Method for urban forest carbon storage analysis based on terrestrial LiDAR

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Introduction

LiDAR has become widely used in forest surveys, substantially reducing labor and time. Key structural parameters—tree height, canopy closure, and DBH—can be derived efficiently with LiDAR. LiDAR-based assessments generally fall into two types: airborne and terrestrial. Early airborne applications faced sparse point densities, prompting accuracy-focused research (Wynne, 2006). Today, carbon stock estimation largely relies on satellite, airborne, or UAV LiDAR, which works for large, structurally uniform forests but underperforms in small, heterogeneous urban stands due to coarser spatial resolution (Zhuang, 2022). In contrast, terrestrial LiDAR (TLS) provides much higher point density and captures detailed tree-level 3D structure (Hopkinson, 2004). For carbon accounting, AGB is commonly estimated via allometric equations using DBH and height, yet applying locally derived models beyond their intended scale introduces bias (Sun, 2024).

This study seeks to integrate field survey data with TLS-derived parameters to establish allometric equations tailored to urban forests in Nagoya. The expected outcome is improved accuracy in AGB and carbon storage estimation, offering a more reliable methodology for urban ecosystem assessment and management, particularly in contexts where traditional remote sensing approaches prove inadequate.

Experimental Procedures

First, ten 300m² sample plots were established in Nagoya City for field surveys. Within each plot, DBH of all trees was measured, and species were recorded. Simultaneously, terrestrial LiDAR was used to collect point cloud data of trees and the ground, providing the basis for DBH, DEM, and DSM extraction. Using the field DBH data, tree height will be estimated with the Näslund equation (Matsumura, 2003), and carbon storage will be calculated with the equation proposed by Tadaki (2004) for Nagoya. Following IPCC (2006), carbon storage will then be converted into AGB. On the LiDAR side, DEM, DSM, and DBH will be derived through point cloud processing (e.g., CloudCompare), and CHM will be generated. Finally, by combining field-based AGB with LiDAR-derived DBH and CHM, localized allometric equations will be developed to construct an urban forest AGB estimation model using terrestrial LiDAR data.

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