i-Tree Hydro

Water Resilient Cities conference
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Outline
1. Intro to the tool; modeling & management
2. Briefing on background, inputs & outputs
3. Summary of 3 real-world applications
4. Additional resources & next steps
What is i-Tree Hydro?

Simulates effects of:  
- Tree cover
- Impervious cover

on:
- Stream flow
- Water quality

Current vs. Management Scenario

- Current Total Flow (m³/hr)
- Management Total Flow (m³/hr)
- Current Base Flow (m³/hr)
- Management Base Flow (m³/hr)
- Current Overland Flow (m³/hr)
- Management Overland Flow (m³/hr)
- Current Impervious Flow (m³/hr)
- Management Impervious Flow (m³/hr)
- Rainfall (mm/hr)
How can i-Tree Hydro Help?

Modeling & Management

Precipitation

Evapotranspiration

Interception

Throughfall

Runoff

Infiltration
i-Tree Hydro

Model Background

- Process-based, first-order rainfall-runoff model
- 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

Casey Trees
Modeled Hydrologic Processes

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

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 Semi-Spatial Distribution
13 Outputs
   a) Water quantity
   b) Water quality
Model Inputs

Landcover

- 5 main cover classes
  - Bare Soil
  - Shrub/Grass/Herbaceous (Short Vegetation)
  - Impervious Surface
  - Tree Cover over Impervious Area
  - Tree Cover over Pervious Area

*i-Tree Canopy survey for photo-interpretation of i-Tree Hydro’s land cover inputs*
Model Calibration

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

### Daily Model Calibration Results

<table>
<thead>
<tr>
<th>Enabled</th>
<th>Name</th>
<th>Volumetric Efficiency</th>
<th>Peak Flow Fit</th>
<th>Base Flow Fit</th>
<th>Balanced Flow Fit</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Discharge</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rainfall</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suggested Default Values</td>
<td>-1.42625</td>
<td>-49.1535</td>
<td>-4.22019</td>
<td>-13.8412</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Values from file param.dat 1</td>
<td>-2.04194</td>
<td>-91.1213</td>
<td>-5.54488</td>
<td>-17.8398</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AutoCalibrated Parameters</td>
<td>-0.980474</td>
<td>-29.0002</td>
<td>3.26107</td>
<td>-10.8383</td>
<td></td>
</tr>
</tbody>
</table>

The Peak Flow, Base Flow, and Balanced Flow calibration metrics are a measure of how well the predicted flow matches the flow observed at the gaging station. These values range from negative infinity to 1.0. A value of 1.0 indicates a perfect match between the predicted and observed streamflow. A value of 0.0 indicates the predictions are no better at matching the observations than using the average observed streamflow. Negative values indicate the predictions are worse than using the average observed streamflow. Typically "good" calibration metrics range from 0.3 to 0.7, with higher values being better. Sources: Peak Flow Metric - Nash and Sutcliffe, 1970, Base Flow Metric - Ye et al., 1997, Balanced Flow...
Outputs

- Water Quantity Outputs
  - Predicted streamflow vs. observed (if available)
  - Yearly, Monthly, Daily bar-graphs
  - Hourly time-series & Export options

Exported Figures from i-Tree Hydro's Sample Project
Outputs

Water Quality Outputs

- Pollution – Loading estimates
  - Total pollutant mass
  - Based on EMC values – from EPA’s NURP data
  - Available in same formats as water quantity outputs
### Exported Outputs & Examples of Additional Processing

<table>
<thead>
<tr>
<th>Site condition</th>
<th>Total flow (m³)</th>
<th>Base flow (m³)</th>
<th>Pervious flow (m³)</th>
<th>Impervious flow (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>12,322</td>
<td>5,063</td>
<td>4,700</td>
<td>2,559</td>
</tr>
<tr>
<td>Post-development</td>
<td>37,277</td>
<td>6,488</td>
<td>14,327</td>
<td>16,462</td>
</tr>
<tr>
<td>Increased Gallons</td>
<td>6.6 million</td>
<td>376 K</td>
<td>2.5 million</td>
<td>3.7 million</td>
</tr>
<tr>
<td>Percent Increase</td>
<td>303%</td>
<td>28%</td>
<td>305%</td>
<td>643%</td>
</tr>
</tbody>
</table>

![3D Graph: Annual Flow Change (%) vs Tree Cover (%) vs Impervious Cover (%)](image)

![Bar Chart: Percent change from base scenario](image)
Additional Examples of i-Tree Hydro Modeling
Supporting Water Resilient Cities

- **“Briarlake Forest Conversation Project Using i-Tree Hydro”**
  by Eric Kuehler of the USDA Forest Service, 2015
  - Successful community forest conservation backed up by data from i-Tree Hydro

- **“Modeling Urban Forest Scenarios and Hydrology in Grand Rapids, Michigan”**
  by Ian Hanou of Plan-It Geo, 2015
  - Value of urban forests reducing impervious runoff

- **“Modeling Hydrological Ecosystem Services of Juvenile Trees in Worcester, Massachusetts”**
  by A. Filipovic & J. Rogan of Clark University, 2016
  - Hydrologic impact of deforestation due to ALB & reforestation

For more info on these projects, please visit: [iTreeTools.org/Resources/Reports.php](http://iTreeTools.org/Resources/Reports.php)
Online Resources

- Download & more information - [itreetools.org](http://itreetools.org)
- Support Forum - [forums.itreetools.org](http://forums.itreetools.org)
  - FAQs - on Support Forum > Official i-Tree FAQs > Hydro
- Email – [info@itreetools.org](mailto:info@itreetools.org)

Upcoming Workshop

- WEFTEC2016, full-day hands-on workshop
  - September 25 in New Orleans

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