

i-Tree Eco model enhancements for version 6

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Air pollutant removal and associated monetary values by grasslands

Functionality to estimate air pollutant removal by grasslands (a combination of maintained and wild grass as well as herbaceous) was implemented. Monetary values associated with adverse health effects avoided by improving air quality were estimated using the same method of BenMAP as trees. For this implementation, Leaf Area Index (LAI) and some model parameters were modified as explained below.

State level daily LAI for a year derived from 2000-2012 MODIS products (NASA 2018) was employed for wild grass and herbaceous. Snow and ice coverage was distinguished in the dataset so the grassland LAI only shows those areas not covered by snow/ice. For maintained grass, a default value of summer-time maximum LAI of 1.2 was employed (Brede and Duech 1984). As the air pollutant removal is computed for grasslands, in which cover % for these three grass types estimated from field plots were combined, hourly LAI values for the combined grasslands are also estimated based on the two datasets mentioned and cover %.

As stomata exist on both sides of a leaf of a grass, the stomatal conductance used to calculate the stomatal resistance was doubled. In addition, the number of vertical layers of vegetation which is used to estimate the solar radiation penetration through vegetation was set to 1 for grass as opposed to 30 for canopy and shrubs. Other parameters that were adjusted for grass includes rate of electron transport at 25 °C, and carboxylation rate of CO₂ between leaf and atmosphere.

Transpiration

Unit was changed from g/m²/hr (mass of water per unit tree cover of 1 m² per hour) to mm/hr

(depth of water uniformly distributed over the tree cover per hour).

Air pollutant removal

Version 5 (v.5) uses the legacy winter canopy resistance (R_c) calculation routine in which R_c was calculated based on the maximum summer LAI (LAIs for the winter were not available) and evergreen % using hard-coded parameters. In version 6 (v.6), LAIs for the winter are available and thus this routine is no more used. This change generally reduced R_c that led to greater deposition velocity (V_d) and greater air pollutant removal in v.6. Another minor change made in v.6 is a bug fix from v.5 in which an angle already in Radians is mistakenly converted to Radians again in the process of computing aerodynamic resistance (R_a) for dry deposition estimates. This would only cause a very minor change in air pollutant removal in v.6.

Air quality improvement and air pollution concentration change

While it is assumed that the Eco analysis is always performed in an urban area in v.5, users can specify a rural or urban area for their Eco analysis in v.6, which affects the computation of mixing height as it may differ for rural and urban areas. This in turn affects the air quality improvement and concentration change due to air pollution removal by trees.

Monetary value for air pollutant removal

In the conterminous United States

- Due to the rural/urban switch mentioned above, pollutant metrics (e.g., annual mean of maximum change in hourly concentration) used in the BenMAP valuation function may change between v.5 and v.6, which in turn affects the final monetary values.
- Incidence and value for Hospital Admissions due to O_3 may increase as the population for age 0 was newly added for the computation. Incidence and value for Acute Myocardial Infarction due to $PM_{2.5}$ may decrease by about 50% compare to v.5 results as an average of intermediate calculations is taken.

In Alaska, Hawaii, Puerto Rico/Australia/Canada/The UK:

v.6 uses regression equations constructed from the United States county-based run (Nowak et al. 2012) that estimate monetary values per metric-ton of NO₂, O₃, PM_{2.5} and SO₂ removal based on population density. The equations are:

$$\text{NO}_2: y \left(\frac{\$US}{\text{ton}} \right) = 0.7298 + 0.5242 \times x \left(\frac{\text{people}}{\text{km}^2} \right)$$

$$\text{O}_3: y \left(\frac{\$US}{\text{ton}} \right) = 9.4667 + 3.5089 \times x \left(\frac{\text{people}}{\text{km}^2} \right)$$

$$\text{PM}_{2.5}: y \left(\frac{\$US}{\text{ton}} \right) = 428.0011 + 121.7864 \times x \left(\frac{\text{people}}{\text{km}^2} \right)$$

$$\text{SO}_2: y \left(\frac{\$US}{\text{ton}} \right) = 0.1442 + 0.191 \times x \left(\frac{\text{people}}{\text{km}^2} \right)$$

References

- Brede, A.D. and J.M. Duech (1984), Initial mowing of Kentucky bluegrass-perennial ryegrass seeding turf mixtures, *Agronomy Journal*, 76(5):711-714.
- National Aeronautics and Space Administration (NASA) (2018). MODIS-derived Biophysical Parameters for 5-km Land Cover, North America, 2000-2012. http://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1210 (Accessed Jan. 2018).
- Nowak, D.J., Hirabayashi, S., Bodine, A., Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. *Environ. Pollut.* 193: 119–129.