Northern Research Station

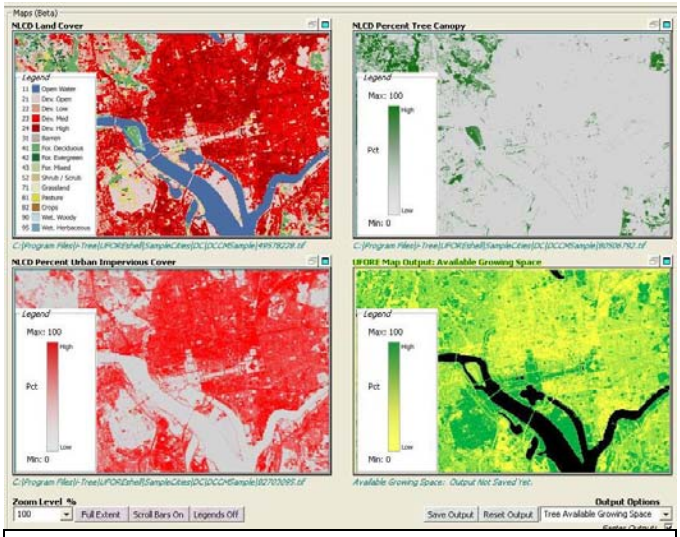
Urban Forests, Human Health and Environmental Quality *Syracuse, NY*

Estimating Ecosystem Services and Values

This document is intended to provide a brief overview of the research and tool development of the USDA Forest Service Research Unit in Syracuse, NY as related to quantifying ecosystem services and values. This research and development is conducted in cooperation with numerous partners.

Overview

Our research unit focuses on field measurements and monitoring of urban vegetation structure (e.g., species composition and distribution, number of trees and tree sizes) and its effects on various ecosystem attributes (e.g., air and water quality, air temperature, soils). To aid in improving urban forest management, various tools have been developed to quantify urban forest structure and its effects on ecosystem services and values. The primary model developed has been the Urban Forest Effects (UFORE) model. This model has been incorporated within a suite of free, technically supported, urban forest software tools called i-Tree (www.itreetools.org). Through i-Tree, UFORE now includes automatic report generation, basic mapping capabilities by linking with National Land Cover Data (NLCD 2001), and a species selection program to help select the most appropriate species based on desired tree functions.



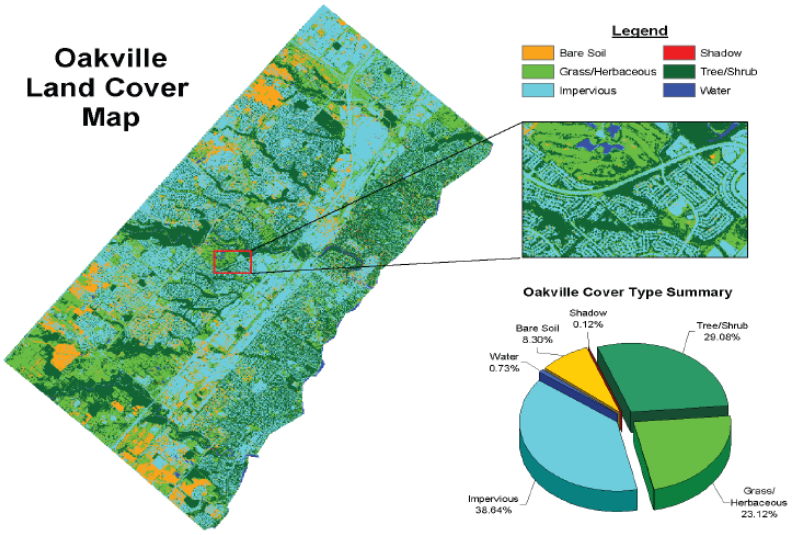
Community Mapper program allows users to display basic urban forest data without GIS software or skills

Assessing Urban Forest Structure

The first step in quantifying ecosystem services is to have an accurate measure of the vegetation structure within the area of interest. This measurement is conducted in two ways:

1) Aerial assessments
2) Ground-based assessments

Aerial Assessments – This approach uses aerial imagery to develop cover maps (e.g., from high-resolution color-infra-red digital images or medium resolution satellite data) or determine percent cover types (e.g., photo-interpretation) within the area of interest. Aerial assessments provide a quick estimate of the tree and other surface cover, but only provide limited two-dimensional information on the vegetation.



Ground-based Assessments – This approach involves random sampling of the area of interest to determine the physical attributes of the vegetation and other surface characteristics. Within i-Tree, several tools are available to aid in locating field sample locations and collect the required data to assess ecosystem services. This ground-based information is necessary to determine many critical forest attributes that can not be obtained from aerial imagery (e.g., number of trees, tree sizes, species composition, leaf area and biomass, tree biomass). This structural information is quantified for the tree population within UFORE to aid in urban forest management (e.g., by providing total tree species distribution by land use; risk to various pests) and in quantifying ecosystem services.

Assessing Ecosystem Services

Based on the structural field data and local hourly air pollution and meteorological data, the following ecosystem services are calculated within UFORE:

- Hourly amount of pollution removed by the urban forest, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns)[1].
- Hourly urban forest volatile organic compound (VOC) emissions and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year[2].
- Total carbon stored and net carbon annually sequestered by the urban forest[3].

[1] Based on a hybrid multi-layer bigleaf model that calculates hourly tree transpiration and gas exchange using leaf area calculations and local hourly weather and pollution data. Particle pollution removal is based on average measured values of pollutant deposition to leaf surfaces

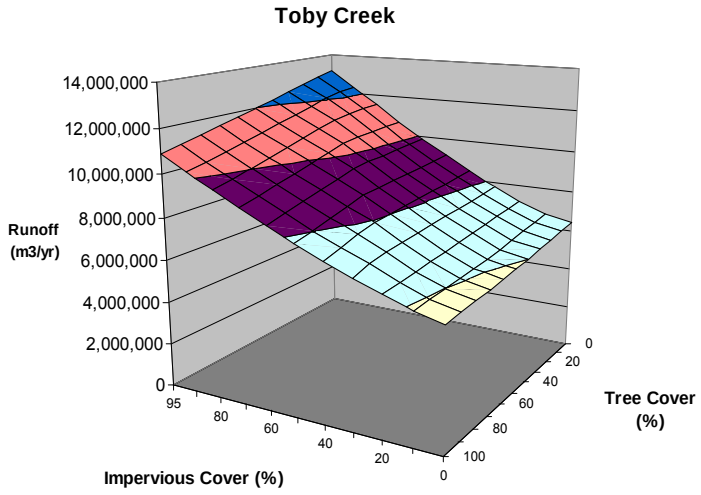
[2] Based on protocols of the Biogenic Emissions Inventory System that use leaf biomass calculations by species and local hourly weather data

[3] Based on allometric equations to calculate tree biomass that use tree species, diameter and height data; and local growing conditions and tree health to estimate growth rates

- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants[4].

Urban forest field data from UFORE exist for numerous areas: Atlanta, GA; Baltimore, MD; Baltimore County, MD; Beijing, China; Boston, MA; Brooklyn, NY; Calgary, Alberta; Casper, WY; Freehold, NJ; Florence, Italy; Fresno, CA; Fuenlabrada, Spain; Gainesville, FL; Gainesville, GA (street trees); Greenville-Spartanburg, SC; Golden, CO; Greenwich, CT (street trees); Halifax, Nova Scotia; Hartford, CT; Houston, TX; Hefei, China; Indiana (state assessment); Jersey City, NJ; Kelowna, British Columbia; Kennedy Meadows, CA; Kent, OH; Little Rock, AR (street trees); Louisville, KY (campus); Milan, Italy, Minneapolis, MN; Moorestown, NJ; Morgantown, WV; Mount Union, OH (campus); Nebraska City, NE; New York, NY; Ningbo, China; Northern KY (3 cities street trees); Oakville, ON; Petrozavodsk, Russia; Philadelphia, PA; Piazzola, Italy (street trees); Porto Alegre, Brazil (parks); Prince Williams Forest, VA; San Francisco, CA; San Juan, PR, Santiago, Chile; Syracuse, NY; Tampa Bay, FL; Toronto, Ontario; Portland, OR (parks); Visalia, CA; Washington, DC; Wilmington, DE; Wisconsin (state assessment); and Woodbridge, NJ. Areas currently or soon to be analyzed are: Baton Rouge, LA; Chicago, IL; Colorado (state assessment); Fredericton, New Brunswick; Los Angeles, CA; Miami, FL; New Jersey (state assessment); Phoenix, AZ; Scranton, PA; Shenzhen, China; Singapore, and Tennessee (state assessment). Many of these cities are analyzed in cooperation with local, state or federal institutions.

UFORE-Hydro – a new tool to assess urban forest effects on stream flow and water quality has been developed. UFORE-Hydro (Urban Forest Effects Hydrological Model) is a semi-distributed, object-oriented, topographical, physical based watershed scale hydrological model with a graphical user interface (GUI) and auto-model calibration. This model is specifically designed to simulate tree and impervious surface effects on stream flows based on local watershed surface characteristics and weather data, with the model calibrated against measured stream flow data.



Assessing Ecosystem Values

Ecosystem service valuation is based on externality values derived from the literature (for carbon and air pollution) and average state energy values for building energy effects. The model estimates the ecosystem service magnitude (e.g., tons, kWh) and

[4] Based on research of McPherson and Simpson on tree effects on building energy use nationally. Model uses sampled tree location and height information to determine seasonal energy effects

multiplies this amount by the associated value from the literature. Structural value of the forest is based on the Council of Tree and Landscape Appraisers valuation procedures.

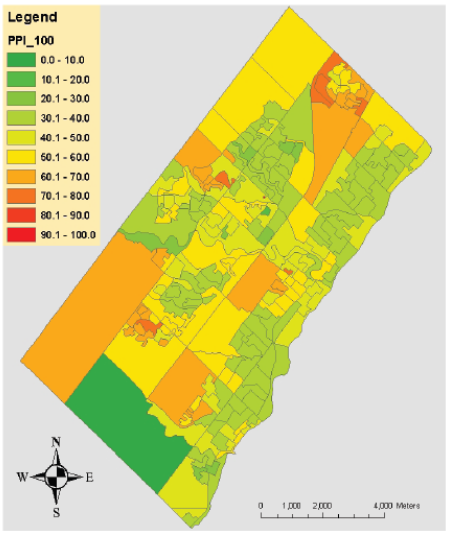
Current Tool Development

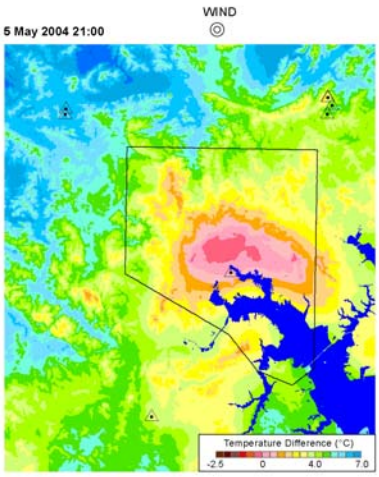
i-Tree has two main development goals over the next five years:

1) Integration of programs
2) Enhanced spatial analyses

Integration – within i-Tree, there are two main programs: a) UFORE, which assesses ecosystem services and values over any sized area, and b) STRATUM, which assesses ecosystem services and values for street populations. This work is designed to integrate these two programs into one program. Thus, users will be able to sample or inventory areas or streets to quantify ecosystem services and values in one tool. This integration will combine the best parts of both tools within one program. Added capabilities to UFORE will include cost-benefit analyses and property valuation.

Spatial Analyses – spatial integration and mapping within i-Tree has begun, with many projects currently under way. This work merges the field data assessments with the aerial cover maps to help illustrate the distribution of ecosystem services. This work is also integrating field-derived ecosystem service information with several spatial modeling components to help determine how forest cover and ecosystem services will likely change in the future and which forest structures are best to optimize ecosystem services to sustain environmental quality and human health. Various spatial tools in development include programs to determine the highest priority planting areas based on tree and human population distribution, how air pollution concentration may vary based on locations relative pollutant sources in cities (risk to exposure); and how tree and impervious locations can affect local air temperatures. This temperature mapping will be integrated with other programs to help determine how changes in tree cover (and air temperatures) affect air pollution removal and concentrations, volatile organic compound emissions, vehicle emissions, and human comfort. Other programs in development will allow users to alter tree cover within land use categories to illustrate what the new cover would look like in the future and the associated changes in ecosystem services and values due to the cover changes. In addition, tree population projection models have been built and existing land use projections will be





incorporated to help determine likely future changes to tree and impervious cover (and ecosystem services) in urban and urbanizing regions. The ultimate goal of these spatial tools is to help planners or managers determine optimal landscape structure to sustain or improve environmental quality and human health at the local to regional scale in urban or urbanizing landscapes.

Program and Management Implications

UFORE can used to provide necessary information on the urban forest resource and its ecosystem services to improve urban forest management and bolster urban forestry programs. As an example, based in part on UFORE results, Conectiv Electric Utility negotiated to have $1 million of an air pollution fine donated to the New Jersey Tree Foundation (a nonprofit organization working with the Community Forestry Program) for a massive Urban Airshed Reforestation project in the Camden, NJ area. Trained volunteers are planting 3-inch caliper shade trees in the communities most directly affected by the air pollution that led to the fines. In Oakville, Ontario, the Town is using UFORE results to create new programs and policies to sustain tree cover and environmental quality for future generations (http://www.oakville.ca/Media_Files/forestry/UFORE.pdf; http://www.treecanada.ca/news/11-08-2006.htm).

Results from UFORE can also be used to help determine the effect of trees on aspects of the environment that are regulated by the U.S. Environmental Protection Agency (US EPA). As the Clean Air and Clean Water Acts impose regulations that affect urban areas, the regulations impact urban development, funding, and management at the local and state levels. As trees affect the environment, the ability to quantify these effects could lead to the incorporation of urban vegetation management strategies (and potential funding) to help meet these environmental regulations. Urban trees can be incorporated as an emerging measure with State Implementation Plans to meet clean air regulations (http://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Emerging_Measures_Summary.pdf). Urban trees could also be used to potentially meet clean water regulations associated with Total Maximum Daily Loads (TMDLs) (http://www.epa.gov/owow/tmdl/intro.html) and storm water programs (http://www.epa.gov/region6/water/npdes/sw/ms4/).

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