Tools and Resources for Integrating Trees in Green Infrastructure

JENNIFER GULICK
URBAN CANOPY WORKS, LLC
You Can’t Fight Mother Nature
So, work WITH Mother Nature instead!
Mimic Nature
Fact:
A single oak tree can absorb 40,000 gallons of stormwater annually.

(USGS)
Effects of Development

Natural Ground Cover
- 25% shallow infiltration
- 25% deep infiltration
- 40% evapotranspiration
- 10% runoff

10%-20% Impervious Surface
- 21% shallow infiltration
- 21% deep infiltration
- 38% evapotranspiration
- 20% runoff

35%-50% Impervious Surface
- 20% shallow infiltration
- 15% deep infiltration
- 35% evapotranspiration
- 30% runoff

75%-100% Impervious Surface
- 10% shallow infiltration
- 5% deep infiltration
- 30% evapotranspiration
- 55% runoff
Trees Work!

• We have the SCIENCE to prove it

• We have the PROJECTS to prove it
i-Tree Tools

A Suite of USDA Forest Service Urban and Community Forestry Analysis and Benefits Assessment Software:

- State-of-the-Art
- Peer-Reviewed
- Free of Charge to the Public
- Easy to Implement
- For Communities of All Sizes
- Promote and Strengthen Urban and Community Forestry Management Efforts
Trees contribute positively to stormwater management

<table>
<thead>
<tr>
<th>Year Completed</th>
<th>i-Tree Reference City</th>
<th>Number of Trees Studied</th>
<th>Annual Stormwater Benefits (dollars)</th>
<th>Rainfall Intercepted Annually by Trees (million gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Albuquerque, N.M.</td>
<td>4,586</td>
<td>$55,833</td>
<td>11.1</td>
</tr>
<tr>
<td>2005</td>
<td>Berkeley, Calif.</td>
<td>36,485</td>
<td>$215,645</td>
<td>53.9</td>
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<tr>
<td>2004</td>
<td>Bismarck, N.D.</td>
<td>17,821</td>
<td>$496,227</td>
<td>7.1</td>
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<tr>
<td>2007</td>
<td>Boise, Idaho</td>
<td>23,262</td>
<td>$96,238</td>
<td>19.2</td>
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<tr>
<td>2005</td>
<td>Boulder, Colo.</td>
<td>25,281</td>
<td>$357,255</td>
<td>44.9</td>
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<tr>
<td>2006</td>
<td>Charleston, S.C.</td>
<td>15,244</td>
<td>$171,406</td>
<td>28.3</td>
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<tr>
<td>2005</td>
<td>Charlotte, N.C.</td>
<td>85,146</td>
<td>$2,077,393</td>
<td>209.5</td>
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<tr>
<td>2004</td>
<td>Cheyenne, Wyo.</td>
<td>17,010</td>
<td>$55,301</td>
<td>5.7</td>
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<tr>
<td>2003</td>
<td>Fort Collins, Colo.</td>
<td>31,000</td>
<td>$403,597</td>
<td>37.4</td>
</tr>
<tr>
<td>2005</td>
<td>Glendale, Ariz.</td>
<td>21,480</td>
<td>$18,198</td>
<td>1.0</td>
</tr>
<tr>
<td>2007</td>
<td>Honolulu, Hawaii</td>
<td>235,800</td>
<td>$350,104</td>
<td>35.0</td>
</tr>
<tr>
<td>2008</td>
<td>Indianapolis, Ind.</td>
<td>117,525</td>
<td>$1,977,467</td>
<td>318.9</td>
</tr>
<tr>
<td>2005</td>
<td>Minneapolis, Minn.</td>
<td>198,633</td>
<td>$9,071,809</td>
<td>334.8</td>
</tr>
<tr>
<td>2007</td>
<td>New York City, N.Y.</td>
<td>592,130</td>
<td>$35,628,220</td>
<td>890.6</td>
</tr>
<tr>
<td>2009</td>
<td>Orlando, Fla.</td>
<td>68,211</td>
<td>$539,151</td>
<td>283.7</td>
</tr>
<tr>
<td>2003</td>
<td>San Francisco, Calif.</td>
<td>2,625</td>
<td>$466,554</td>
<td>99.2</td>
</tr>
<tr>
<td>2001</td>
<td>Santa Monica, Calif.</td>
<td>29,229</td>
<td>$110,784</td>
<td>3.2</td>
</tr>
</tbody>
</table>

U.S. Forest Service’s i-Tree Tools
(www.itreetools.com)

Each year DC’s trees filter 44,274,580 cubic feet of water equating to about $779 million per year. That is equal to about 500 Olympic size swimming pools.

<table>
<thead>
<tr>
<th>SPECIES NAME</th>
<th>NUMBER OF TREES</th>
<th>AVOIDED RUNOFF VALUE ($/YR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TULIP TREE</td>
<td>110,911</td>
<td>$117,343,848</td>
</tr>
<tr>
<td>AMERICAN ELM</td>
<td>47,844</td>
<td>$64,098,587</td>
</tr>
<tr>
<td>COMMON CRAPEMYRTLE</td>
<td>104,387</td>
<td>$39,919,104</td>
</tr>
<tr>
<td>AMERICAN BEECH</td>
<td>387,101</td>
<td>$98,547,221</td>
</tr>
</tbody>
</table>
Species are selected based on three types of information:

1. **Hardiness** – as determined by state and city.
2. **Mature height** – user specified minimum and maximum heights.
3. **Environmental factors** – ranked from 0 to 10:
   - Air pollution removal
   - Air temperature reduction
   - Ultraviolet radiation reduction
   - Carbon storage
   - Pollen allergenicity
   - Building energy conservation
   - Wind reduction
   - Stream flow reduction (storm water management)

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### 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**

- 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)

- VOC Emissions
- Carbon Storage
- Wind Reduction
- Air Temperature Reduction
- UV Radiation Reduction
- Building Energy Reduction
- Streamflow Reduction
- Low Allergenicity
i-Tree Design

Get started with these easy steps:

1. **Draw Structures**
2. **Place Trees**

**Describe your tree:**
- **Tree species:** (Lower Midwest region)  
  Elm, American
- **Tree diameter:** 2 Inches
- **Tree condition:** Excellent
- **Tree exposure to sunlight:** Full sun

**To place a tree:**
- Drag this icon to the location on the map where you would like to place your tree.
- Repeat to place additional trees.
- Hover over any tree you have placed on the map to display its benefits.

**Model the tree(s) future crown growth over time:**

Model Crown Growth
The natural solution is the best solution

Trees intercept rainfall and help increase infiltration and the ability of soil to store water. By retaining water in their canopy – even for a short time – trees can disperse precipitation over a longer time period and reduce velocity of the water when it does fall.
The Guide

• It Works!
• Return on Investment
• Regionally relevant case studies
• Create a customizable report to inform and base decisions

www.treesandstormwater.org
Why Build a Document?

• Because you want to learn about stormwater management and trees
• Because you want someone else to learn the same thing
• Because adding trees to new development and redevelopment initiatives and save money and create healthier, more livable neighborhoods.

Think of this as both a learning and teaching tool ... and a way to stimulate policymakers
How Does it Work?
A detailed questionnaire which enables you to characterize your community, and how it manages its trees.

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our current urban tree canopy covers this % of our community:</td>
<td>Insert % here</td>
</tr>
<tr>
<td>I can’t locate these figures and/or to my knowledge, they don’t exist:</td>
<td>☐️</td>
</tr>
<tr>
<td>Does your community maintain an inventory of street-side and road-side trees:</td>
<td>☐️ Yes ☐️ No ☐️ Not Sure</td>
</tr>
<tr>
<td>Has a comprehensive plan [“comp” plan] been adopted for your community?</td>
<td>☐️ Yes ☐️ No ☐️ Not Sure</td>
</tr>
<tr>
<td>If yes, are there specific provisions that deal with your community’s water resources?</td>
<td>☐️ Yes ☐️ No ☐️ Not Sure</td>
</tr>
<tr>
<td>If there are provisions that deal with water resources, do they call for use of green infrastructure to help implement the plan?</td>
<td>☐️ Yes ☐️ No ☐️ Not Sure</td>
</tr>
<tr>
<td>Is your community part of a regional planning organization?</td>
<td>☐️ Yes ☐️ No ☐️ Not Sure</td>
</tr>
</tbody>
</table>

**Urban Forests in Your Community**

Many communities already have urban forestry projects and programs underway. In this section, we’ll ask you to describe — to the best of your ability — the extent of your urban forest [link to definition]. Often expressed as urban tree canopy, these numbers may be available from your community’s urban forester or arborist, or from your state forestry agency’s urban forestry coordinator. Likewise, you may find them by searching online.

Our current urban tree canopy covers this % of our community: Insert % here

I can’t locate these figures and/or to my knowledge, they don’t exist: ☐️

Does your community maintain an inventory of street-side and road-side trees: ☐️ Yes ☐️ No ☐️ Not Sure

To the best of your knowledge, is your urban tree canopy distributed through all neighborhoods in your community? ☐️ Yes ☐️ No ☐️ Not Sure

Take 20 Minutes to Find Out About Your Urban Forest: Where It Is, and What It Does!

[Link to Tool Landscape]

Download results to your user library.
The Value of Urban Forestry

Trees in neighborhoods provide many vital benefits that aren’t well-known or even acknowledged. And the value of these benefits far outweighs the cost of managing the trees that deliver them.

Tell us what benefits you’d like to explore – and that others in your community need to know about. We’ll add a brief description to your case statement for each of the benefits you mark.

<table>
<thead>
<tr>
<th>For Stormwater Management</th>
<th>[✓] if Interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interception</td>
<td></td>
</tr>
<tr>
<td>Infiltration</td>
<td></td>
</tr>
<tr>
<td>Pollution Reduction</td>
<td></td>
</tr>
<tr>
<td>Evapotranspiration</td>
<td></td>
</tr>
<tr>
<td>Soil Conditions [macropores]</td>
<td></td>
</tr>
<tr>
<td>Flood Control</td>
<td></td>
</tr>
</tbody>
</table>
## The Value of Urban Forestry

<table>
<thead>
<tr>
<th>Benefits to the Public</th>
<th>[✓] if Interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air quality</td>
<td></td>
</tr>
<tr>
<td>Public health</td>
<td></td>
</tr>
<tr>
<td>Children’s health and well-being</td>
<td></td>
</tr>
<tr>
<td>Energy conservation</td>
<td></td>
</tr>
<tr>
<td>Carbon sequestration</td>
<td></td>
</tr>
<tr>
<td>Mitigating urban heat island</td>
<td></td>
</tr>
<tr>
<td>Vibrant business districts</td>
<td></td>
</tr>
<tr>
<td>Safer, healthier and more cohesive neighborhoods</td>
<td></td>
</tr>
<tr>
<td>Other [Type]</td>
<td></td>
</tr>
<tr>
<td>Other [Type]</td>
<td></td>
</tr>
</tbody>
</table>
The Answers

**Why It’s Important to Know Your Canopy Cover.** Trees have long been deemed an essential part of the urban landscape. At the end of the 19th century, advocates praised the cooling, calming effect of trees and noted that their interlocked canopy created healthier neighborhoods. By the late 20th century and into the 21st we learned how to measure and quantify these benefits and more, and to assess their monetary value to the community.

*If No or Not Sure, ADD:* Because we need to know where to start – and more important, what we stand to gain – we should develop at least a rough estimate of both the extent of our tree canopy and the services it provides to our residents.

**Street Tree Inventory.** A street tree inventory enables us to plan periodic inspections, check for pests and disease, remove hazardous trees and reduce liability.

*If No or Not Sure, ADD:* Without one, we’re stuck in a reactive mode, fixing problems as they’re reported – often spending more to accomplish less.
Region:
Great Lakes
This region is characterized by cold winters and warm to hot humid summers. Heavy precipitation can fall anytime of the year but occurs most often in the spring and summer. Snow is common in the winter with heavy accumulations in the northern portions of the region especially the narrow bands on the eastern south eastern shores of the great lakes. This region is home to the world’s largest supply of liquid fresh water. Precipitation range 30 – 50 inches annually.

Urban Forestry in Your Community

With our urban forestry master plan, we can identify the benefits we get from trees, and make certain that these benefits are equitably distributed. Developing an urban forestry master plan can assure we maximize the benefits from our urban forests, expand them to areas that need more trees, and focus our resources – now and in the future – on sustaining our forests, not reacting to threats.

An urban forestry master plan would help identify opportunities to assure healthy trees on both public and private lands, and assure that the community (including the owners) accrue all the benefits these trees deliver – energy savings, stormwater management, cleaner air, and others.

• Covers all sections
• Text correlated to answers from questionnaire
• Can be edited off-line
• Images, maps, charts and tables can be added
• Exportable
What’s Covered

Urban Forestry in Your Community
The Value of Urban Forestry
Characteristics of Your Urban Forests
Private Land Policies in Place in Your Community
Demonstrating How Urban Forestry Helps Manage Stormwater
- Exemplary projects, including schematics
- Case studies
- Flow reduction calculators
- Creating coalitions
- Common barriers and solutions
- Funding
Partnerships are the key to success

Finding and Recruiting Allies

You can’t do it alone. To make yours a tree-rich community, you’ll need to find and recruit allies from other municipal departments, community leaders, and the public itself.

Engaging and Motivating Stakeholders

To achieve green infrastructure and tree canopy goals, you must influence what residents, businesses, and institutions do on their own property.
The Guide Has Resources for You
### Case Studies

- Community Engagement (8)
- General Guidance (23)
- Innovative Design (4)
- Modeling Impacts (4)
- Multi Agency Alignment (7)
- Plans (35)
- Public Private Partnerships (3)
- Use of Available Technologies (9)
- Zoning, Ordinances, Regulations, Incentives (7)

### Stormwater Impact

- Best Management Practice (10)
- Fact Sheet (7)
- General Guidance (18)
- Tools & Calculators (12)
- Tree Selection (6)
- Useful Approaches (10)
Project Design & Co-Benefits
## Public Policies & Planning Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>Best Management Practices</td>
<td>8</td>
</tr>
<tr>
<td>Community Engagement</td>
<td>4</td>
</tr>
<tr>
<td>General Guidance</td>
<td>28</td>
</tr>
<tr>
<td>Manuals</td>
<td>3</td>
</tr>
<tr>
<td>Model Ordinance</td>
<td>16</td>
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<tr>
<td>Plans</td>
<td>6</td>
</tr>
<tr>
<td>Tools</td>
<td>2</td>
</tr>
<tr>
<td>Zoning, Ordinances, Regulations, Incentives</td>
<td>8</td>
</tr>
</tbody>
</table>
Resource
Library
Examples
Case Study – Covington, Kentucky

- SANITATION DISTRICT NO. 1
- I-75 TERRACED REFORESTATION
EXISTING LAND COVER

- Open space
- Grass
- Ground cover
- Tree cover
- Impervious

PROPOSED LAND COVER
Trees in Urban Redevelopment
Regulations and Ordinances

915.02.D  Tree Protection and Replacement

The Zoning Administrator shall require the protection and preservation of trees with a diameter of twelve (12) inches or more, measured at a point four (4) feet above grade. If said trees are removed during site preparation or development, they shall be replaced, at a minimum, equal to the combined total diameter of removed trees. Diameter measurements shall be taken at a point four (4) feet above grade.

Purpose. The purpose of this Article is to promote and protect public health, safety, and general welfare of citizens by improving the environmental conditions impacted by the built environment through the effective protection of and use of trees to accomplish the following:

- **Stormwater Impact.** Reduce stormwater impacts and costs associated with the movement of earth, flooding, erosion, expansion of impervious surface areas, and removal of vegetation.
Chapter 2. Tree Canopy Coverage Standards

Tree Canopy Defined. The tree canopy in Pittsburgh is defined as the topmost layer of leaves, branches, and stems comprising the crowns of trees as defined in (Article x - Tree Ordinance).

Tree Canopy Cover Measurement. The current and future total tree canopy cover throughout the City of Pittsburgh and the total within each zoning district shall be calculated on a regular basis by the Department of Public Works or its agent.

Minimum Canopy Coverage Standards. The city desires to maintain the maximum practical tree canopy cover across all land uses within the city’s jurisdiction. When canopy removal is subject to the provisions of this Section, the following minimum tree canopy coverage percentages are required within the zoning lot boundaries and can be inclusive of public right-of-way.

<table>
<thead>
<tr>
<th>Land Use and Zoning</th>
<th>Minimum Canopy Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Density Single-Family Residential</td>
<td>50%</td>
</tr>
<tr>
<td>Low Density Single-Family Residential</td>
<td>40%</td>
</tr>
<tr>
<td>Low Density Single- and Two-Family Residential</td>
<td>30%</td>
</tr>
<tr>
<td>Medium and High Density Single- and Two-Family Residential</td>
<td>20%</td>
</tr>
<tr>
<td>Medium Density Multi-Family Residential</td>
<td>40%</td>
</tr>
<tr>
<td>High Density Multi-Family Residential</td>
<td>30%</td>
</tr>
<tr>
<td>Commercial</td>
<td>30%</td>
</tr>
<tr>
<td>Institutional</td>
<td>40%</td>
</tr>
<tr>
<td>Mixed Use</td>
<td>40%</td>
</tr>
<tr>
<td>Downtown and Business Districts</td>
<td>15%</td>
</tr>
</tbody>
</table>
Trees are a great tool for communities......

......if they are preserved. Size matters!
Why we need to protect trees ----

Riverbend Development Canopy Cover
(126 acre property)

- Pre-Development: 68%
- During Development: 11.5%
- After Initial Planting (348 trees): 12.0%
- Annual growth, approx. 0.05 acres of canopy per year
- Canopy after 30 years: 13.1%
Urban Forests in Watershed Plans

• “Efforts should be focused to preserve and protect high quality forested areas where features are present that significantly contribute to protecting water quality and quantity.”

• *Forests First: Water Wins!*
Critical Areas Identification

- Using GIS tools to identify forests most valuable for protecting watersheds.

- Forest Cover
- Floodplain
- Steep Slopes
- Riparian Corridor
- Impervious Surface
- Runoff Potential
Critical Areas for Protection

- Total = 12,188 acres
- 33% of entire watershed

![Critical Areas for Protection](image-url)

Legend:
- Low
- Medium
- High

Map 4
Bannock Watershed Issues: Characterization and Analysis

Critical Areas
- Low: 15%
- Medium: 13%
- High: 72%
Urban Forest Management/Master Plans

 PRESERVING AND ENHANCING CHARLOTTE'S URBAN FOREST

Charlotte Urban Forest Master Plan 2017
Cool New Tool!
Figure 1 Factors to consider for effective tree selection.

Adapted from Johnston and Hirons (2014)

[Diagram showing factors for tree selection: Site, Biological, Practical, Site, Succession, Tolerance, Constraints, Tree Ecophysiology, Ecosystem Services, Aesthetics.]
Green Infrastructure Center Tools

http://www.gicinc.org/trees_stormwater.htm
The Swiss Army Knife of Natural Resources
Un-muddy the Waters Through Education