# i-Tree: Global Tools to Assess Tree Benefits and Risks to Improve Forest Management

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i-Tree (www.itreetools.org) is a suite of freely-available software tools designed to assess the benefits and values derived from trees and forests. Originally released in 2006 and designed to work in the United States, these tools have expanded globally among professional and non-professional users (e.g., universities, citizens, schools, land managers, foresters) in more than 130 countries. i-Tree was developed through a collaborative public-private partnership and is designed to engage people in assessing and valuing their forest resources, understanding forest risk, and developing sustainable forest management plans to improve environmental quality and human health. These tools can be scaled to assess individual trees or entire forests in both urban and rural areas.

i-Tree's vision is to improve forest and human health through easy-to-use technology that engages people globally in enhancing forest management and resiliency. To attain this vision, i-Tree continues to develop tools with the ultimate goals of allowing anyone to easily assess:

- Local forest conditions
- Ecosystem services and values derived from forests
- Local risks to forest and human health
- How changes in forest structure will lead to changes and tradeoffs among ecosystem services and values
- Best locations, tree species and planting rates to optimize ecosystem services and values through time and across space to enhance human health and well-being

Achieving these goals allows i-Tree users to create healthy, sustainable, and resilient forest landscapes across the urban to rural continuum. The purpose of this article is to provide a brief overview of i-Tree tools within a global context.

## i-Tree Usage

Since its release in 2006, i-Tree usage has grown exponentially to meet global demand (Figure 1). By the end of 2017, there had been over 247,000 unique users of i-Tree products in 131 countries (Figure 2).

## i-Tree Tools

The i-Tree modeling suite is comprised of many tools, seven tools of which can be used outside of the United States:

**i-Tree Eco:** this tool uses sample or inventory-based field data to assess forest structure, ecosystem services and values
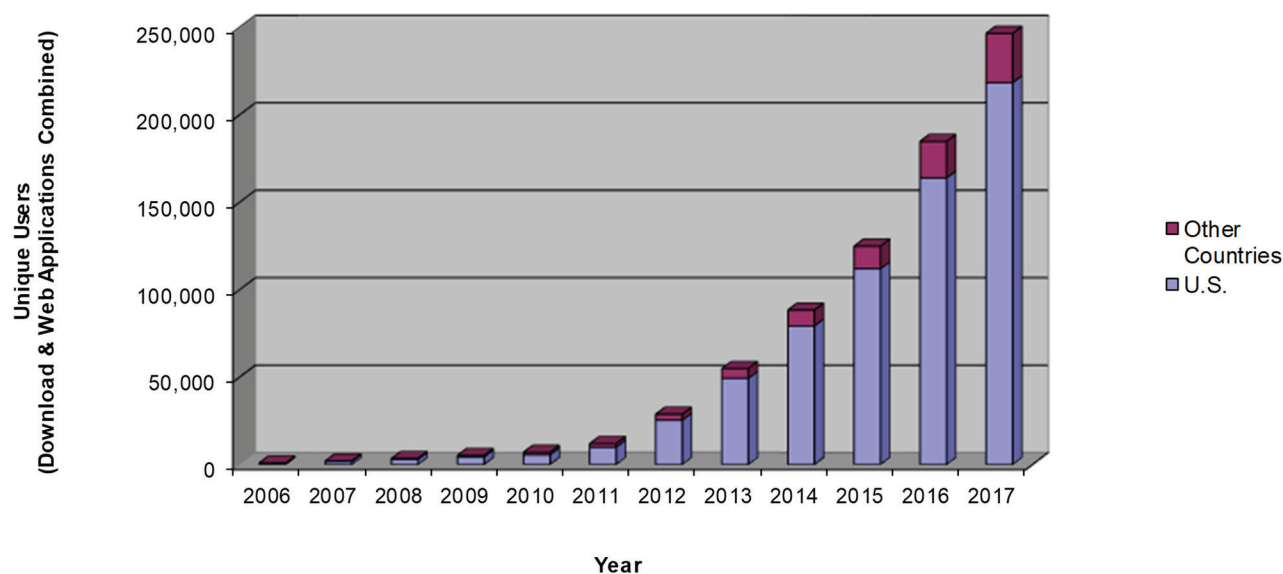


**Figure 1. Cumulative number of unique i-Tree users: 2006–2017.**

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**Figure 2. Global distribution map of i-Tree users (2006–2017).**

for any tree population (including number of trees, diameter distribution, species diversity, air pollution removal and health effects, carbon storage and sequestration, runoff reduction, VOC emissions, UV radiation reduction, building energy effects). i-Tree Eco is the core i-Tree tool and is designed to easily guide users from start to finish through project set-up, data collection and analyses. Useful functions include plot selection programs, mobile data entry programs, table/graphic reporting and exporting, and automatic report generation. i-Tree Eco can also forecast future tree population totals, canopy cover, and ecosystem services and values. Due to the field data collection requirements, i-Tree Eco provides the best estimates of tree benefits.

The program is designed to work in the United States, Canada, Australia, Mexico and the United Kingdom, with a 2018 update to include almost all countries in Europe. Other countries in development include Colombia, New Zealand and South Korea. For areas without national versions of i-Tree Eco, the i-Tree Database program (see below) can be used to enable i-Tree Eco for use in their area.

**i-Tree Database** is a web-based tool that allows international users to submit local geographic (e.g., latitude, longitude), pollution and precipitation data for importation into i-Tree. Once the data are processed, users can run i-Tree Eco for that international city or area. Users can also view and submit new tree species information to help build a global tree database.

**i-Tree Canopy:** This web-based tool allows users to quickly and easily photo-interpret Google aerial images of their area to produce statistical estimates of tree cover and other cover types (e.g., grass, buildings, water) along with calculations of the uncertainty of those estimates. This tool provides a simple, quick and inexpensive means for cities and forest managers to accurately estimate their tree and other cover types. i-Tree Canopy can be used worldwide wherever high-resolution, cloud-free Google images exist. Use of historical imagery can also be used to aid in change analyses. In addition, some ecosystem services and values of trees are estimated based on U.S. environmental conditions.

**i-Tree Design:** This web-based tool also relies on Google maps and allows users to sketch their home to see how the trees around the home affect energy use and savings, as well as other environmental services and values. This program works in the United States and Canada, but could be developed for any area globally where i-Tree Eco functions.

**MyTree:** This tool is a simple, web-based application geared towards mobile devices that allows users to easily quantify the benefits and values of individual trees. This program uses U.S. and Canadian environmental conditions to estimate local tree benefits, but could also be developed more fully for any area globally where the i-Tree Eco and Design programs function.

**i-Tree Hydro:** This tool is designed to simulate the effects of changes in tree and impervious cover on hourly stream flow and water quality within a watershed.

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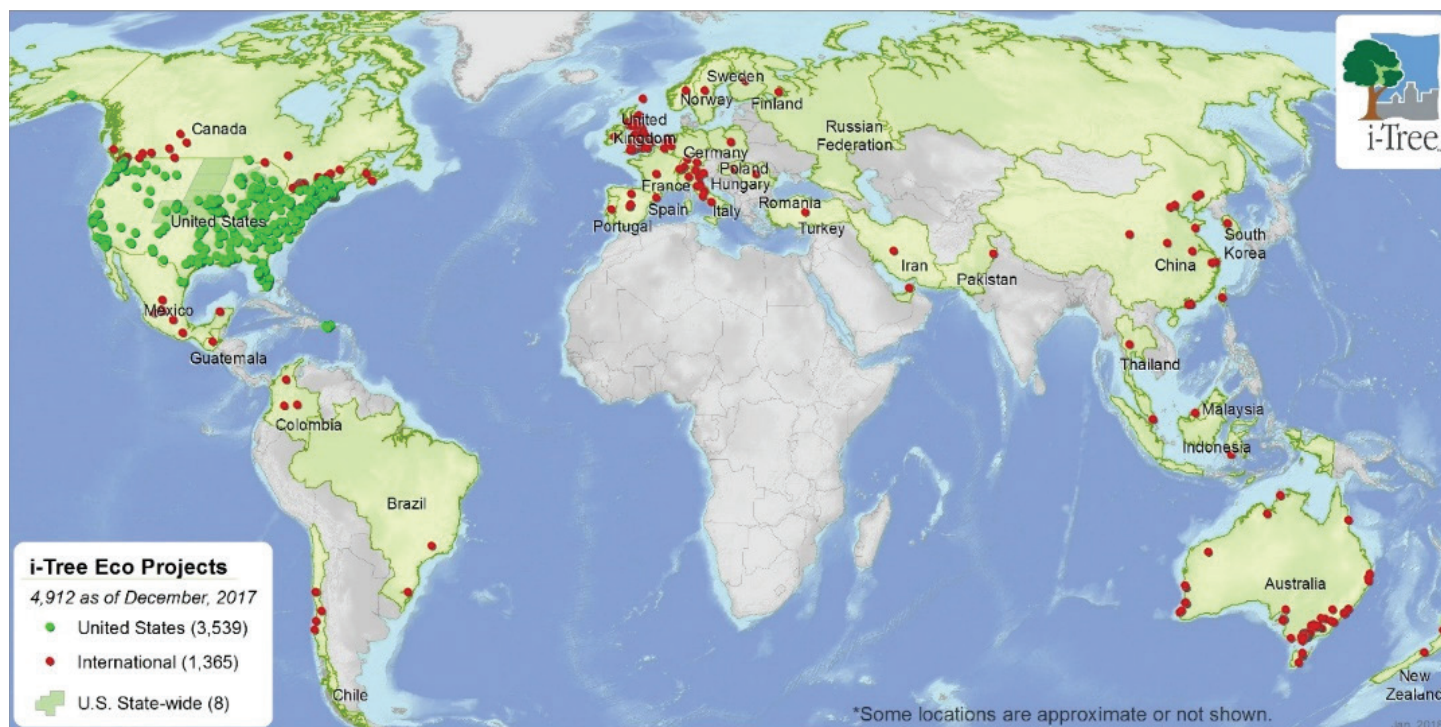


**Figure 3. Known i-Tree Eco projects.**

It contains auto-calibration routines to help match model estimates with measured hourly stream flow. It ultimately produces tables and graphs of changes in flow and water quality due to changes in tree and impervious cover within the watershed. This tool can work globally where sufficient weather and stream flow data exist.

**i-Tree Species:** This tool is a web-based utility designed to help users select the most appropriate tree species based on desired environmental functions and geographic area. It relies on the assessments of functions performed by many tree species at maturity.

Other i-Tree tools that are specific to the United States are:

**i-Tree Landscape:** This web-based tool allows users to explore tree canopy, land cover, forest data and basic demographic information anywhere in the conterminous US. With the information provided by i-Tree Landscape, users can quickly:

- Learn about the benefits and values of trees (carbon storage, air pollution removal, reduced runoff) in their area
- Understand local risks to people and forests
  - Insects and diseases
  - Wildfire potential
  - Ultraviolet radiation exposure
  - Land surface temperatures
  - Urban-wildland interfaces
  - Air pollution exposure
  - Projected climate change
- Map areas in which to prioritize tree planting or protection efforts to improve both forest and human health and sustainability.

**i-Tree Planting:** This web tool estimates the long-term environmental benefits from a tree planting project. Users select their location, enter groups of different species they wish to plant, and set mortality rates and project lifespan. The program estimates the cumulative values of the trees over the project lifespan.

## International Projects

The development of i-Tree Eco has expe-

dited urban and rural forest data collection and analysis across the world, with nearly 5,000 known i-Tree Eco projects (Figure 3). Examples of international analyses based on i-Tree include reports from London (Rogers et al. 2015) and Torbay (Rogers et al. 2011), England; Edmonton (City of Edmonton 2012), Oakville (McNeil and Vava 2006), and Toronto (Nowak et al. 2013), Canada; Perth, Australia (Saunders et al. 2012); Merida, Mexico (de la Concha et al. 2018); Zurich, Switzerland (Wälchli 2012); Strasbourg, France (Selmi et al. 2016); Porto, Portugal (Graça et al. 2017, 2018); Barcelona, Spain (Chaparro and Terradas 2009); Belfast and Dublin, Ireland (Mills et al. 2016).

This international data collection provides valuable new data to aid in understanding the benefits and values of forests, promoting improved forest management, and understanding the patterns and variations in urban forest ecosystem services and values. By using a standard data collection process, i-Tree Eco can help serve as a global standard on data collection and analyses of urban forests.

## Future International Development

Through international partnerships and additional funding, the i-Tree team plans to continue to improve the science behind the models, add new ecosystem services and values, and expand development and applications globally (e.g., adding new national versions). New ecosystem services and values in development include tree effects on stream temperatures, air temperatures (e.g., Yang et al. 2013) and air temperature impacts on human health. Currently, the international focus is on developing national models of i-Tree Eco and translating the program and manuals into Spanish. Once i-Tree Eco is developed for a nation, i-Tree Design, Canopy and MyTree can also be developed to help raise awareness of tree values among citizens and improve forest management. More information on international development of i-Tree can be found at: https://www.itreetools.org/resources/intl_overview.php.

The ultimate objective of i-Tree is to develop best management practice prescriptions based on local environmental and forest data. These prescriptions will aid managers in sustaining healthy and functional forests to improve human health and well-being by detailing the best tree species, locations, and planting rates to attain desired outcomes.

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