The importance of stand structure and tree allometry for local-scale variation in aboveground biomass

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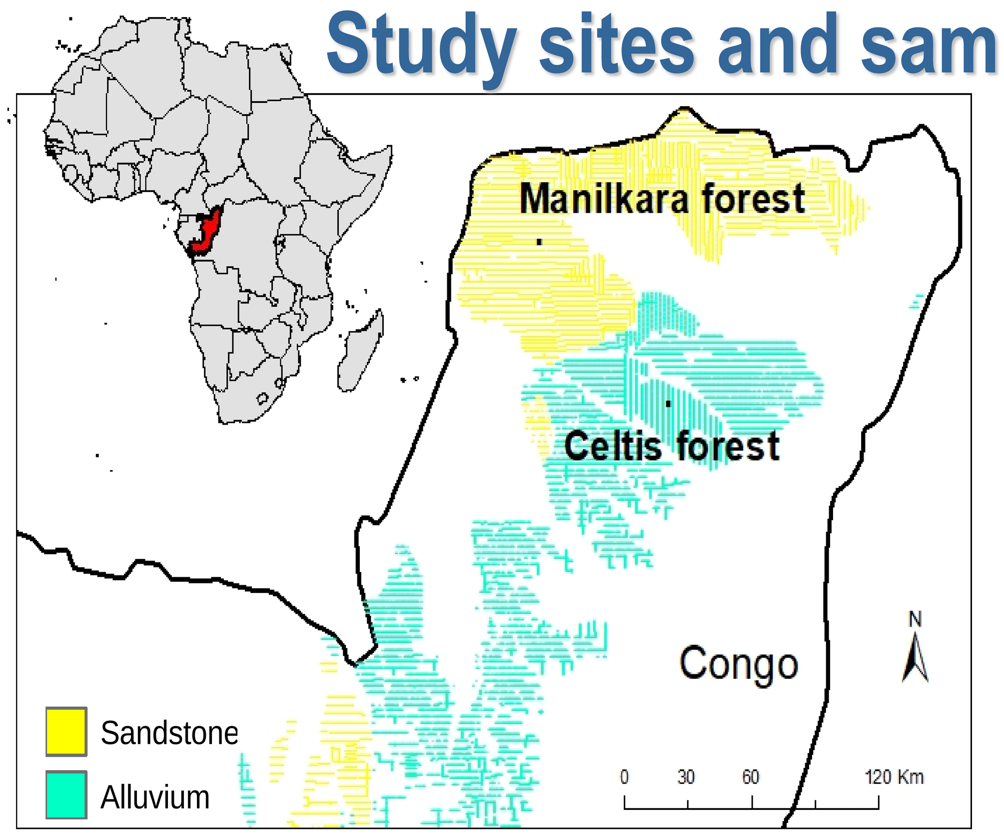
Background

Tropical forests play a key role in the global carbon cycle and climate regulation (Pan et al., 2011). However, a lot of uncertainty remains on the amount of aboveground biomass (AGB) and carbon stored in tropical forests, and spatial variation. To improve estimates of AGB/carbon stocks, and specifically to calibrate remote-sensing products, reference sites with detailed knowledge on local-scale AGB variation, are needed, in order to derive AGB/carbon maps.

Using extensive inventory and allometry data for two sites in northern Congo, we addressed

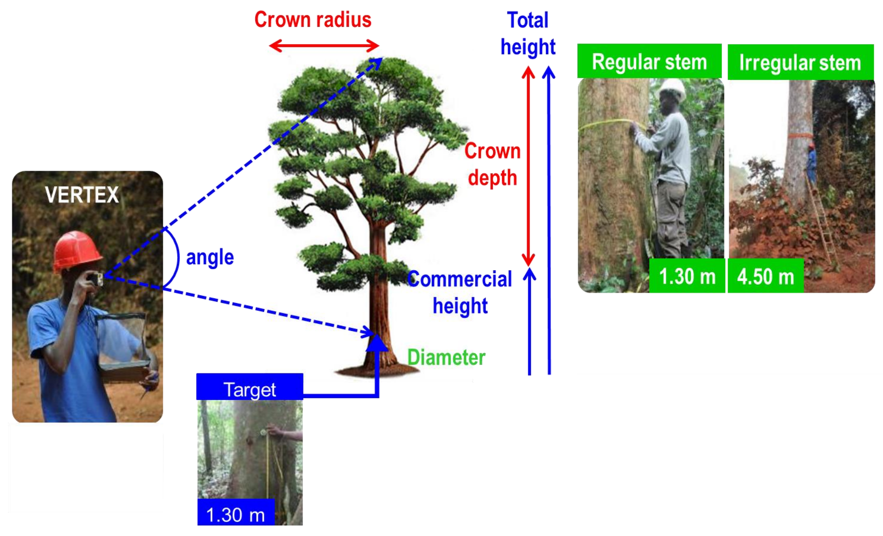
1. Between-site variation in tree allometry
2. Between-site variation in AGB
3. Local-scale variation in AGB

Study sites and sampling

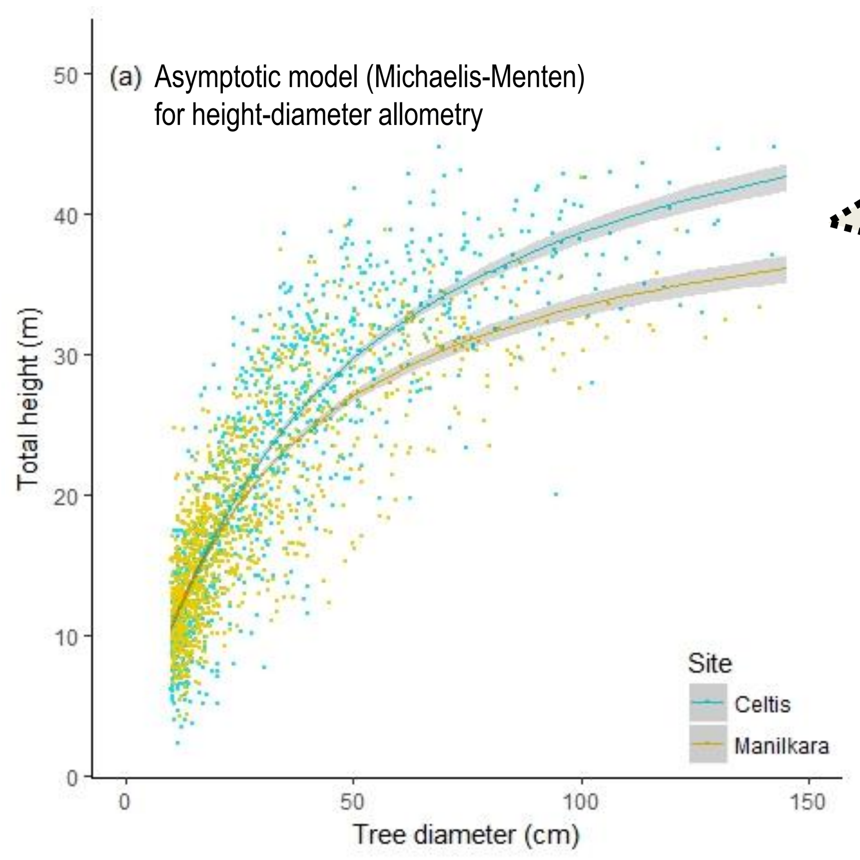


Two forest sites under the same climate but with contrasted geological substrates and soils

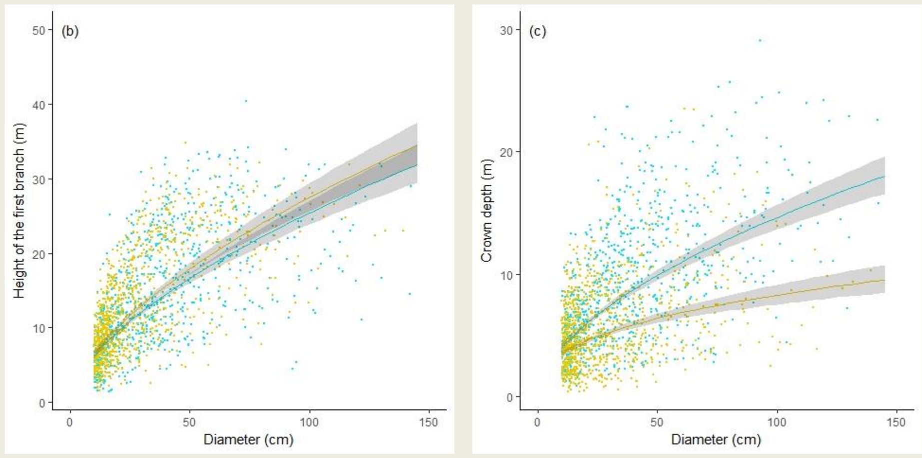
- Sampling for inventory data (36 ×1-ha plots) all trees ≥ 10 cm in diameter in each site
- Subsampling for allometry data (18 ×1-ha plots) height and crown dimensions



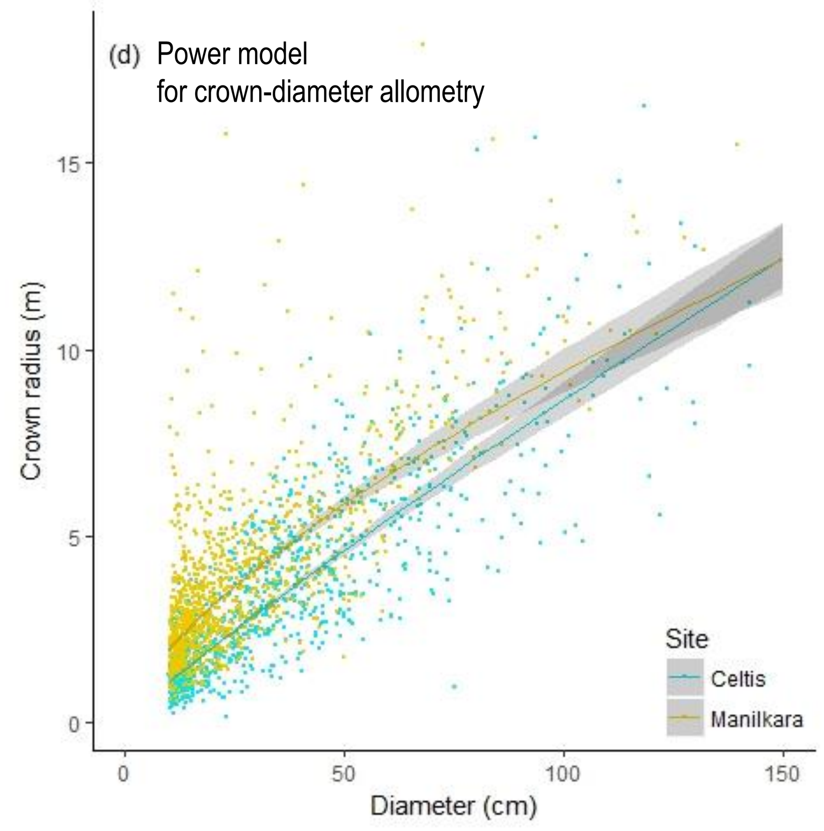
1. Between-site variation in tree allometry



The difference in height-diameter allometry between the *Celtis forest* and the *Manilkara forest* resulted from crown depth variation and not from trunk height..



For a given diameter, trees were found to be taller and to had deeper and narrower crowns in the *Celtis forest* than in the *Manilkara forest*.
Similar trends were observed for shared species, suggesting an environmental control on tree allometry.

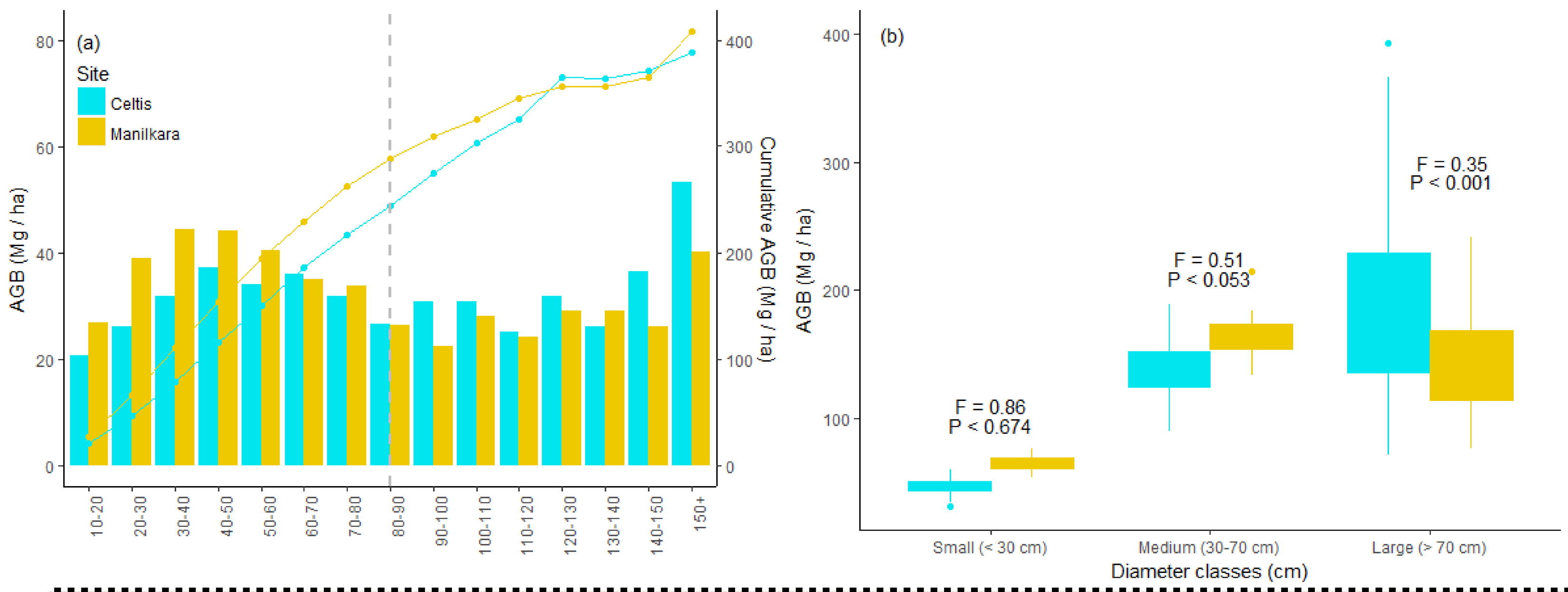


2. Between-site variation in AGB

The most recent pantropical equation was used to estimate tree AGB

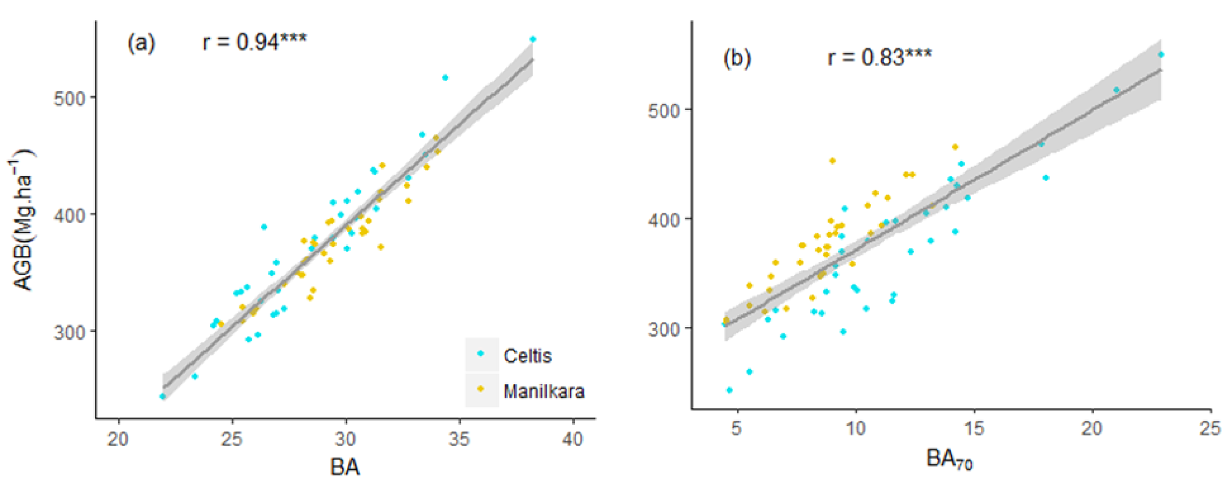
$$AGB = 0.0673 \times (\rho D^2 H)^{0.976}$$

Chave *et al.* (2014)



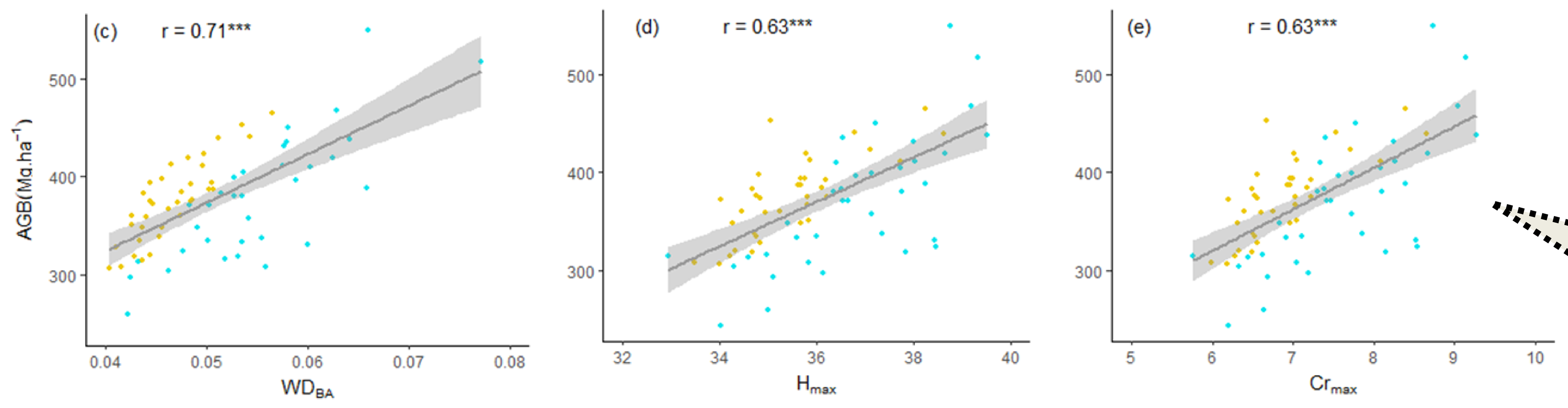
The two forest sites store a large fraction of AGB in the largest diameter classes (tree ≥ 70 cm in diameter), with significantly greater AGB in the *Celtis forest* than in the *Manilkara forest*, for the whole plot and for the largest trees.

3. Local-scale variation in AGB



Using mixed linear models, the variation in plot AGB was related to:

- basal area (BA)
- basal area of large trees (BA_{70})
- BA-weighted wood density (WD_{BA})
- maximum height (H_{max})
- maximum crow radius (Cr_{max})



Take-home message

Both stand structure (density of large trees) and tree allometry (maximum height), and to a lesser extent species composition (wood density) are important determinants of local-scale AGB variation.
Using these two forest sites, as reference sites for calibrating remote-sensing products, offers direct and strong practical implications for AGB and carbon stocks monitoring in Central African forests.

Among the set of forest attributes tested, structural (BA, BA_{70}), compositional (WD_{BA}) and allometric (H_{max} and Cr_{max}) attributes are important determinants of AGB variation between and within the *Celtis* and the *Manilkara* forests.

Reference

Chave, J., et al. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. Glob. Chang. Biol. 20, 3177–3190.
Pan, Y., et al. (2011). A Large and Persistent Carbon Sink in the World's Forests. Science 333, 988–994.