info
- Streamflow
- Weather



i-Tree

- **Step 1**
- Project Location
- Basic WS Info
- Streamflow
- Weather
- Topographic

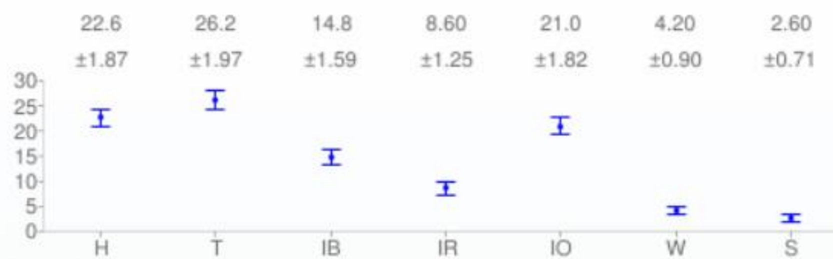
i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Land Cover Data (via i-Tree Canopy)

How It Works | Report | Export | Start Over | Exit

?

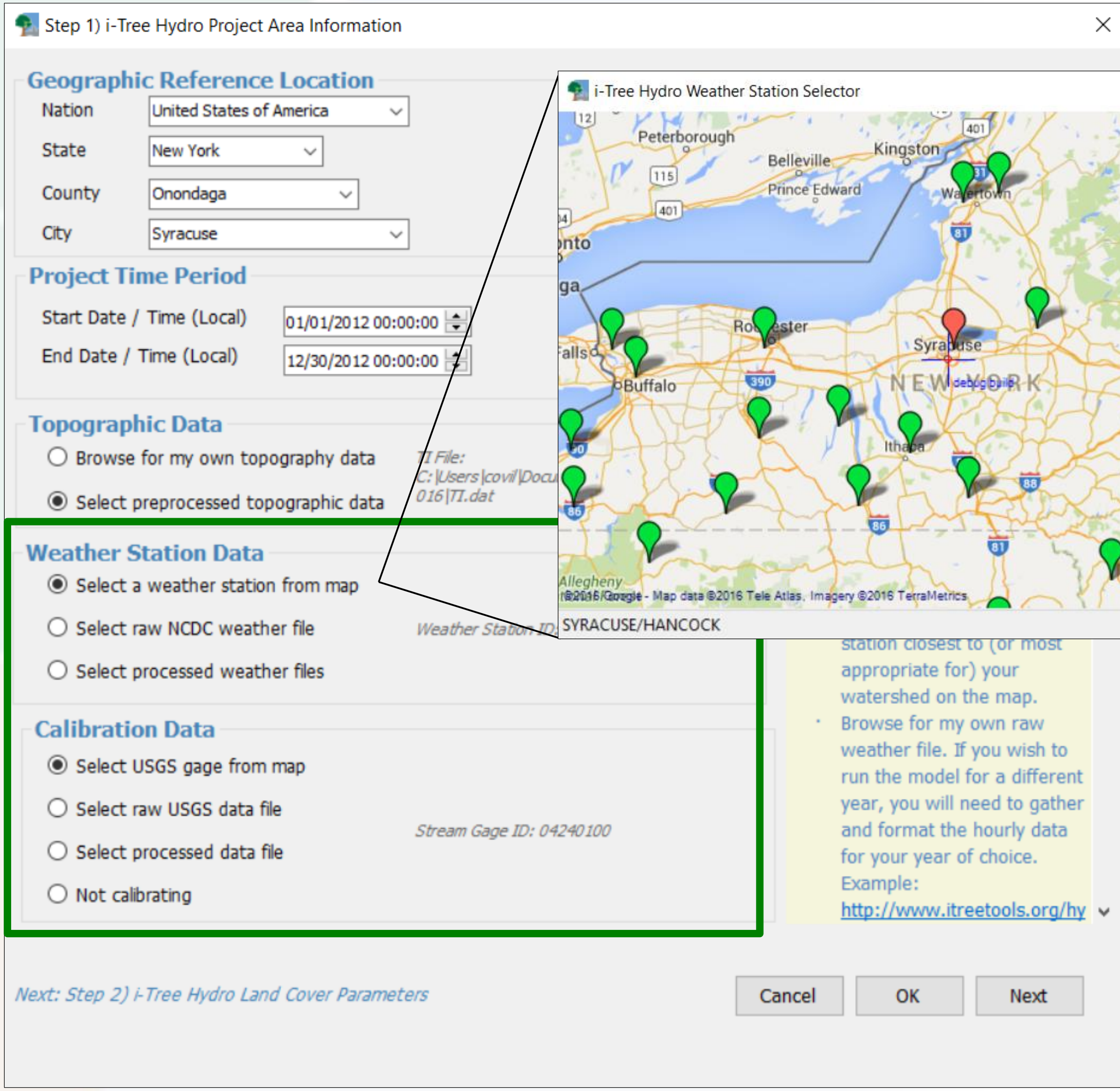
i-Tree Canopy v6.1

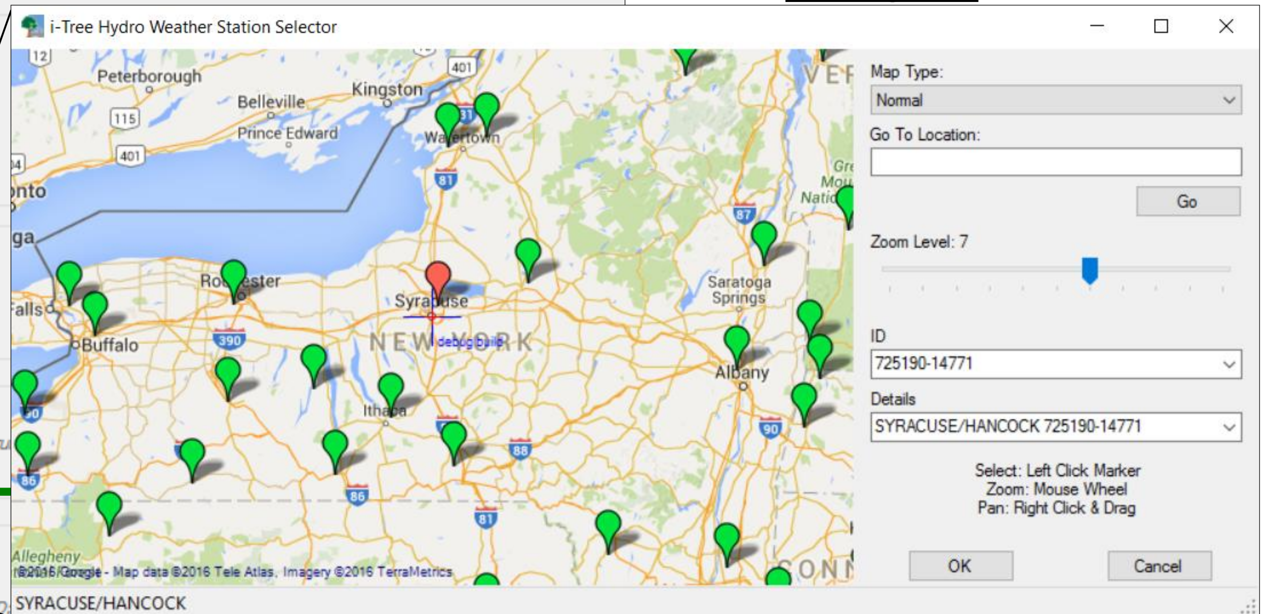


Id	Cover Class	Latitude	Longitude
491	Grass/Herbaceous	41.79033	-72.68715
492	Impervious Road	41.74460	-72.68292
493	Impervious Buildings	41.75931	-72.69842
494	Tree/Shrub	41.77135	-72.70451
495	Grass/Herbaceous	41.77403	-72.70396
496	Soil/Bare Ground	41.77663	-72.69132
497	Impervious Buildings	41.73789	-72.67604
498	Tree/Shrub	41.80099	-72.68062
499	Grass/Herbaceous	41.73083	-72.67079
500	Impervious Road	41.76210	-72.66642

Page 50 of 50 View 491 - 500 of

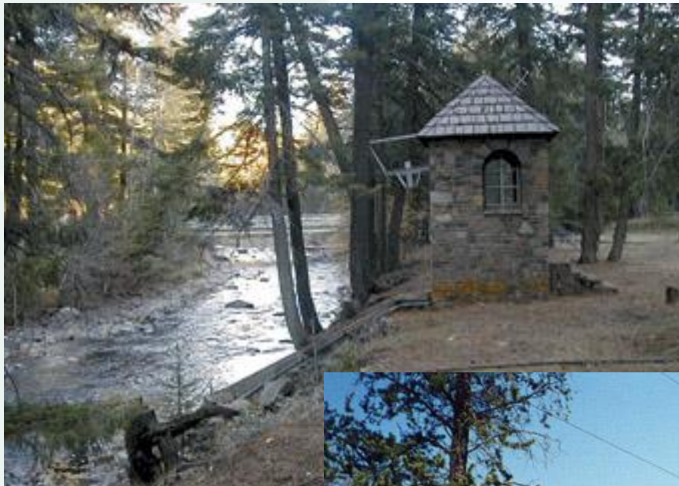
Step 1





- [Streamflow]
- [Weather]

i-Tree Hydro: Stream Data



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QOBS.dat - Notepad
File  Edit  Format  View  Help
yyyymmdd     Hr:Min:Sec   Discharge(m/hr)

20110101     0:00:00      2.25638E-004
20110101     1:00:00      2.25638E-004
20110101     2:00:00      2.25638E-004
20110101     3:00:00      2.25638E-004
20110101     4:00:00      2.25638E-004
20110101     5:00:00      2.25638E-004
20110101     6:00:00      2.25638E-004
20110101     7:00:00      2.25638E-004
20110101     8:00:00      2.25638E-004
                             8E-004
                             8E-004
                             8E-004
                             8E-004
                             8E-004
                             8E-004
                             8E-004
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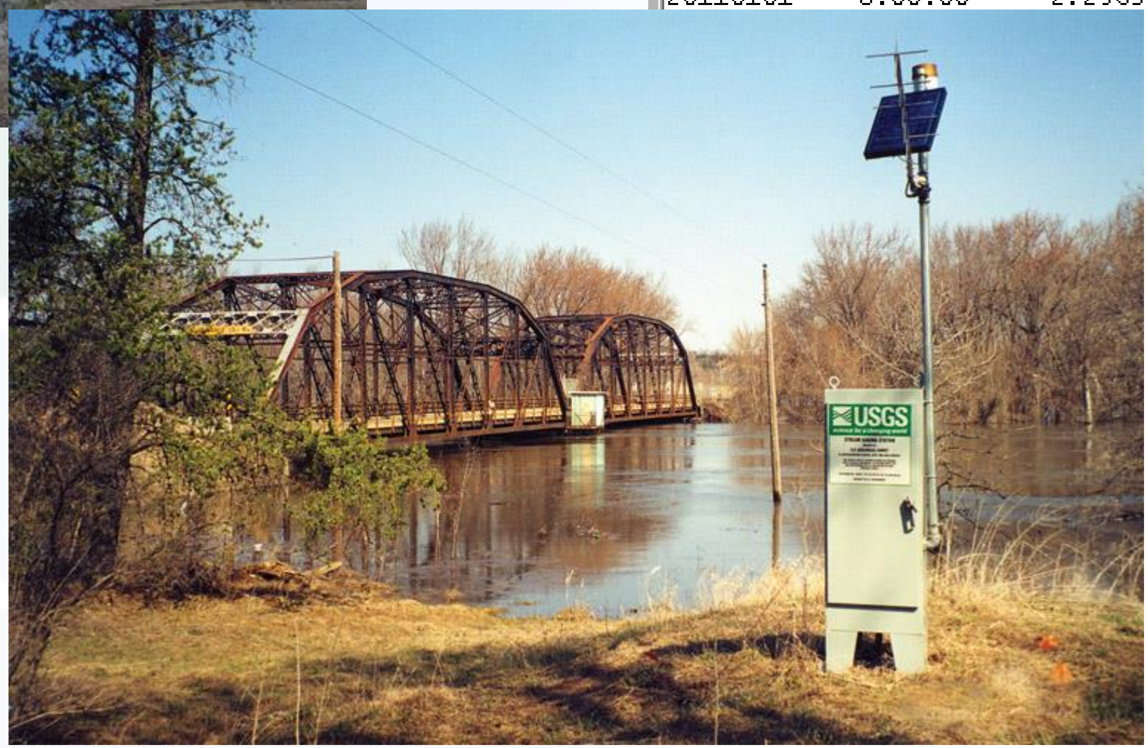


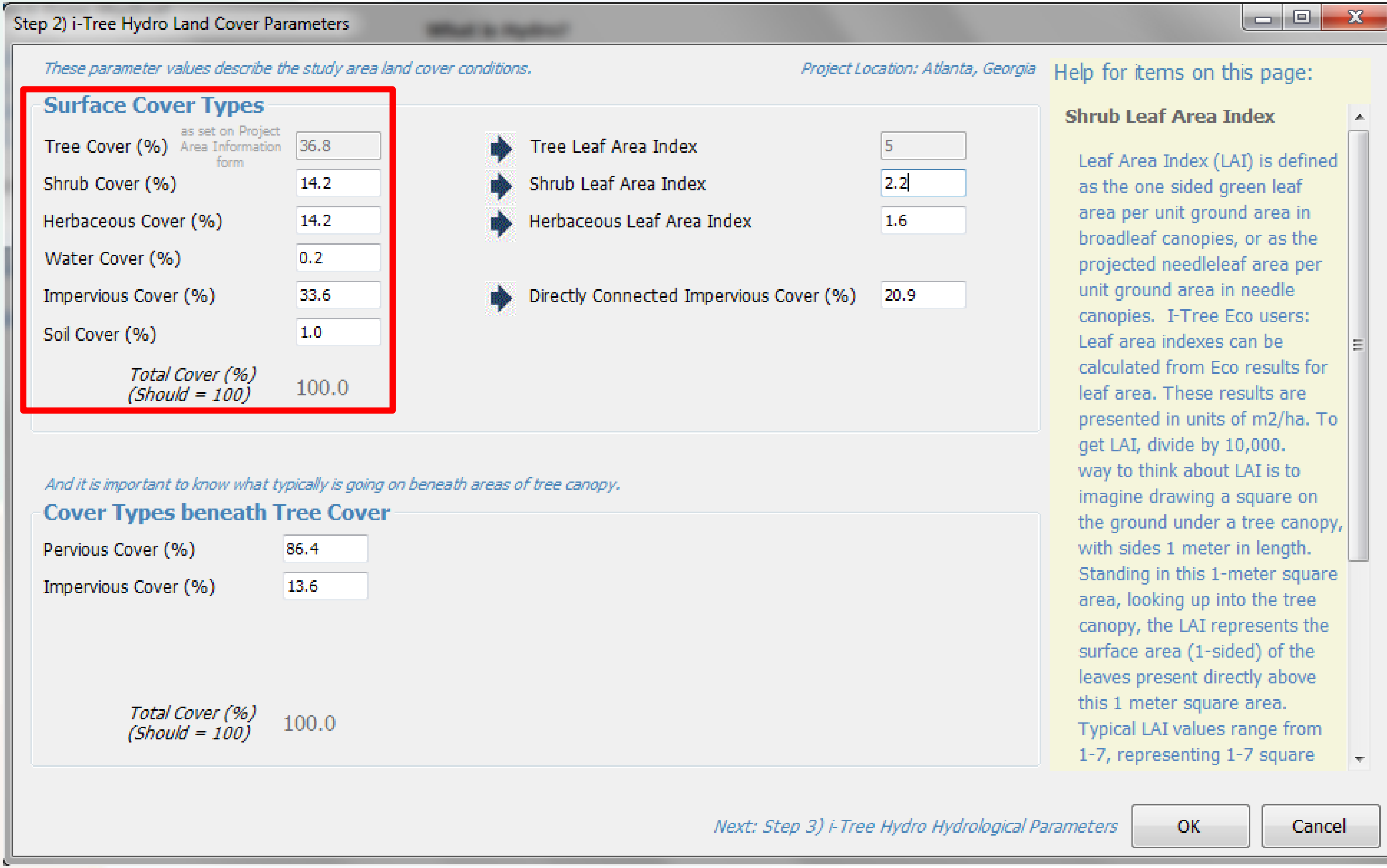
i-Tree Hydro: Weather Data

WeatherData.dat - Notepad

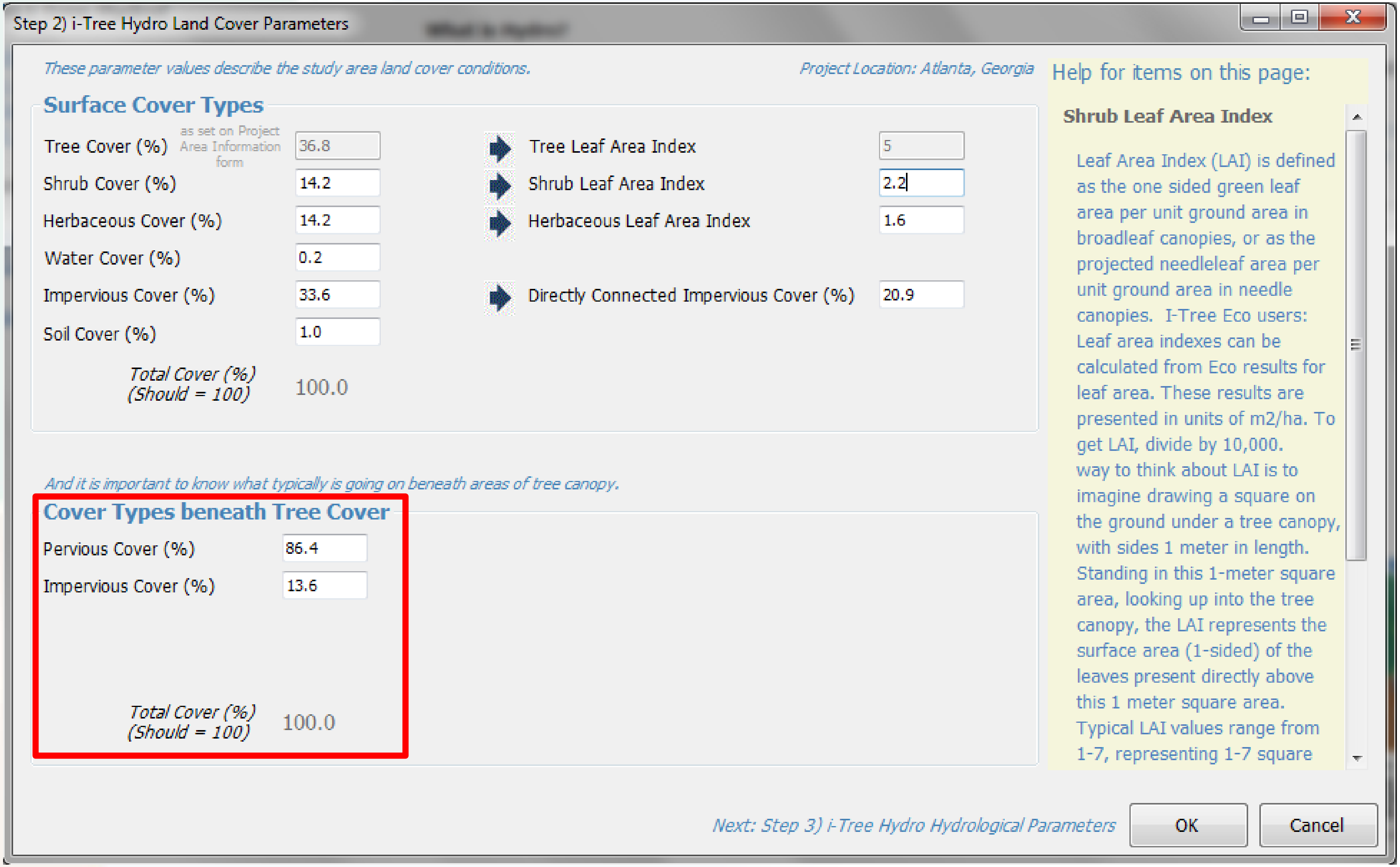
File Edit Format View Help

yyyymmdd	Hr:Min:Sec	Tair(F)	Tdew(F)	NetRad(W/m^2)	WndSpd(m/s)	Precip(m/hr)	Snow(m/hr)
20110101	00:00:00	42.70000000	34.90000000	0.00000000	3.44210997	0.00000000	0.00000000
20110101	01:00:00	40.00000000	34.00000000	0.00000000	2.23513634	0.00000000	0.00000000
20110101	02:00:00	42.10000000	34.10000000	0.00000000	3.48681270	0.00000000	0.00000000
20110101	03:00:00	42.90000000	35.00000000	0.00000000	2.68216361	0.00000000	0.00000000
20110101	04:00:00	42.00000000	35.00000000	0.00000000	2.68216361	0.00000000	0.00000000
20110101	05:00:00	36.85000000	36.00000000	0.00000000	0.00000000	0.00025400	0.00000000
20110101	06:00:00	36.76000000	36.00000000	0.00000000	1.01922217	0.00000000	0.00000000
20110101	07:00:00	36.00000000	36.00000000	0.00000000	1.34108181	0.00000000	0.00000000
20110101	08:00:00	35.31578947	35.31578947	12.50021015	0.00000000	0.00000000	0.00000000
20110101	09:00:00	36.00000000	36.00000000	53.31007742	0.44702727	0.00000000	0.00000000
20110101	10:00:00	37.00000000	37.00000000	88.96392811	0.00000000	0.00000000	0.00000000
20110101	11:00:00	47.00000000	41.00000000	180.3095209	2.77156907	0.00000000	0.00000000
20110101	12:00:00	47.20000000	41.10000000	382.4534808	3.48681270	0.00000000	0.00000000
20110101	13:00:00	49.00000000	42.00000000	174.0454807	2.68216361	0.00000000	0.02540000
20110101	14:00:00	49.90000000	42.90000000	131.4296478	3.17389361	0.00000000	0.00000000
20110101	15:00:00	49.00000000	42.00000000	159.7079611	3.71032633	0.00000000	0.00000000
20110101	16:00:00	49.00000000	42.00000000	27.88483690	4.91729996	0.00000000	0.00000000
20110101	17:00:00	46.00000000	41.90000000	0.00000000	3.57621815	0.00000000	0.00000000
20110101	18:00:00	46.30000000	41.10000000	0.00000000	3.63582179	0.00000000	0.00000000
20110101	19:00:00	49.00000000	42.00000000	0.00000000	3.12919088	0.00000000	0.02540000
20110101	20:00:00	49.10000000	40.90000000	0.00000000	3.71032633	0.00000000	0.00000000
20110101	21:00:00	50.00000000	40.00000000	0.00000000	5.05140814	0.00000000	0.00000000
20110101	22:00:00	50.00000000	40.00000000	0.00000000	6.25838176	0.00000000	0.00000000
20110101	23:00:00	49.00000000	39.00000000	0.00000000	6.79481448	0.00000000	0.00000000
20110102	00:00:00	48.90000000	39.10000000	0.00000000	7.42065266	0.00000000	0.02540000
20110102	01:00:00	48.00000000	40.00000000	0.00000000	5.81135449	0.00000000	0.02540000

i-Tree Hydro: Land Cover Parameters



i-Tree Hydro: Land Cover Parameters



i-Tree Hydro: Land Cover Parameters

i-Tree

Step 2) i-Tree Hydro Land Cover Parameters

These parameter values describe the study area land cover conditions.

Project Location: Atlanta, Georgia

Surface Cover Types

Tree Cover (%)	as set on Project Area Information form	36.8
Shrub Cover (%)		14.2
Herbaceous Cover (%)		14.2
Water Cover (%)		0.2
Impervious Cover (%)		33.6
Soil Cover (%)		1.0
Total Cover (%) (Should = 100)		100.0

Tree Leaf Area Index	5
Shrub Leaf Area Index	2.2
Herbaceous Leaf Area Index	1.6
Directly Connected Impervious Cover (%)	20.9

And it is important to know what typically is going on beneath areas of tree canopy.

Cover Types beneath Tree Cover

Pervious Cover (%)	86.4
Impervious Cover (%)	13.6
Total Cover (%) (Should = 100)	100.0

Help for items on this page:

Shrub Leaf Area Index

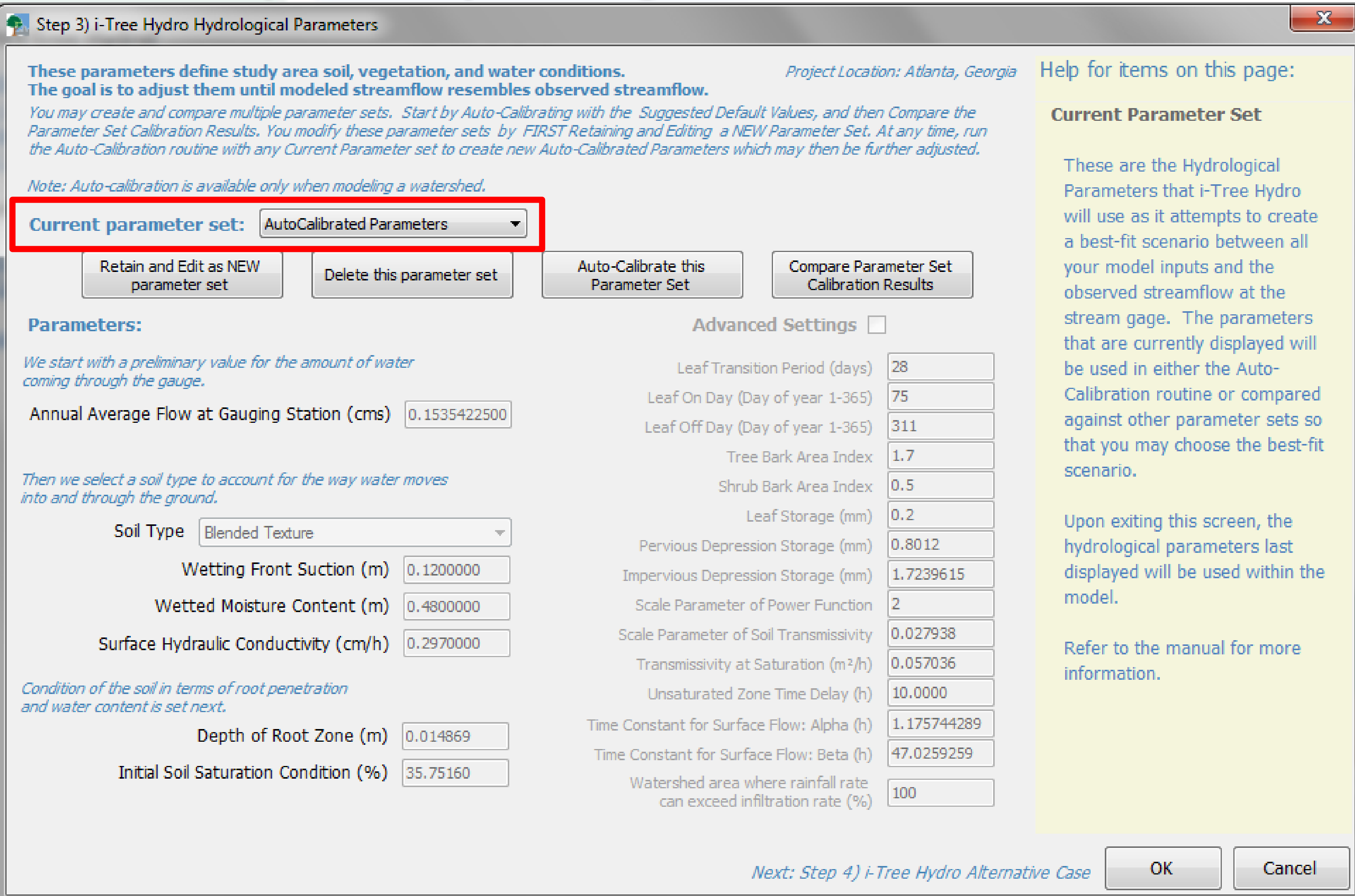
Leaf Area Index (LAI) is defined as the one sided green leaf area per unit ground area in broadleaf canopies, or as the projected needleleaf area per unit ground area in needle canopies. I-Tree Eco users: Leaf area indexes can be calculated from Eco results for leaf area. These results are presented in units of m2/ha. To get LAI, divide by 10,000. way to think about LAI is to imagine drawing a square on the ground under a tree canopy, with sides 1 meter in length. Standing in this 1-meter square area, looking up into the tree canopy, the LAI represents the surface area (1-sided) of the leaves present directly above this 1 meter square area. Typical LAI values range from 1-7, representing 1-7 square

Next: Step 3) i-Tree Hydro Hydrological Parameters

OK Cancel

i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Hydrological Parameters



i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Hydrological Parameters

Step 3) i-Tree Hydro Hydrological Parameters

These parameters define study area soil, vegetation, and water conditions.
The goal is to adjust them until modeled streamflow resembles observed streamflow.

Project Location: Atlanta, Georgia

You may create and compare multiple parameter sets. Start by Auto-Calibrating with the Suggested Default Values, and then Compare the Parameter Set Calibration Results. You modify these parameter sets by FIRST Retaining and Editing a NEW Parameter Set. At any time, run the Auto-Calibration routine with any Current Parameter set to create new Auto-Calibrated Parameters which may then be further adjusted.

Note: Auto-calibration is available only when modeling a watershed.

Current parameter set: AutoCalibrated Parameters

[Retain and Edit as NEW parameter set] [Delete this parameter set] [Auto-Calibrate this Parameter Set] [Compare Parameter Set Calibration Results]

Parameters:

We start with a preliminary value for the amount of water coming through the gauge.

Annual Average Flow at Gauging Station (cms): 0.1535422500

Then we select a soil type to account for the way water moves into and through the ground.

Soil Type	Blended Texture
Wetting Front Suction (m)	0.1200000
Wetted Moisture Content (m)	0.4800000
Surface Hydraulic Conductivity (cm/h)	0.2970000

Condition of the soil in terms of root penetration and water content is set next.

Depth of Root Zone (m)	0.014869
Initial Soil Saturation Condition (%)	35.75160

Advanced Settings ☐

Leaf Transition Period (days)	28
Leaf On Day (Day of year 1-365)	75
Leaf Off Day (Day of year 1-365)	311
Tree Bark Area Index	1.7
Shrub Bark Area Index	0.5
Leaf Storage (mm)	0.2
Pervious Depression Storage (mm)	0.8012
Impervious Depression Storage (mm)	1.7239615
Scale Parameter of Power Function	2
Scale Parameter of Soil Transmissivity	0.027938
Transmissivity at Saturation (m^2/h)	0.057036
Unsaturated Zone Time Delay (h)	10.0000
Time Constant for Surface Flow: Alpha (h)	1.175744289
Time Constant for Surface Flow: Beta (h)	47.0259259
Watershed area where rainfall rate can exceed infiltration rate (%)	100

Help for items on this page:

Current Parameter Set

These are the Hydrological Parameters that i-Tree Hydro will use as it attempts to create a best-fit scenario between all your model inputs and the observed streamflow at the stream gage. The parameters that are currently displayed will be used in either the Auto-Calibration routine or compared against other parameter sets so that you may choose the best-fit scenario.

Upon exiting this screen, the hydrological parameters last displayed will be used within the model.

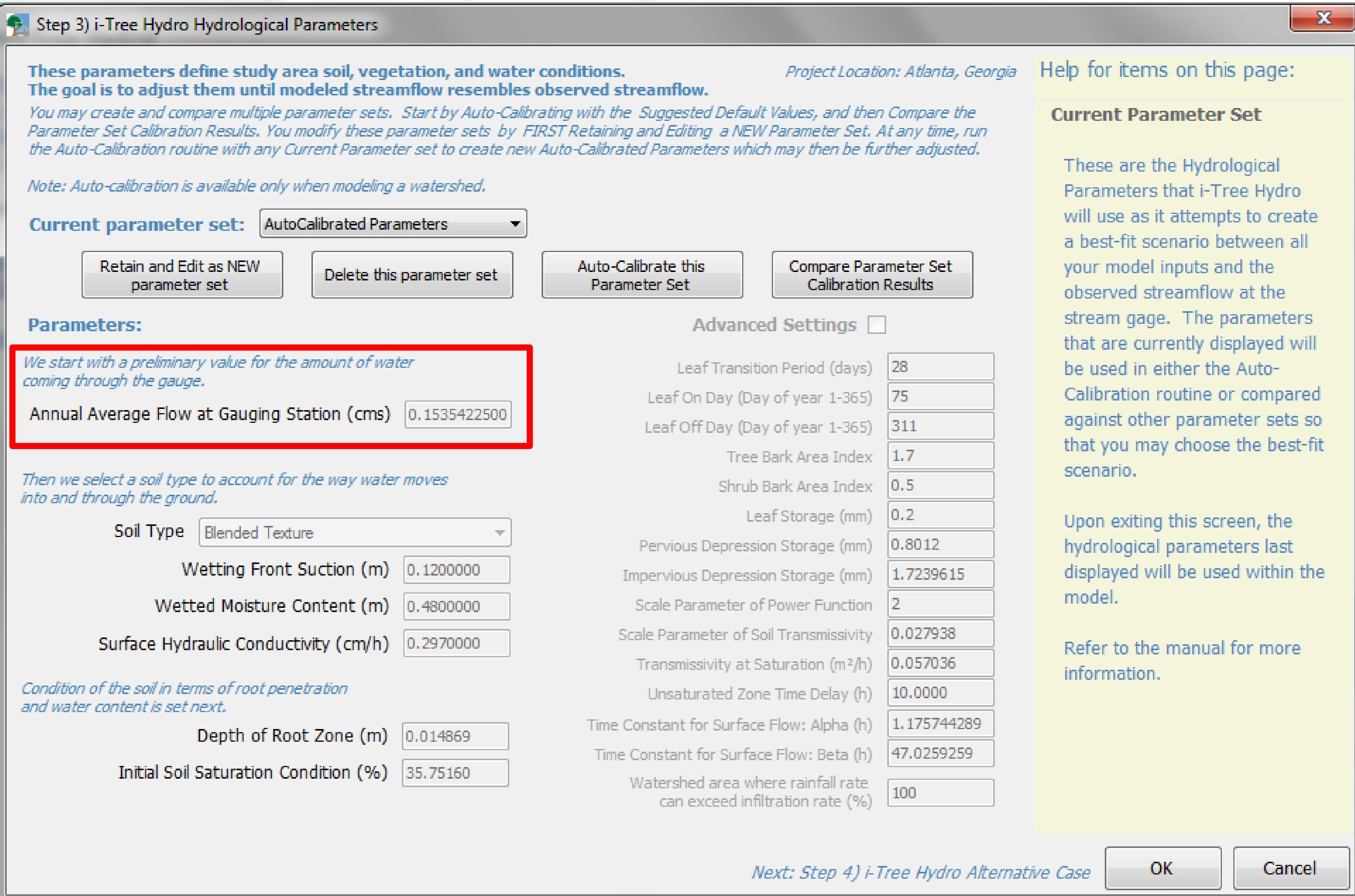
Refer to the manual for more information.

Next: Step 4) i-Tree Hydro Alternative Case

[OK] [Cancel]

i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Hydrological Parameters



i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Hydrological Parameters

i-Tree

Step 3) i-Tree Hydro Hydrological Parameters

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Project Location: Atlanta, Georgia

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Retain and Edit as NEW parameter set | Delete this parameter set | Auto-Calibrate this Parameter Set | Compare Parameter Set Calibration Results

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Advanced Settings

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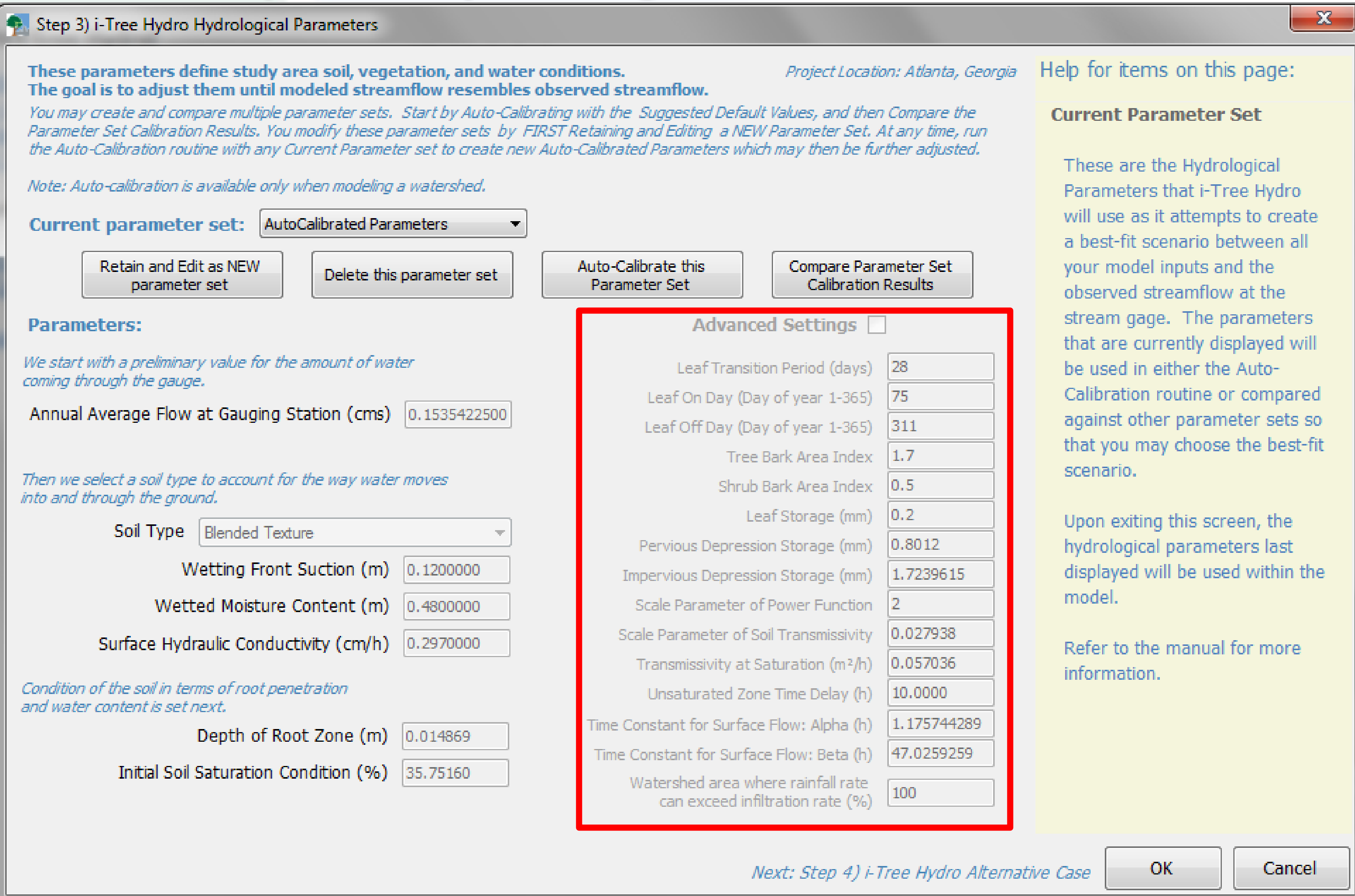
Refer to the manual for more information.

Next: Step 4) i-Tree Hydro Alternative Case

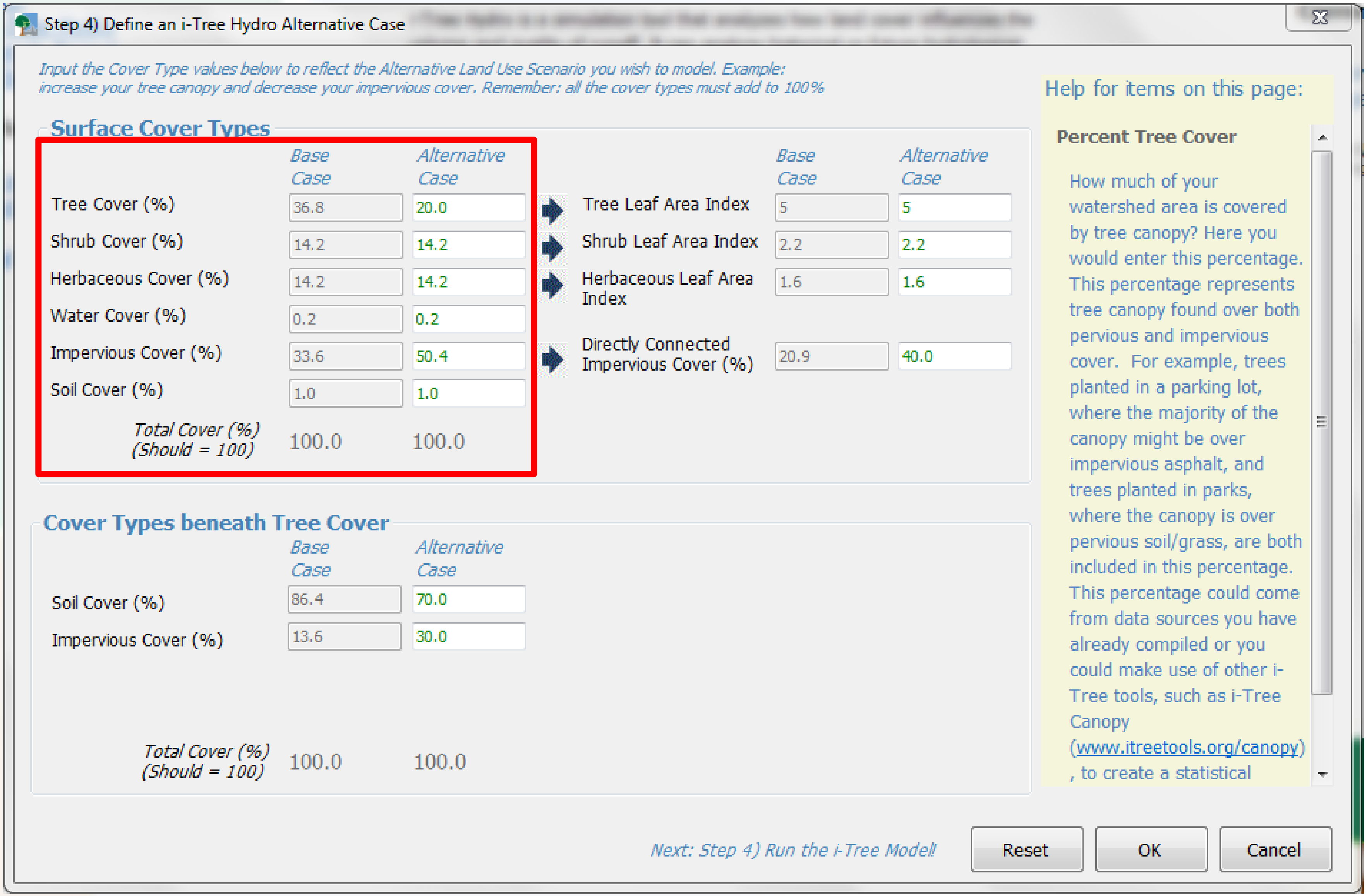
OK | Cancel

i-Tree Hydro: Hydrological Parameters



i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Alternative Case



i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Alternative Case

Step 4) Define an i-Tree Hydro Alternative Case

Input the Cover Type values below to reflect the Alternative Land Use Scenario you wish to model. Example: increase your tree canopy and decrease your impervious cover. Remember: all the cover types must add to 100%

Surface Cover Types

	Base Case	*Alternative Case*
Tree Cover (%)	36.8	20.0
Shrub Cover (%)	14.2	14.2
Herbaceous Cover (%)	14.2	14.2
Water Cover (%)	0.2	0.2
Impervious Cover (%)	33.6	50.4
Soil Cover (%)	1.0	1.0
Total Cover (%) (Should = 100)	100.0	100.0

	Base Case	*Alternative Case*
Tree Leaf Area Index	5	5
Shrub Leaf Area Index	2.2	2.2
Herbaceous Leaf Area Index	1.6	1.6
Directly Connected Impervious Cover (%)	20.9	40.0

Cover Types beneath Tree Cover

	Base Case	*Alternative Case*
Soil Cover (%)	86.4	70.0
Impervious Cover (%)	13.6	30.0
Total Cover (%) (Should = 100)	100.0	100.0

Help for items on this page:

Percent Tree Cover

How much of your watershed area is covered by tree canopy? Here you would enter this percentage. This percentage represents tree canopy found over both pervious and impervious cover. For example, trees planted in a parking lot, where the majority of the canopy might be over impervious asphalt, and trees planted in parks, where the canopy is over pervious soil/grass, are both included in this percentage. This percentage could come from data sources you have already compiled or you could make use of other i-Tree tools, such as i-Tree Canopy (www.itreetools.org/canopy) , to create a statistical

Next: Step 4) Run the i-Tree Model!

Reset | OK | Cancel

i-Tree is a Cooperative Initiative among these partners

i-Tree Hydro: Alternative Case

i-Tree

Step 4) Define an i-Tree Hydro Alternative Case

Input the Cover Type values below to reflect the Alternative Land Use Scenario you wish to model. Example: increase your tree canopy and decrease your impervious cover. Remember: all the cover types must add to 100%

Surface Cover Types

	Base Case	Alternative Case		Base Case	Alternative Case
Tree Cover (%)	36.8	20.0	Tree Leaf Area Index	5	5
Shrub Cover (%)	14.2	14.2	Shrub Leaf Area Index	2.2	2.2
Herbaceous Cover (%)	14.2	14.2	Herbaceous Leaf Area Index	1.6	1.6
Water Cover (%)	0.2	0.2			
Impervious Cover (%)	33.6	50.4	Directly Connected Impervious Cover (%)	20.9	40.0
Soil Cover (%)	1.0	1.0			
Total Cover (%) (Should = 100)	100.0	100.0			

Cover Types beneath Tree Cover

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Next: Step 4) Run the i-Tree Model!

Reset | OK | Cancel

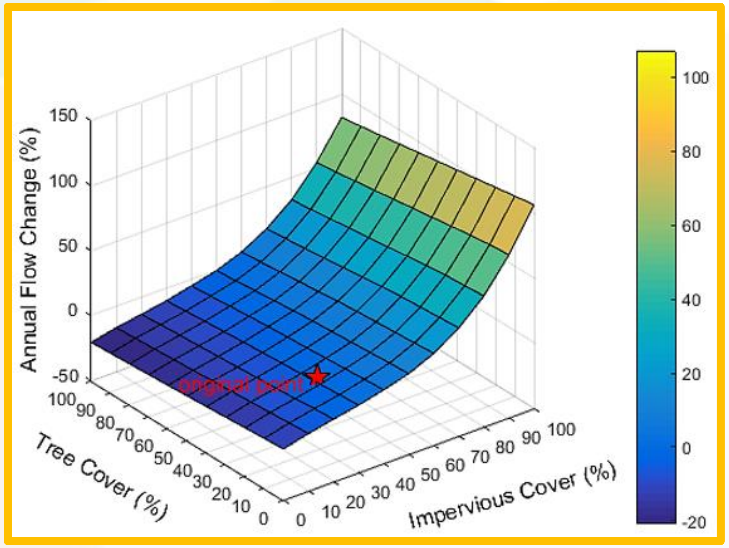
i-Tree is a Cooperative Initiative among these partners

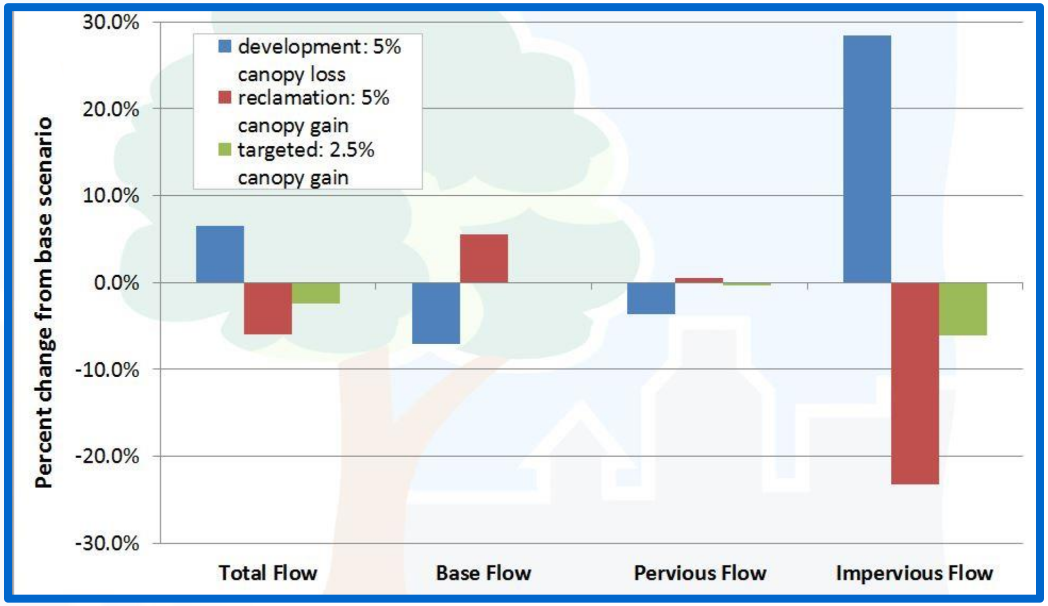
DAVEY · Arbor Day Foundation · SMA Society of Municipal Arborists · ISA · Casey Trees · ESF State University of New York College of Environmental Science and Forestry · NAASF · EPA United States Environmental Protection Agency

Outputs: In the User Interface

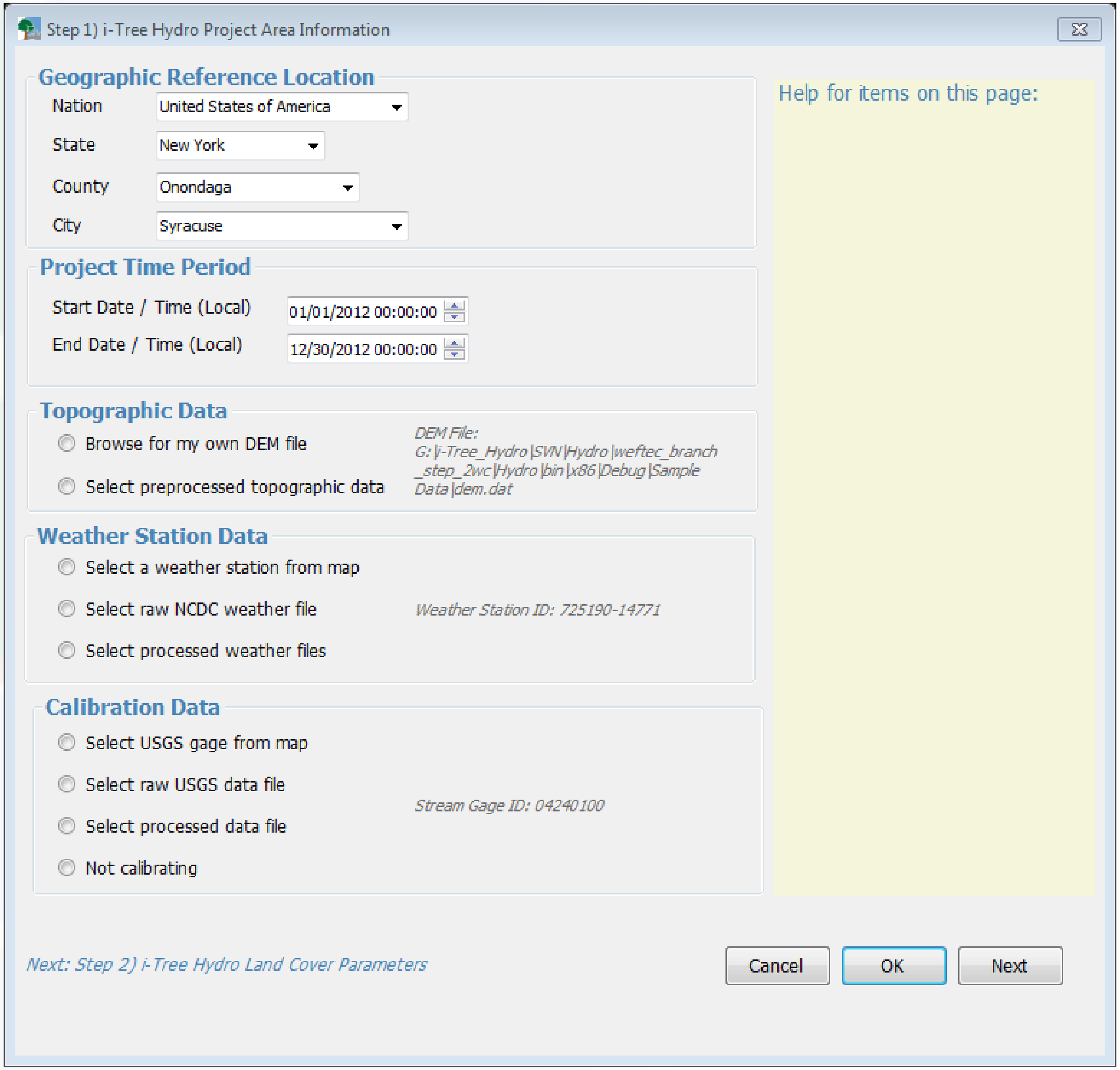
Exported Outputs
& Examples of Additional Processing

Site condition	Total flow (m^3)	Base flow (m^3)	Pervious flow (m^3)	Impervious flow (m^3)
Current	12,322	5,063	4,700	2,559
Post-development	37,277	6,488	14,327	16,462
Increased Gallons	6.6 million	376 K	2.5 million	3.7 million
Percent Increase	303%	28%	305%	643%

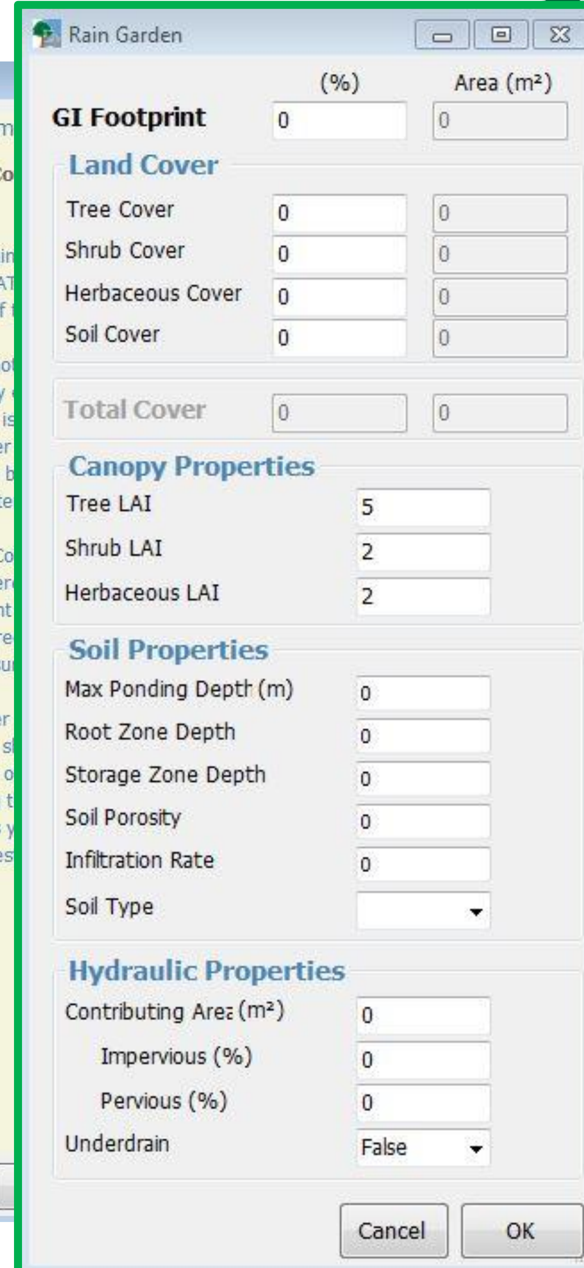




Preview of i-Tree Hydro Version 6

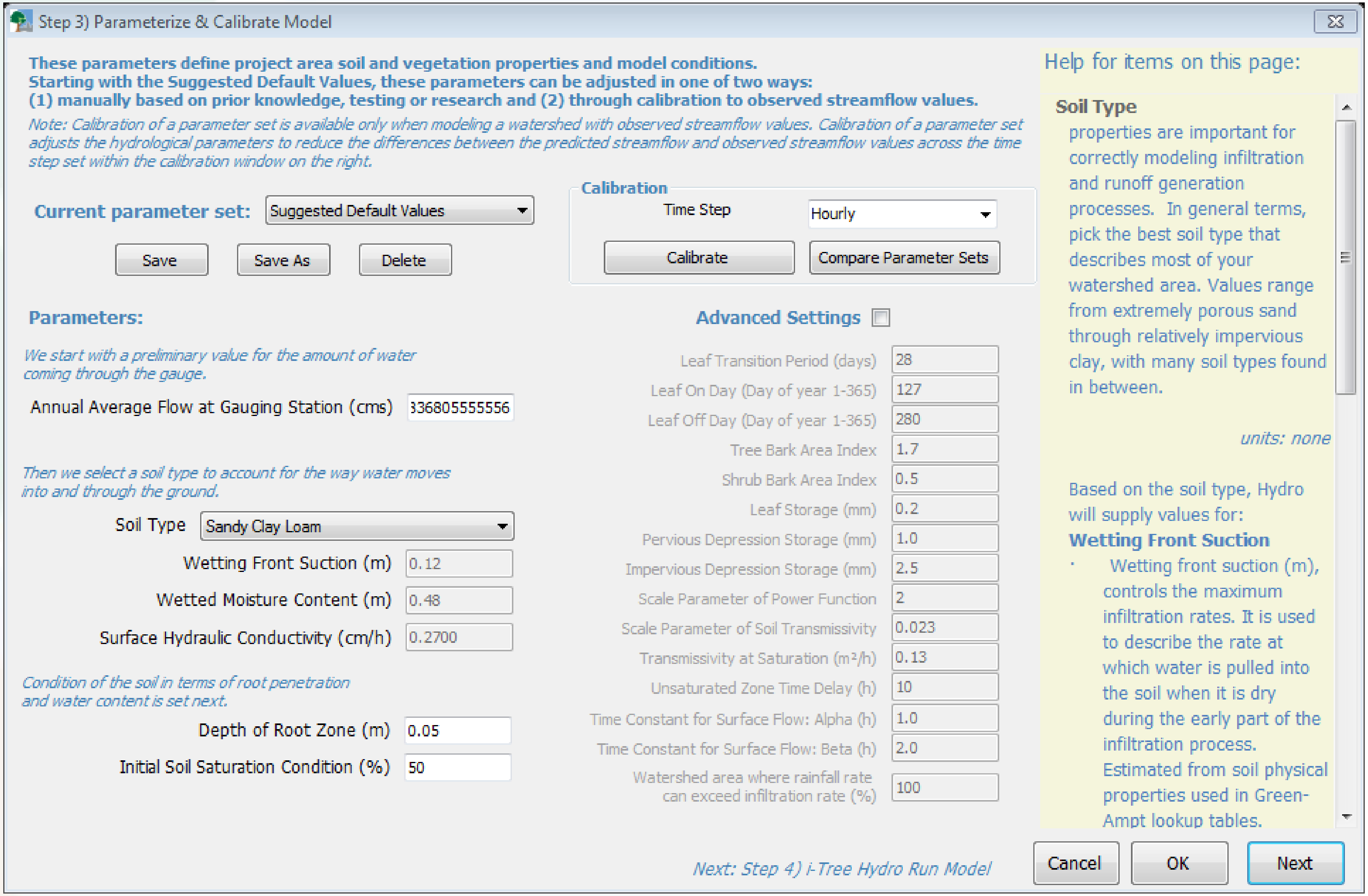


Preview of i-Tree Hydro Version 6



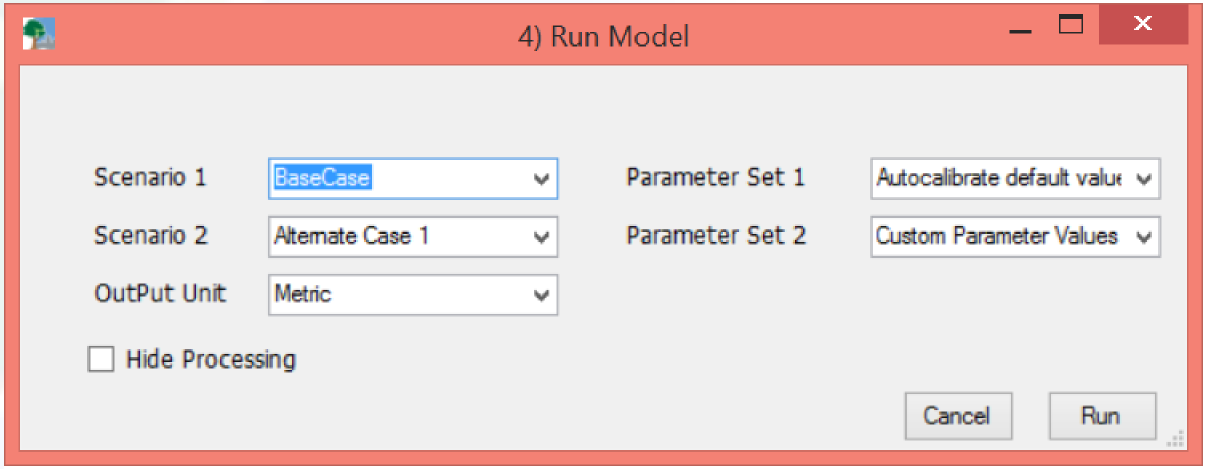
i-Tree is a Cooperative Initiative among these partners

Preview of i-Tree Hydro Version 6



Preview of i-Tree Hydro Version 6

i-Tree



Preview of i-Tree Hydro Version 6

i-Tree

Design Rain

Location Input

State : Wisconsin

Location : (•) Address ( ) Latitude,Longitude

Show Location on Map

Duration and Frequency Input

Input/Output Units : **Units** (•) SI (cm) ( ) BG (in)

Duration : 24-hr

Rainfall Distribution Type : IA

Recurrence Interval : 100-yr

View US Rainfall Distribution Type

Get Rain Data

Rain Depth (cm/in) : 15.215

IDF Table (in inches)

Duration	One yr rec	Two yr rec	Five yr rec	Ten yr rec	Twenty Five yr rec	Fifty yr rec	Hundre
12hr	1.965	2.218	2.699	3.162	3.894	4.534	5.238
24-hr	2.253	2.547	3.101	3.632	4.467	5.193	5.990
2-day	2.536	2.903	3.577	4.207	5.180	6.012	6.917
3-day	2.786	3.170	3.879	4.542	5.566	6.443	7.396
4-day	3.011	3.407	4.138	4.822	5.879	6.784	7.769
7-day	3.582	4.034	4.854	5.608	6.758	7.732	8.782
10-day	4.091	4.598	5.501	6.319	7.547	8.575	9.673
20-day	5.577	6.232	7.356	8.339	9.767	10.927	12.138
30-day	6.845	7.634	8.955	10.081	11.673	12.936	14.228
45-day	8.480	9.458	11.053	12.373	14.183	15.574	16.961
60-day	9.895	11.050	12.898	14.393	16.397	17.898	19.361

Save **Close**

i-Tree is a Cooperative Initiative among these partners

DAVEY · Arbor Day Foundation · sma Society of Municipal Arborists · ISA · Casey Trees · ESF State University of New York College of Environmental Science and Forestry · NAASF · EPA United States Environmental Protection Agency

Thoughts & Questions

www.itreetools.org

Videos

Documentation

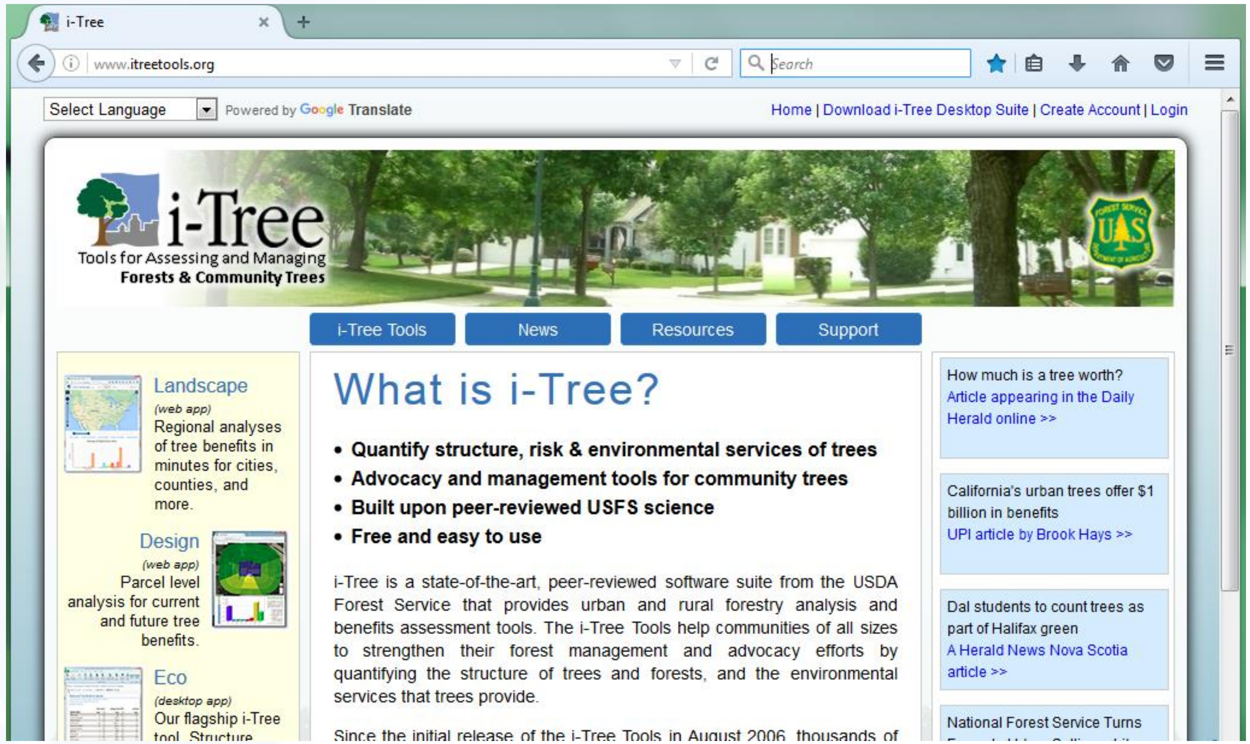
Online tools

Support

Examples

Downloads

Newsletters



info@itreetools.org

i-Tree is a Cooperative Initiative among these partners

Thank you!

Robbie Coville
robert.coville@davey.com

Dr. Ted Endreny
te@esf.edu

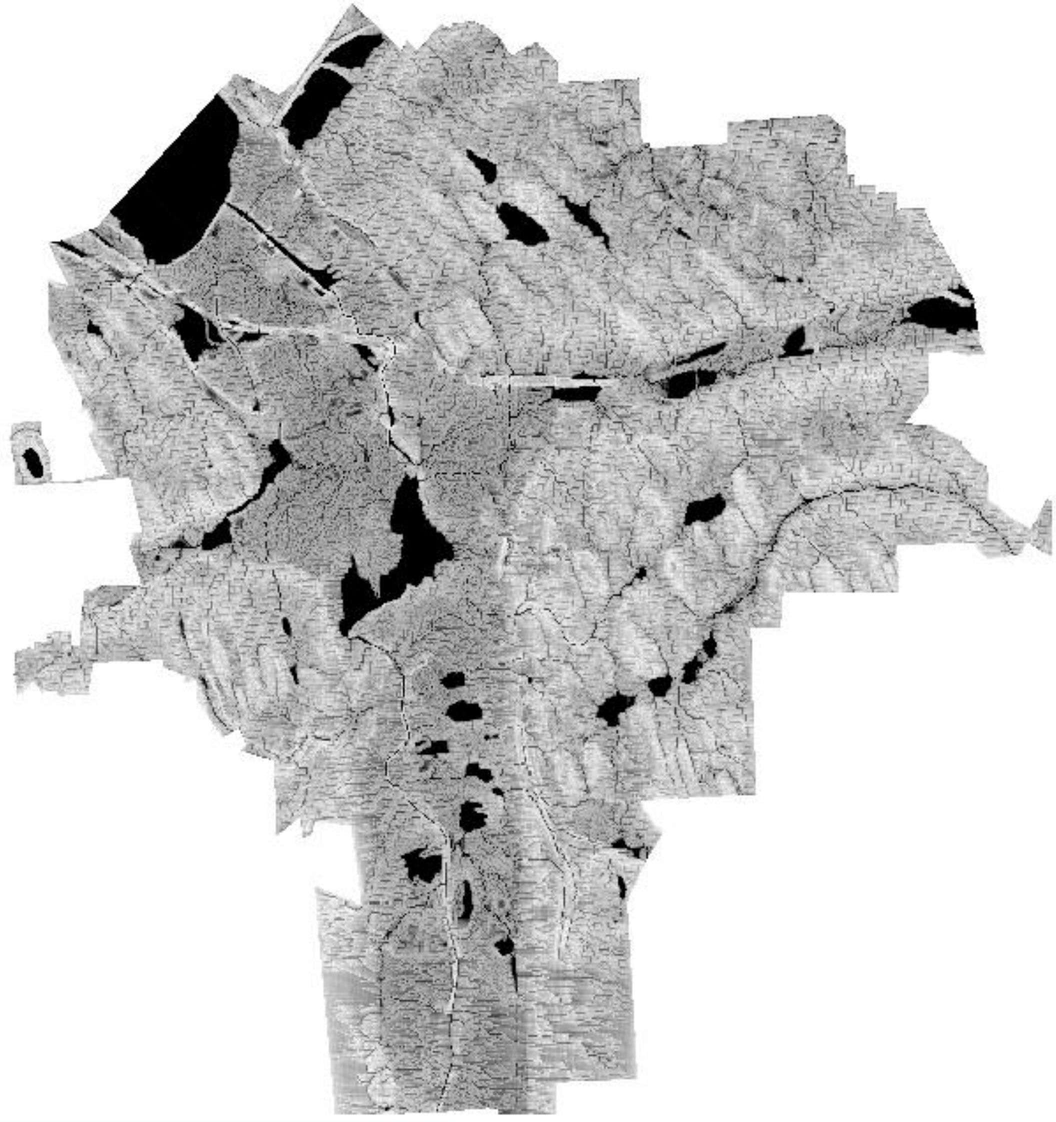
In-depth technical slides to address questions

Hydro: Model Assumptions

- Topographic index
  - Affected by DEM resolution
  - Increasing DEM resolution – small cell sizes
    - TI values decrease for most cells
      - Minimum, median values decrease
    - TI values may increase for river/stream network cells
      - Maximum value may increase
  - Decreasing DEM resolution – larger cell sizes
    - Has the opposite effect

Hydro: Model Assumptions

TI Syracuse, NY



Hydro: Model Assumptions

- Hydraulic Conductivity – Transmissivity
  - Same everywhere in the watershed
  - Decay profiles – decays with soil depth
    - Exponential vs. Power

$$K_s(z) = K_o \exp(-fz) \qquad K_s(z) = K_o(1 - fz)^n$$

    - Default model setting is power law decay
    - Changed in hydrological parameters screen

Hydro: Model Assumptions

- Saturation/infiltration excess
  - Effects pervious areas
    - Tree cover over pervious, shrub/herbaceous, bare soil
  - Percentage of watershed area that is controlled by infiltration excess – rest is saturation excess

- Land cover
  - Average or sampled – typically only an estimation
  - DCIA value – estimated
  - Problems with NLCD resolution

HP: Modeling Metrics

- Calibration
  - Method:
    - Determining optimal model parameter set
      - Optimization algorithm - PEST
    - Repeated model runs
      - Comparing predicted and observed values
    - Maximize goodness of fit metrics
  - Problems:
    - Equifinality – Different parameter sets, same optimum
    - Disagreement between field data and model parameters

HP: Modeling Metrics

Calibration Metrics

- Values range from -∞ to 1
  - Negative – Worse than observed average value
  - Zero – Equal to observed average value
  - Positive – Better than observed average value
- Volumetric Efficiency
  - Criss and Winston, 2008
- Baseflow fit
  - Perrin et al., 2001
- Peak flow fit
  - Nash – Sutcliffe Efficiency (1970)
- Overall fit
  - Ye et al., 1997

$$NSE = 1 - \frac{\sum (Q_{\text{calc}} - Q_{\text{obs}})^2}{\sum (\overline{Q}_{\text{obs}} - Q_{\text{obs}})^2}$$

HP: Modeling Metrics

Validation

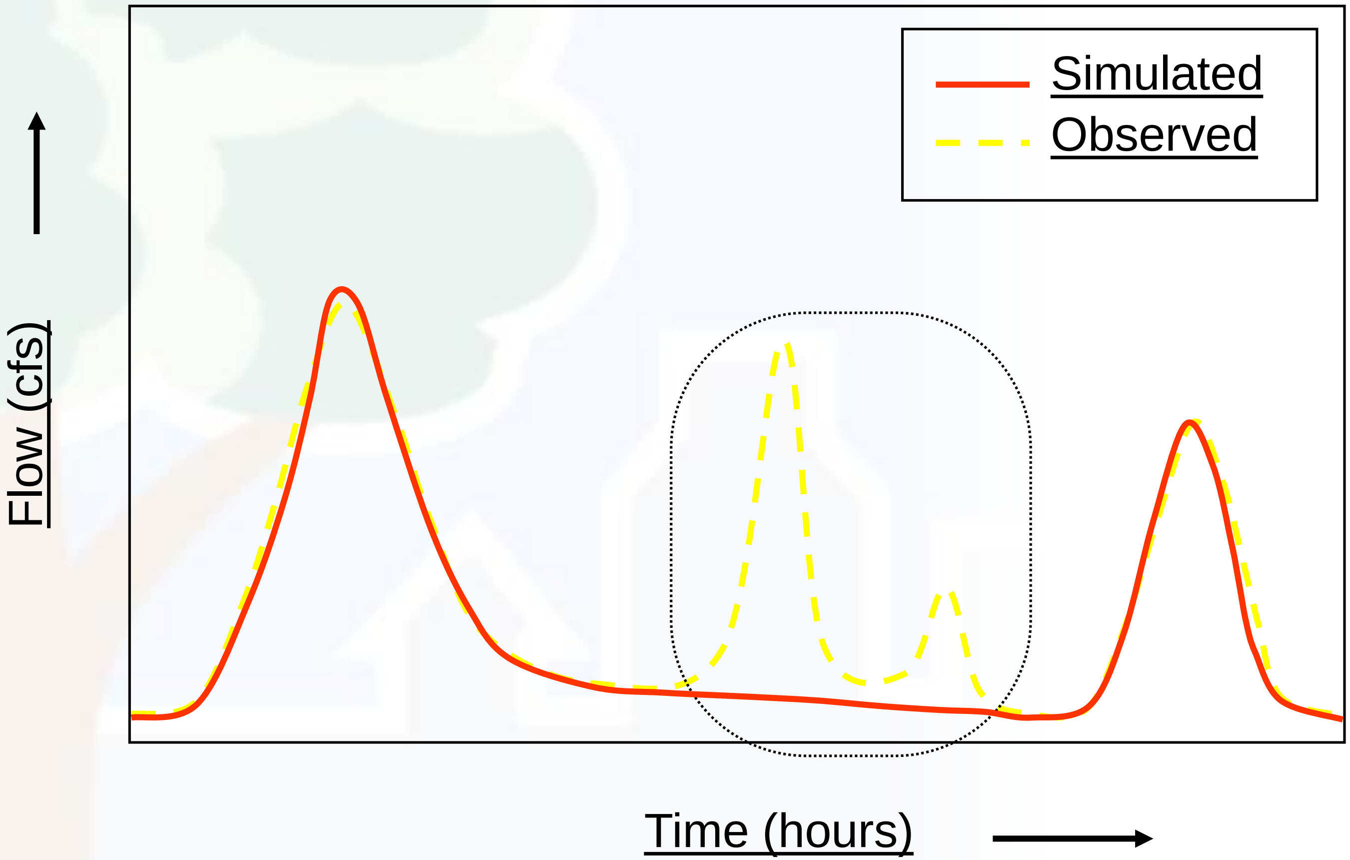
- Using optimized parameter set to predict forward
  - Without further alteration/optimization
- Necessary to build confidence in the model
  - Trust structure and calibrated parameter set

Verification

- Alter model structure or routines
  - Switch model routines – different governing equations
  - Revise model code – numerical solutions, code structure

HP: Modeling Metrics

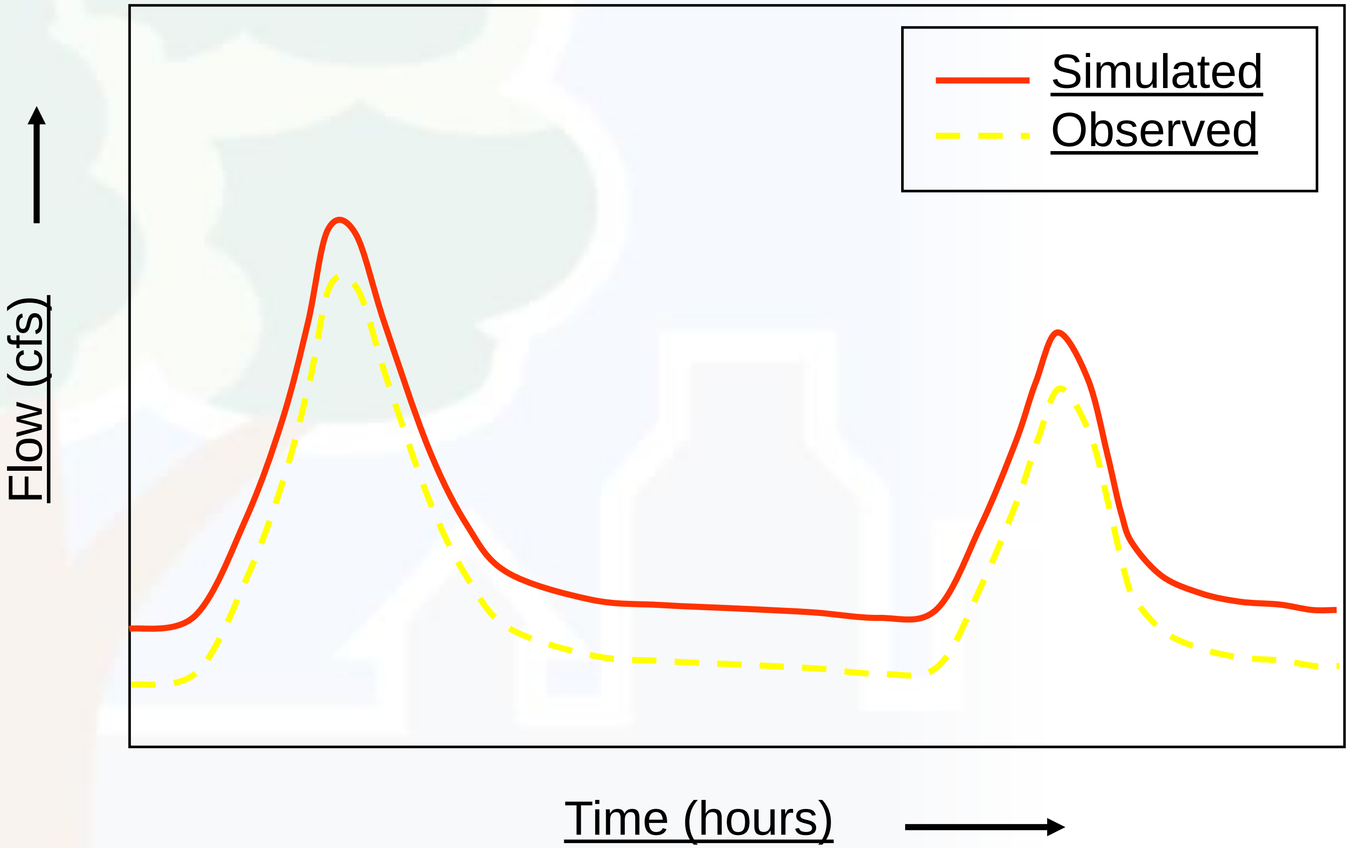
- Common calibration problems
  - Weather station isn't representative, gage errors



- Check weather station location, dominant weather patterns
- Check input data period for errors

HP: Modeling Metrics

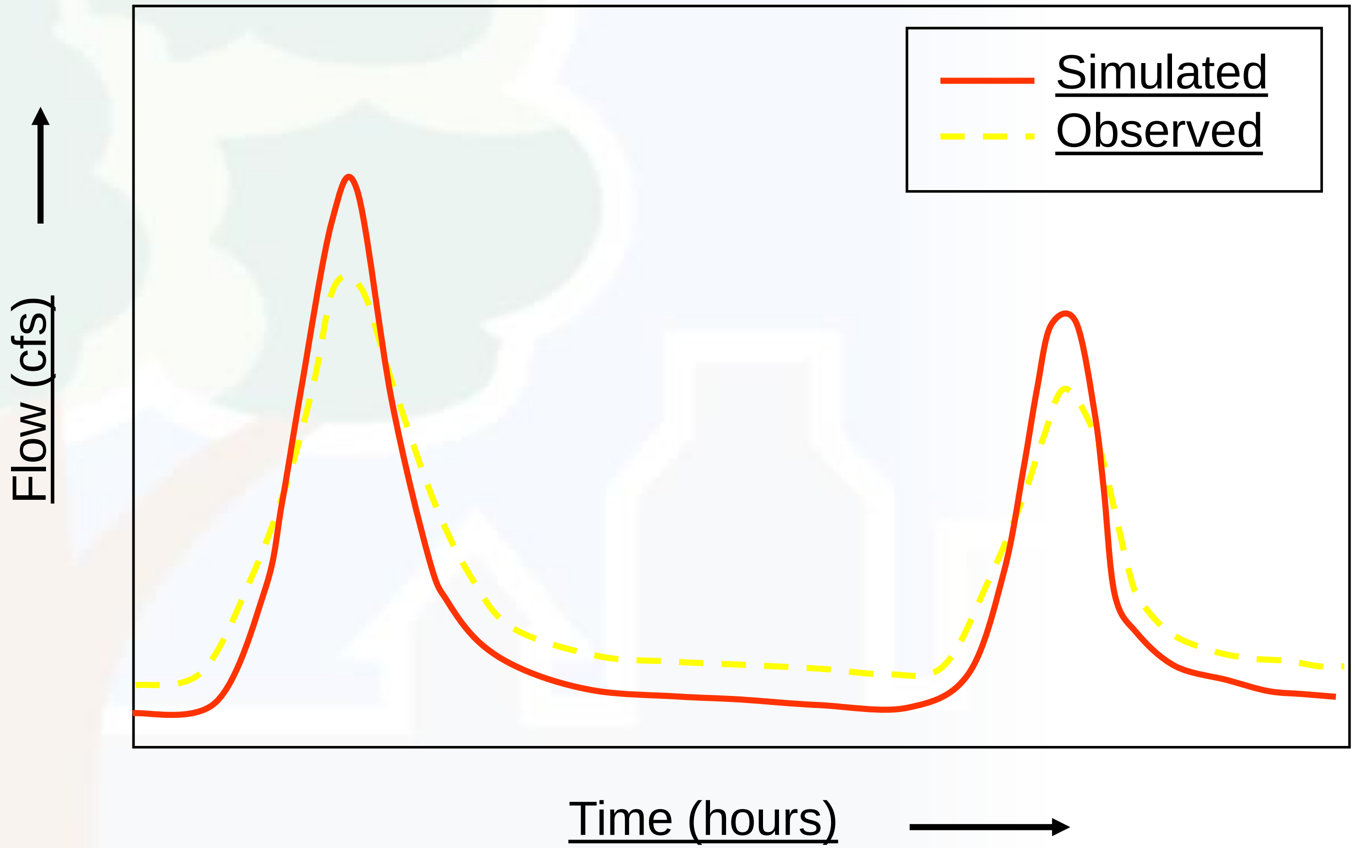
- Common calibration problems
  - High base flow, too little evapotranspiration



- Check landcover estimates
- Check weather data (net rad., temp, windspeed)
- LAI, K_{sat} values

HP: Modeling Metrics

- Common calibration problems
  - Incorrect partitioning of baseflow/overland flows



- Check landcover estimates
- Check contributing area/DEM footprint
- LAI, K_{sat} values