Remote Sensing of Tree Structure and Biomass in north Australian mesic savannah

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BIOMASS

- Biomass - Organic material both above-ground and below-ground, and both living and dead, e.g., trees, crops, grasses, tree litter, roots etc. (FRA 2005). The unit of measure is commonly *g/m2* or *kg/ha.*

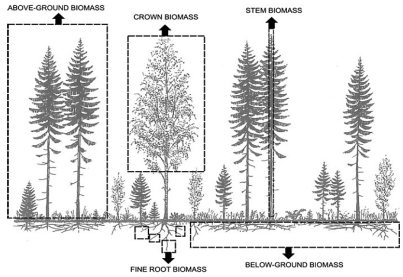


Figure1: Biomass components above- and below-ground (Maltamo, Næsset et al. 2014)

WHY ESTIMATION OF BIOMASS IS IMPORTANT?

- Forest resource management:
  - ✓ forest inventory
  - ✓ estimation of timber volume
  - ✓ Forest dynamics and conservation
- As an energy and bioenergy source
- Critical component of tracking carbon and greenhouse gases cycling
  - ✓ (above ground biomass (AGB) is approximately 48% carbon)
- Forest fire management:
  - ✓ Forest fuel and their vertical structure distribution

BIOMASS ESTIMATION APPROACHES

- In general, biomass can be measured via three primary methods:
  - **a) destructive measurement by field work;**
  - **b) non-destructive estimates using allometric equations or conversion;**
  - **c) by using remote sensing**

Allometry assumes that a relationship exists, by species, based on size or amount of tree size (e.g. diameter at breast height (DBH), top height, and crown area) to the dry weight of the above and/or below ground components of biomass

(typical allometric model - single-tree diameter/height)

MEASUREMENT OF FOREST BIOMASS

TWO MAIN APPROACHES

- Single tree approach, relying on individual tree detection

tree metrics used:

Tree species (wood density); diameter at breast height; Height

- Area-based approach, based on statistical canopy height distribution

tree metrics used:

Tree species; tree basal area (m2); Total basal area (m2/ha)

(canopy height, crown area, or geometric canopy volume as independent variables)

REMOTE SENSING AND BIOMASS ESTIMATION

- Biomass cannot be directly measured by remote sensing sensors
- An indicator is the canopy/tree height, based on the close association between tree height and wood volume
- Canopy height models (CHM) provide accurate estimates of forest parameters such as canopy heights, stand volume, and the vertical structure . CHM is result of subtraction of bare ground values (Digital Terrain Model (DTM)) from the canopy layer (Digital Surface Model (DSM)).
- Most accurate height estimations and 3D structure of vegetation could be obtained using Light Detection And Ranging (LiDAR) systems

LIDAR principle

- LiDAR measure the range (i.e., distance) from the sensor to a target, determined by timing the round-trip travel time of a pulse of laser light reflected from a surface. Travel time is converted to distance using the speed of light.
- Position of reflected point calculated by combining distance with knowledge of the position of the sensor in a coordinate frame (GPS+IMU) and a vector that defines the location of the reflecting target.

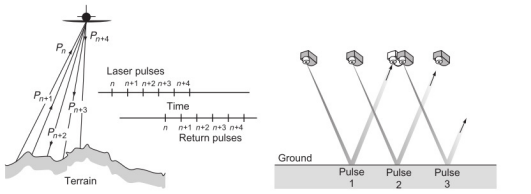
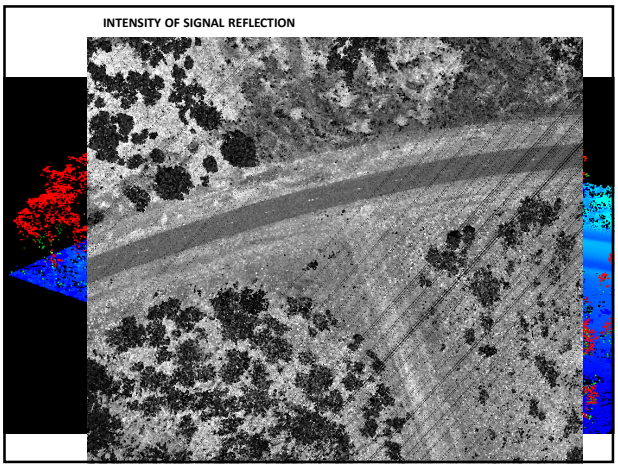
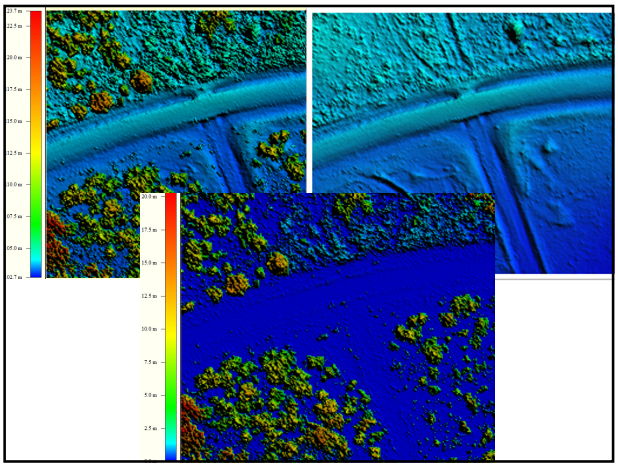


Figure2 from (Shan; and Toth 2008)

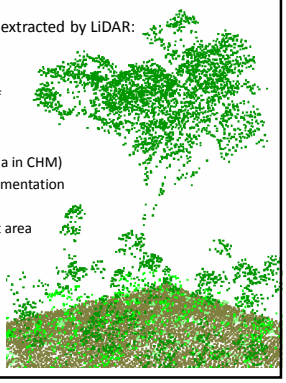




LASER SCANNING IN FORESTRY USE

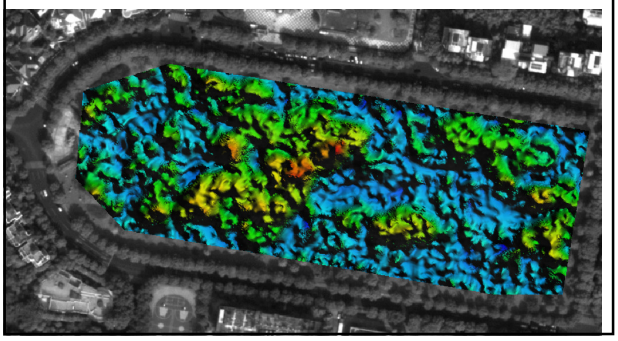
Parameters and forest inventory attributes extracted by LiDAR:

- Tree Heights
- DTM
- Average Elevation, slope and aspect of relief
- DSM
- CHM – Canopy Height Model
- Tree Peak identification (finding local maxima in CHM)
- Canopy Projection Area (CPA) – result of segmentation
- Centroid of the CPA
- Local tree density - number of trees per unit area
- Canopy volume
- Canopy base Height (CBH)



REMOTE SENSING ALTERNATIVES

- By using the high-performance image-matching technique, the canopy height information can be easily and automatically extracted from satellite and aerial images in stereo and multi-image mode.



REMOTE SENSING ALTERNATIVES

	Advantages	Disadvantages
Airborne laser scanning	Direct data georeferencing; Provides information from under the dominant canopy; Accurate estimation of forest attributes; Detailed 3D spatial information	Limited information on species diversity and forest health; High cost
Satellite optical sensors	Higher coverage at relatively low cost; Regular temporal resolution and homogeneity in acquisition; Image spectrometry information;	Less precise estimates; Unable to penetrate the canopy; Lower spatial resolution; Need precise indirect georeferencing;

Relations between different land coverage scales and remote sensing data

- Precisely exchanging data between scales is essential as many environmental and resource management problems can only be dealt with effectively at broad scales (Wu & Qi, 2000).