i-Tree Hydro: Assessing How Land Use Changes Affect Water Quantity & Quality in Watersheds, Municipalities, and Other Areas

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Introduction to i-Tree Tools

Trees in urban communities can mitigate many adverse effects associated with anthropogenic activities and climate change (e.g. urban heat island, greenhouse gas, air pollution, and floods). To protect environmental and human health over time, managers need to make informed decisions based on model results about urban forest management practices. However, it is difficult for them to get the appropriate model results due to obstacles such as difficulties in preparing inputs, limited access to needed models, and unsuitable outputs or user interfaces.

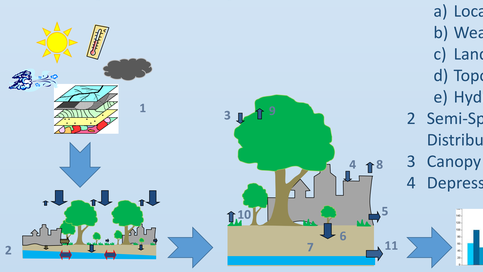
i-Tree Tools are a set of models developed through a consortium of partners, including USDA Forest Service, Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry, which help communities of all sizes strengthen urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide. i-Tree is in the public domain and freely available for download or use through the i-Tree web site (www.itreetools.org). Continuous development and technical support is also provided free of charge.

Background on i-Tree Hydro

Urbanization significantly alters stream flows and water quality due to increased impervious surfaces, increased pollutants emitted from various sources and decreases in natural vegetation cover. These changes lead to increased runoff and flashiness of stream flow after storms, potential flooding issues, and poorer water quality that affect human health and well-being.

Many existing urban hydrology models are either highly parameterized or overly simplistic, and both extremes are limited in management applications. In both cases, urban hydrology models tend to lack explicit consideration of vegetation's contribution. The research behind the creation of i-Tree Hydro is based on a middle-ground and an emphasis on urban forests: creating **a relatively simple, process-based model to explicitly represent the effects of vegetation and soils on the urban hydrological cycle** (Wang et al, 2008).

i-Tree Hydro model processes



1 Inputs
- a) Location
- b) Weather
- c) Land Cover
- d) Topography
- e) Hydrology & Soil

2 Semi-Spatial Distribution
3 Canopy Interception
4 Depression Storage
5 Surface Runoff
6 Infiltration
7 Soil Moisture
8 Surface Evaporation
9 Veg Evaporation
10 Evapotranspiration
11 Subsurface Runoff
12 Outputs
- a) Water quantity
- b) Water quality

i-Tree Hydro is a stand-alone application designed to simulate the effects of changes in tree and impervious cover characteristics within a defined watershed on stream flow and water quality. It was designed specifically to handle urban vegetation effects so urban natural resource managers and urban planners can quantify the impacts of changes in tree and impervious cover on local hydrology to aid in management and planning decisions. It is also designed for ease of use, utilizing available data sets as inputs to the model.

Current Features

Simulation of land cover scenarios in hourly time-steps, analyzing how land cover influences runoff volume & quality.

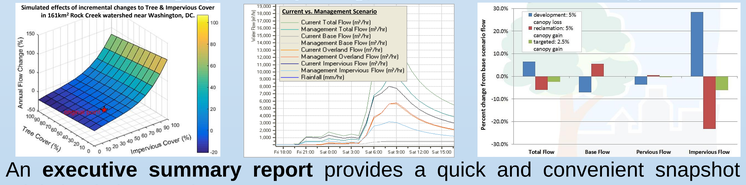
› **Watershed areas can be modeled quantitatively using an auto-calibration tool** to find the best fit between hydrological parameters and measured stream discharge.

› Users can select **non-watershed areas**, such as cities or campuses, and simulate water flow and water quality changes qualitatively by modeling tree and impervious cover changes.

› **Topographic data is pre-loaded for U.S. cities, counties, states, and watersheds**, which eliminates the need for GIS skills to produce and import a digital elevation model.

› Hourly U.S. **weather data** and **measured stream discharge data** is now **pre-loaded for years 2005 - 2012**.

› **Flexible formats, graphics, exporting, and DEM visualization** support results.



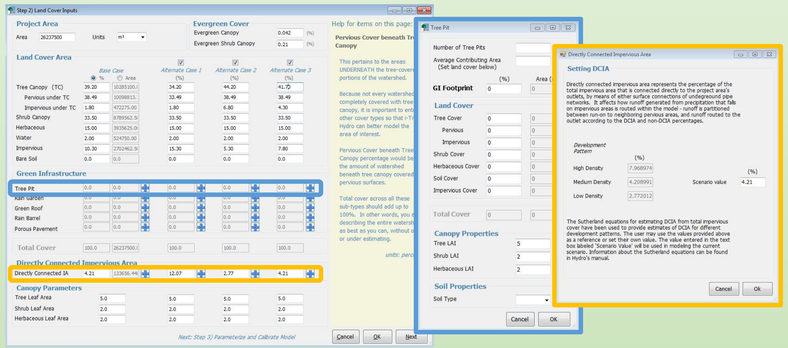
› An **executive summary report** provides a quick and convenient snapshot of model simulation results.

› A **user-friendly dynamic help panel** explains terminology and guides users through the entire modeling process.

Upcoming Features

i-Tree Hydro version 6 is in-the-works! Here are some upgrades to look forward to:

› **Green infrastructure modeling** of tree pits, rain barrels, green roofs, rain gardens, pervious pavement, and bio-retention basins.



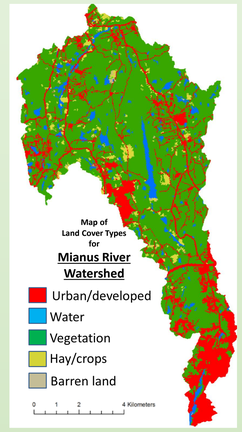
› **Design Rain tool** for accessing precipitation data from simulated storms based on NOAA data and Intensity-Duration-Frequency (IDF) curves.

› **Curve Number tool** for runoff prediction based on the NRCS TR-55 method required in many stormwater management projects.

› Enhanced **accessibility** & **user-friendliness**, based on user-feedback and hundreds of simulations run on watersheds near major U.S. cities.

Mianus River Gorge Case Study

The Mianus River watershed has an area of 91 km² and falls across the border of Connecticut & New York. A map of this watershed's land cover types is shown to the right. The Mianus River Gorge Preserve (MRGP), a not-for-profit nature preserve & conservation organization, seeks to use results from i-Tree Hydro to demonstrate the impact of land use and management decisions on the water quality and quantity within the watershed.



Base vs. Alternative Case: Mianus River Watershed

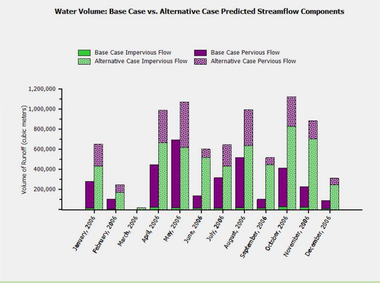
TOTAL AREA (km²):	91			
Hydro Land Cover Inputs:	Base		Alternative	
	%	Area (km²)	%	Area (km²)
Tree Cover	82.80	75.35	40.00	36.40
PC beneath Tree Canopy	91.10	68.64	80.00	29.12
IC beneath Tree Canopy	8.90	6.71	20.00	7.28
Impervious Cover	6.40	5.82	45.00	40.95
Herbaceous	4.30	3.91	6.40	5.82
Shrub Cover	4.30	3.91	6.40	5.82
Soil Cover	0.00	0.00	0.00	0.00
Water Cover	2.20	2.00	2.20	2.00
DCIA*	4.5%		40.0%	
Total impervious Area (km2)	12.53		48.23	

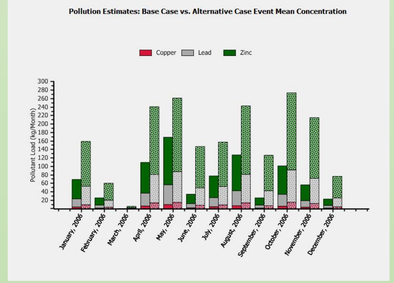
Project Inputs
Reference location: Bedford, NY
Simulation time span: 01/01/2006 – 12/30/2006
Weather station: USAF-WBAN 725037-94745
Calibration stream gauge: USGS 01209901
Land cover inputs: based on 2013 aerial photo-interpretation using 500 points in i-Tree Canopy.
See table to left & below for more on land cover.

*** Directly Connected Impervious Area (DCIA) Calculator**

Based on Sutherland Equations	DCIA	
Development Density	Base	Alt
Low Density	3.453	34.145
Medium Density	5.109	38.585
High Density	9.306	46.902
Agriculture	1.896	28.090

› **The Mianus River watershed i-Tree Hydro simulation demonstrates the effect of major development on the watershed**. This simulation is based on inputs shown in the tables above. The results below show the change in pervious and impervious runoff, and the change in pollutant load of Copper, Lead, and Zinc, for each month of the simulation, comparing the base case to the alternative case.





References & Acknowledgments

Wang, Jun, Theodore A. Endreny, and David J. Nowak, 2008. Mechanistic Simulation of Tree Effects in an Urban Water Balance Model. Journal of the American Water Resources Association (JAWRA) 44(1):75-85.

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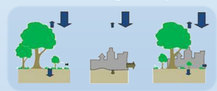

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i-Tree is a cooperative initiative. Thanks to the partners involved:
The Arbor Day Foundation; Society for Municipal Arborists; International Society of Arboriculture; Casey Trees; SUNY-ESF; Davey Institute of the Davey Tree Expert Company; and Forest Inventory and Analysis of the USDA Forest Service.

For more information, please visit http://itreetools.org/hydro or contact the poster author at robert.coville@davey.com