NCASI Fact Sheet
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Calculators Estimating Tree CO_2 Sequestration

Overview

NCASI has assessed prominent calculators that estimate the amount of carbon dioxide (CO_2) sequestered by planting trees. While these calculators are described as being useful for estimating the climate benefits of tree growth, individual results vary significantly. NCASI has evaluated the features and limitations of four calculators, compared the results with detailed analyses, and provided recommendations regarding their use.

Tools

Trees store carbon in their trunks, branches, leaves, and root systems throughout their lifespan. Tree growth and carbon storage is influenced by multiple factors including species, soil quality, water availability, light exposure, and other environmental variables. To account for these aspects, a calculator estimating CO_2 sequestration by trees should, at a minimum, detail or allow user selection of carbon pools, carbon storage timeframe, tree species, and geographic scale. Among the selected tools, four incorporate the minimum methodological detail and data quality necessary for a detailed evaluation[1], as summarized in Table 1. A Data Quality Indicator (DQI) score (0-100, higher is better) has been assigned for each based on our analysis.

Table 1: *Summary description of the calculators evaluated in this publication.*

Tool	Provider	Brief Description	Use & Scale	DQI Score
CUFR Tree Carbon Calculator (CTCC)[a]	USDA Forest Service	CO_2 sequestration by individual trees. Inputs: - Location: 16 pre-defined zones for the US; - Tree details: species, size (d.b.h.)[b] or age.	single tree, urban, US only	70
i-tree Planting	USDA Forest Service / Davey Tree Expert Company	Assists tree planting projects. Inputs: - Location: US state, county, and city; - Tree details: species, size at planting (d.b.h.); - Other: Insolation intensity, tree condition, mortality rate.	single tree, urban, US only	90
Forest Landscape Restoration (FLR) Climate Impact Tool	Winrock International	Estimates CO_2 removals by specific activities. Inputs: - Location: country and province/state; - Species: Ex. pine, oak, other broadleaf, other conifer; - Activity type: Ex. plantation, natural restoration; - Number of hectares planted each year.	forests, restoration, worldwide	75
US Greenhouse Gas Equivalencies Calculator[c]	US Environmental Protection Agency (US EPA)	Converts emissions or energy data to CO_2 emissions. Inputs: - Energy consumption data; or emissions data.	forests, urban, US only	70

a- The Center for Urban Forestry Research (CUFR) has discontinued CTCC, which can be provided by NCASI upon request.
b- The diameter at breast height (d.b.h.) is a standard measurement used in forestry to quantify the diameter of a tree trunk.
c- The US EPA tool employs an approach that captures average annual carbon stock variations across forest land in the contiguous US, which complicates comparisons with other calculators on the same scale by not allowing selection of species, regions, or states.

[1] Tree Canada offset calculator and 8 billion trees calculator were excluded from the in-depth analysis due to insufficient methodological detail. i-tree Design was excluded first, due to its similar methodology to i-tree Planting, but also because it focuses on individual trees at the parcel level to gain insight into community benefits rather than precise carbon calculations.

Evaluation and Results

NCASI simulated results for species in three regions of the US. Pine and broadleaf species of the Southeast (SE), Pacific Northwest (PNW), and Northeast (NE) were selected based on their geographic distribution. Figure 1 shows the number of trees required to offset one metric ton of carbon dioxide (t CO_2) for each species in their respective regions over a 20-year period. USDA Forest Inventory and Analysis (FIA) data were used as a benchmark estimate of a forest's above- and belowground carbon in live trees.

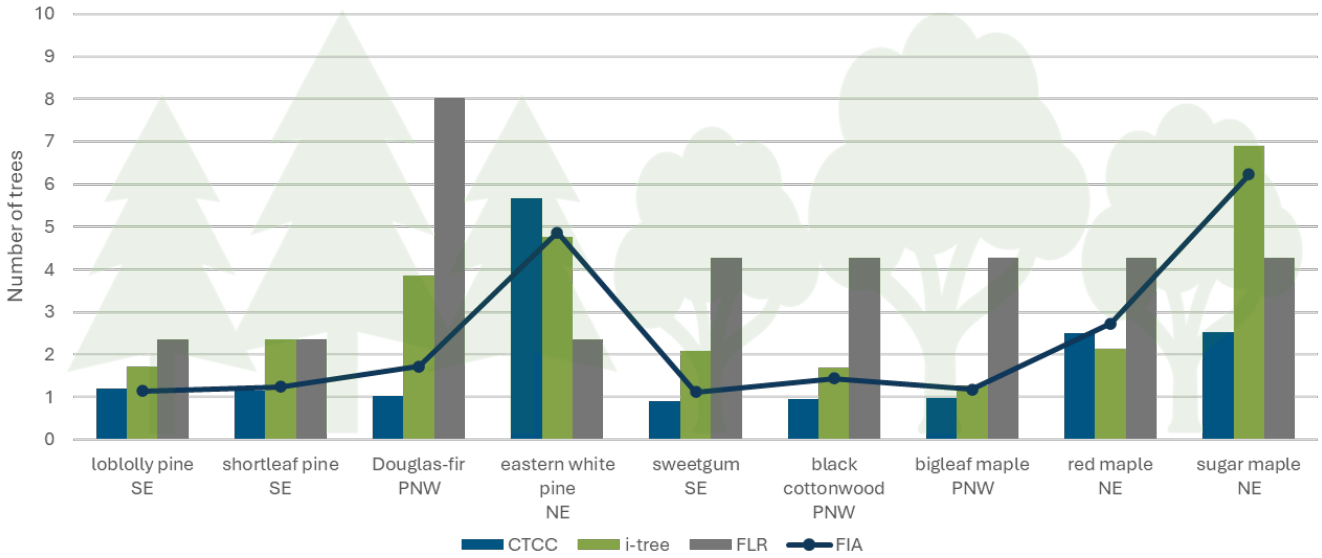

Figure 1: *Results for the estimated number of trees to sequester 1 metric ton of CO_2 over a 20-year period for the selected conifers (loblolly pine, shortleaf pine, Douglas-fir, eastern white pine) and broadleaves (sweetgum, black cottonwood, bigleaf maple, sugar maple) species, respectively. Not shown in the graph, US EPA's calculation estimates 19 trees for the US average forest lands.*

The calculators produced a range of CO_2 sequestration results. For instance, over 20 years, i-tree Planting calculated deciduous trees stored, on average, 580 kg of CO_2 /tree, except for the sugar maple, which is a slow-growth species taking approximately 40 years to store this same amount of CO_2. The FLR calculator, in contrast, considers all selected deciduous species as a single set, and estimated an average storage of 234 kg of CO_2 /tree.

Limitations and Remarks

Modeling and predicting tree growth rates is a complex task, and characterizing tree species using a uniform growth rate excludes a multitude of aspects that affect tree development. None of the calculators were explicitly designed for quantifying forest carbon stocks nor do they address all the relevant elements necessary for calculating the CO_2 sequestered by a particular tree planting or offset project.

While i-tree Planting most closely matches the rigorous FIA data analysis, it is primarily designed for urban tree settings. Urban trees generally grow in more open spaces at lower planting densities than forest trees. Tree diameter distributions, growth, mortality rates, and CO_2 sequestration rates differ between the two environments.

These calculators may be useful for simplistic preliminary assessments of the scale of CO_2 tree sequestration. For accurate carbon storage estimation, however, unique aspects of each project should be evaluated, complemented with literature review and expert analysis.

Additional details, references, and results are available upon member request to info@ncasi.org.