i-Tree Design Methods

Entering an address:
The address that you enter tells Design what city, county, state, and climate region your area of interest is located in. This helps localize your results.

- City – The city of the area of interest informs the length of growing season, which is important for tree growth rates.
- County – The county of the area of interest informs which pollution multipliers are most relevant (see description of Air Quality methods below).
- State – The state of the area of interest informs which emissions factors to apply as well as which pollution multipliers are most appropriate if no county values are available.
- Climate region – The climate region is assigned based on the location of the area of interest. Many of the variables used in the energy calculations are informed by the climate region (see description of Energy methods below).

Drawing structures:
The building footprints drawn on the map are used to determine distance and direction of trees to buildings (see description of Energy methods below).

- Vintage of building – Based on when the building was constructed, there is an assigned energy efficiency coefficient by climate region.
- Heated or air conditioned – Based on the assigned climate region and whether the structure is heated and/or air conditioned, the percentage of the total energy usage that is attributed to various energy sources (e.g., wood, natural gas, etc.) are used to determine the kilowatt-hours and therms of energy avoided.

Placing trees:
The tree information that you enter is used for the following:

- Species type determines the leaf type (deciduous or evergreen) of your tree which is taken into account when calculating energy. For example, an evergreen species is going to have a greater shading effect in the winter than a deciduous species. Species type is also used to determine which growth equations and carbon equations are most suitable (see description of Carbon Dioxide methods below).
- Tree diameter or circumference is used to calculate the height of the tree and crown width.
- Tree condition (amount of canopy missing) adjusts tree growth, energy effects, and leaf area index. For example, a tree in poor condition that is missing much of its canopy may have fewer energy effects because it does not shade a building as well as a tree with a full canopy would.
- Sunlight exposure adjusts growth rate and carbon sequestration rate.

Calculating benefits:

- Future benefits are estimated using a forecasting model that calculates tree height for each consecutive year until the user-specified “future year.” For example, if the user wants to estimate benefits 10 years into the future, tree height is estimated for 2014, 2015, 2016,…2024. The forecasting model uses growth rates to estimate the changing

size of the tree and calculate the benefits for each year. The model assumes that there is no change to tree condition and sunlight exposure.
- Past benefits are also estimated using the forecasting model. Benefits are calculated each consecutive year in the past until the modeled tree size reaches 1 inch in diameter.

Ecosystem services:

1. **Stormwater**

Stormwater interception is based on a series of lookup tables. Each lookup table is organized by climate zone, species, and tree diameter. Based on user inputs, Design locates a tree within the lookup table and returns the amount of annual stormwater interception.

Please refer to Xiao et al. (1998) for more details on the rainfall interception model used to create the lookup tables:
http://www.itreetools.org/streets/resources/Rainfall_interception_by_Sacramentos_UF_Xiao.pdf

Dollar values are calculated from the Community Tree Guide Series available at http://www.itreetools.org/resources/archives.php under the heading "i-Tree Streets Reference City Community Tree Guides." Tree guides are available for each climate zone and provide representative cost of control studies that calculate a regional $ per gallon value of avoided runoff.

For example, see pages 108 and 109 of the Lower Midwest Guide:
Lower Midwest community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-219 Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

2. **Energy**

Trees provide energy benefits by altering the local climate (e.g., decreasing air temperatures), providing shading to structures, and providing wind breaks. Some of the most important factors in calculating the energy effects of a tree are the distance and direction of the tree to a building and the tree size and leaf type (deciduous or evergreen).

Design calculates tree energy benefits based on a series of lookup tables. Using the input variables for the location, structures, and trees of the area of interest, Design retrieves the appropriate variables from the lookup tables. To prevent double counting, Design adjusts energy benefits for trees that have overlapping crowns.

Please refer to McPherson and Simpson (1999) for more details on methods and lookup tables:
http://www.fs.fed.us/psw/programs/cufr/products/cufr_43.pdf

Dollar values are calculated based on state energy costs.

3. Air Quality

The first way that air quality effects are calculated is by looking at the pollution removal by trees in the area of interest. The U.S. Forest Service completed a national analysis of pollution removal by county. The results of this analysis were used to create lookup tables with pollution removal multipliers. The multipliers are presented in grams of pollution removed per square meter of canopy cover by county. Removal of CO, NO2, PM10, and SO2 by trees is calculated in Design by retrieving the multiplier based on the user-entered location and multiplying it by the amount of canopy cover for each tree entered by the user. Canopy cover is estimated based on crown width calculations using tree diameter information.

The second way that air quality effects are calculated is by looking at pollution avoided. This category accounts for the amount of air pollution that is avoided when trees reduce energy consumption. When trees are reducing energy consumption in nearby buildings, fewer fossil fuels need to burned to create the energy and therefore some pollution is avoided. The numbers are based on the amount of reduction in energy consumption and the average types of energy use in your region. If, for example, most of the energy in your region is from hydroelectric sources the avoided pollution would be relatively low since hydroelectric sources do not produce air pollution. If a tree produces no energy benefits there will be no resulting avoided pollutants.

Pollution avoided is calculated for VOCs, NO2, PM10, and SO2 using the following sources:
http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
http://www.cleanerandgreener.org/download/Leonardo%20Academy%20C&G%20Emission%20Factors%20and%20Energy%20Prices.pdf

Pollution valuation comes from three different sources:

- CO and PM10 values are calculated using national median externality values provided in: Murray, F.J., L. Marsh. and P.A. Bradford. 1994. New York State energy plan, vol. II: issue reports. New York State Energy Office, Albany, NY. – Note: values are in $ per metric ton of pollution and adjusted to current rates using the Producer Price Index.
- NO2 and SO2 values use information from the national analysis described above. From the national analysis, lookup tables were created that present multipliers in $ per square meter of canopy cover by county. Pollution value for the national analysis was estimated using the U.S. EPA's BenMAP (http://www.epa.gov/air/benmap/) program.
- VOC values are calculated using the methods provided in: http://ecocalc-test.ecotransit.org/CE_Delft_4215_External_Costs_of_Transport_in_Europe_def.pdf

4. Carbon Dioxide

The first way that tree effects on carbon dioxide are calculated is by looking at carbon dioxide sequestered. To calculate carbon dioxide sequestration, Design uses species-specific carbon equations. If carbon equations are not available for the input tree, then genus-level equations are

used. These equations provide the amount of carbon that is sequestered annually, which is converted to carbon dioxide by multiplying the results by 44/12.

The second way that tree effects on carbon dioxide are calculated is by looking at carbon dioxide avoided. Trees near buildings can reduce heating and air conditioning demands, thereby reducing emissions associated with power production. However, if a tree produces no energy benefits there will be no resulting avoided CO2.

Carbon dioxide valuation is based on the social costs of carbon from the Interagency Working Group on Social Cost of Carbon. The estimated amount of carbon sequestered or avoided is multiplied by a monetary value $78.5 per metric ton of carbon.