

How to estimate forest carbon balance

Hyungwoo Lim, Department of Forest Ecology and Management

As major carbon sinks, forests play a crucial role in global carbon cycling and in mitigating carbon emissions. Carbon forms the backbone of organic compounds that sustain the Earth system and provide essential ecosystem services. Within forest ecosystems, organic carbon is stored in both living and dead materials, including trees and soils, constituting the largest terrestrial carbon pool. Accurately estimating carbon balance is therefore very important for assessing ecosystem functioning, biodiversity, and climate projections.

Forest carbon balance consists of two main components: carbon pools and fluxes. Pools refer to the amount of carbon contained within a specific compartment, whereas fluxes refer to the rate at which carbon moves from one pool to another. Field-based estimation of pools and fluxes is particularly important, as it complements national forest statistics by sharing similar measurement approaches. It also serves to validate carbon flux estimates derived from high-resolution measurements (e.g., eddy covariance towers) and large-scale estimates derived from global carbon models and remote-sensing observations.

Carbon pools in living trees are commonly estimated using measurable tree dimensions, such as stem diameter and height, combined with scaling equations developed from empirical relationships based on allometry theory. Carbon fluxes are then estimated as the change in carbon pools over a given period, plus turnover of the pool, that is, the replacement of old carbon pool by newly produced biomass.

When upscaling these estimates, it is essential to consider population distributions, scaling equations, and organ turnover to minimize bias. However, key measurable components and critical scaling factors are often overlooked due to simplifying or inaccurate assumptions, or the difficulty of obtaining accurate measurements.

My docent lecture explores common errors in forest carbon estimation and presents approaches for minimizing estimation bias.