Mobile LiDAR for assessing structural metrics in tropical forest

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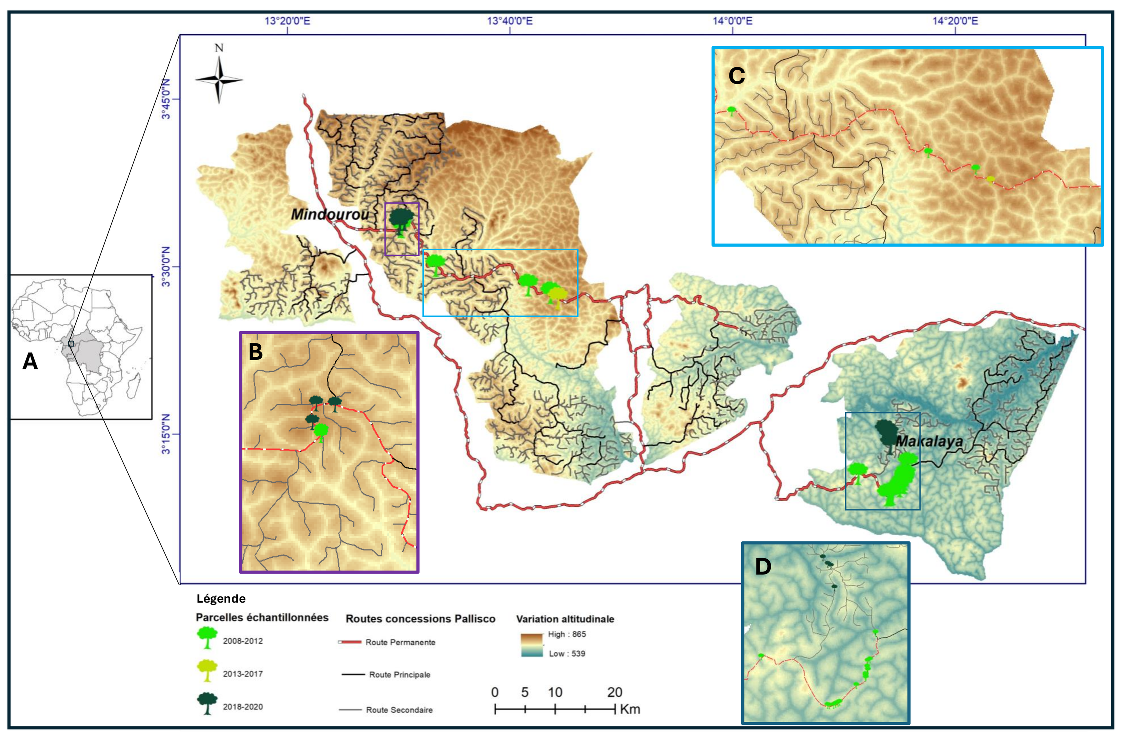
1. Context

For more than **two decades**, **silvicultural enrichment** has been carried out in **Congo Basin**, which is currently one of the **last tropical carbon sinks**. In the best of our knowledge, **scarce** or **no information** is available on the **contribution** of these **enriched zones** in terms of **biomass/carbon** storage. Accurate assessment of above-ground biomass (**AGB**) stocks is an international priority and is required by the **REDD+** initiative, particularly in Central Africa, where a substantial **forest loss** is expected, coupled with an increase in population. **Terrestrial LiDAR** (TLS & MLS) is a promising ground-based technique which can be used to obtain **3D vegetation** structure and provide accurate **non-destructive AGB** data from **tree** to **plot** level. Using this **cutting-edge** technique will provide the **baseline data** needed for remote sensing to ensure benchmarking products from **Global Forest Biomass Reference System**. In this study, a **guideline** for collecting and processing this kind of data is proposed to estimate the AGB stored by enriched forest stands. AGB obtained is compared with those derived from **regional** and **pantropical** allometry.

2. Study site & Field data

Forest inventories (planted and non-planted trees) and MLS surveys were performed on **29** plots varying from **0.2ha to 1.7ha** found in logging concessions managed by **Pallisco. Trees were planted either in lines or in patches**

A total of **5086** trees from **36** species were censused in **reforested** plots between **2008** and **2020**.



3. Methods

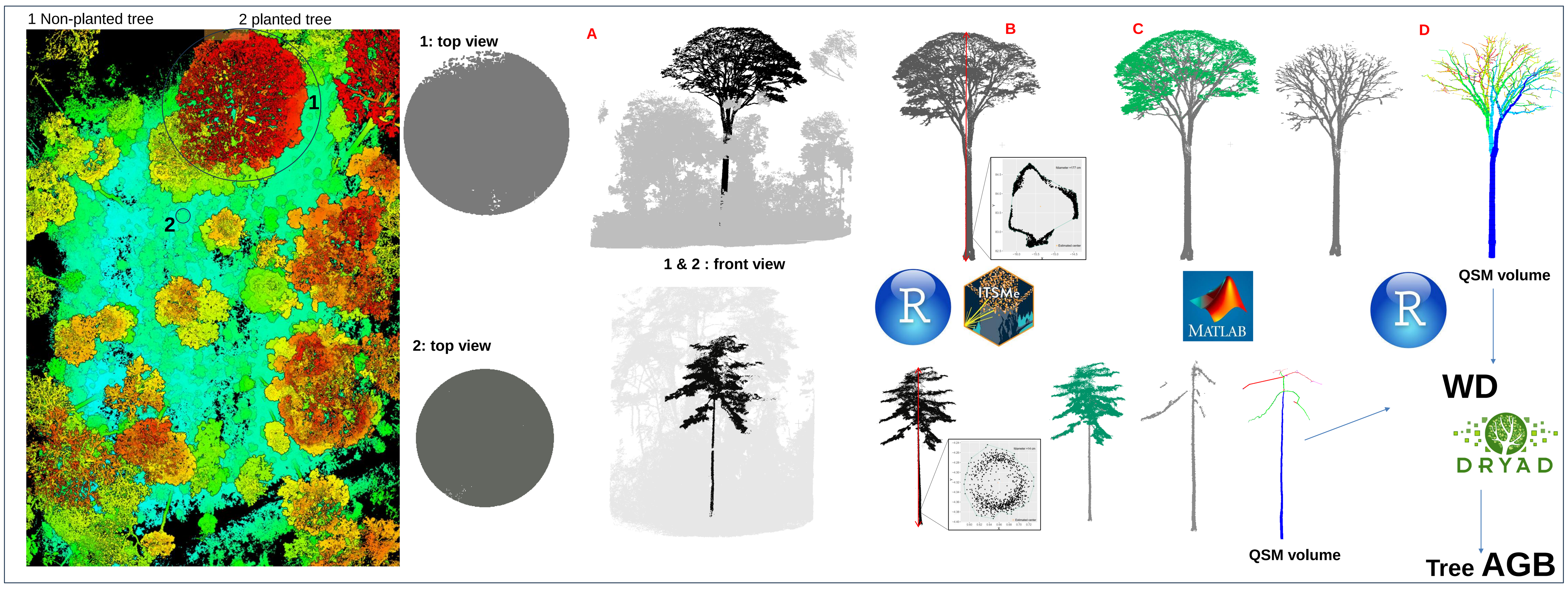
- **MLS data processing**

Currently, **916** trees from **3** plots, covering a wide gradient of size have been processed. MLS trees were isolated through **3** steps
- Tree **segmentation**
- **Leaf** and wood separation
- **QSM volume** determination

Tree reference AGB was obtained by multiplying QSM volume to specific wood density (https://datadryad.org/stash/dataset/doi:10.5061/dryad.234)
We use **ITSMe R** package to get all structural trees metric (**DBH & total height**).
Tree plot AGB was derived by summing each of individual tree AGB

- **Analyses**

We compared **AGB derived** from MLS with local and pantropical models.
For this, we calculated standard metrics such as :
i) Individual tree error
ii) Individual tree relative error
iii) Mean relative error (%) across all trees of each plots



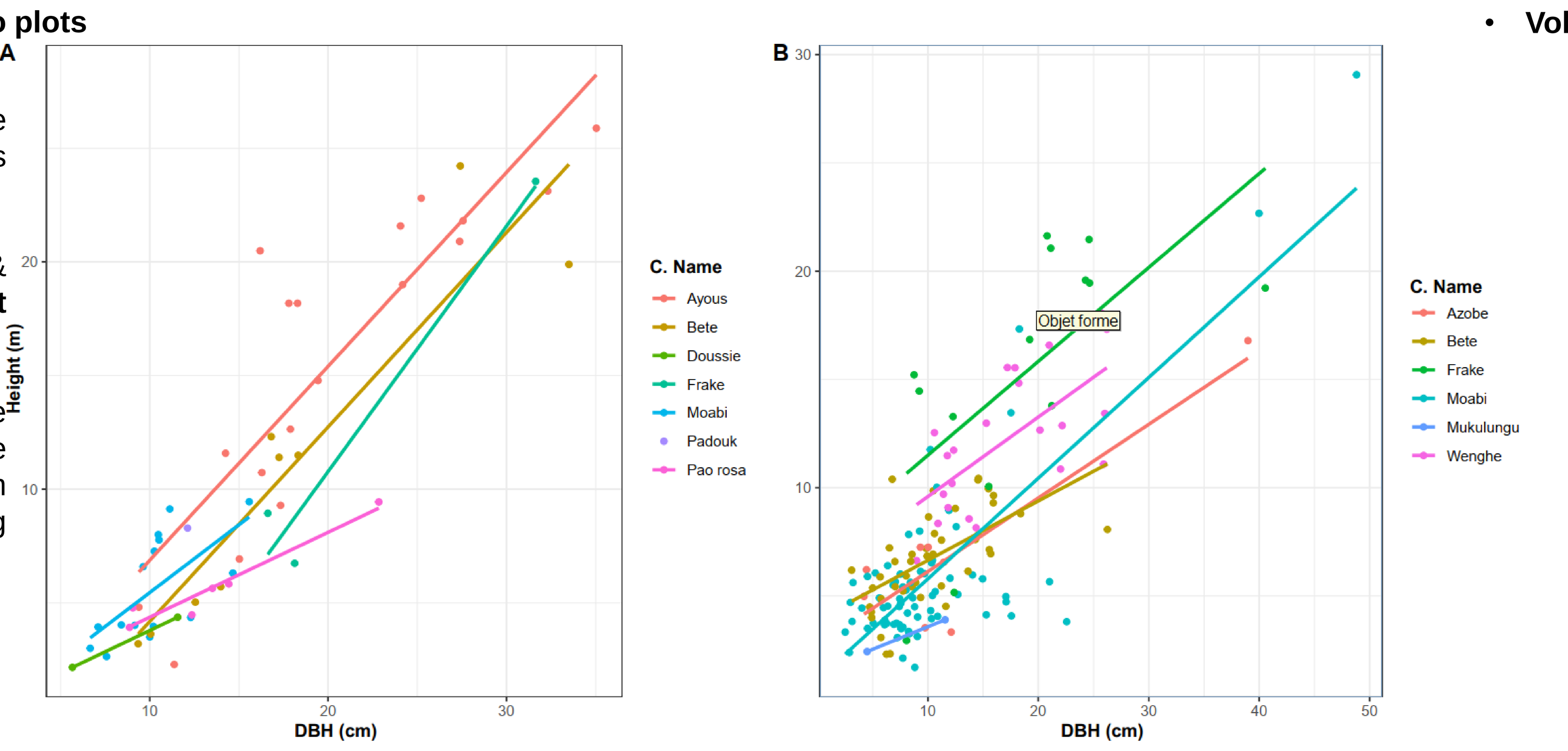
4. Results

- **Structural metrics patterns for two plots**

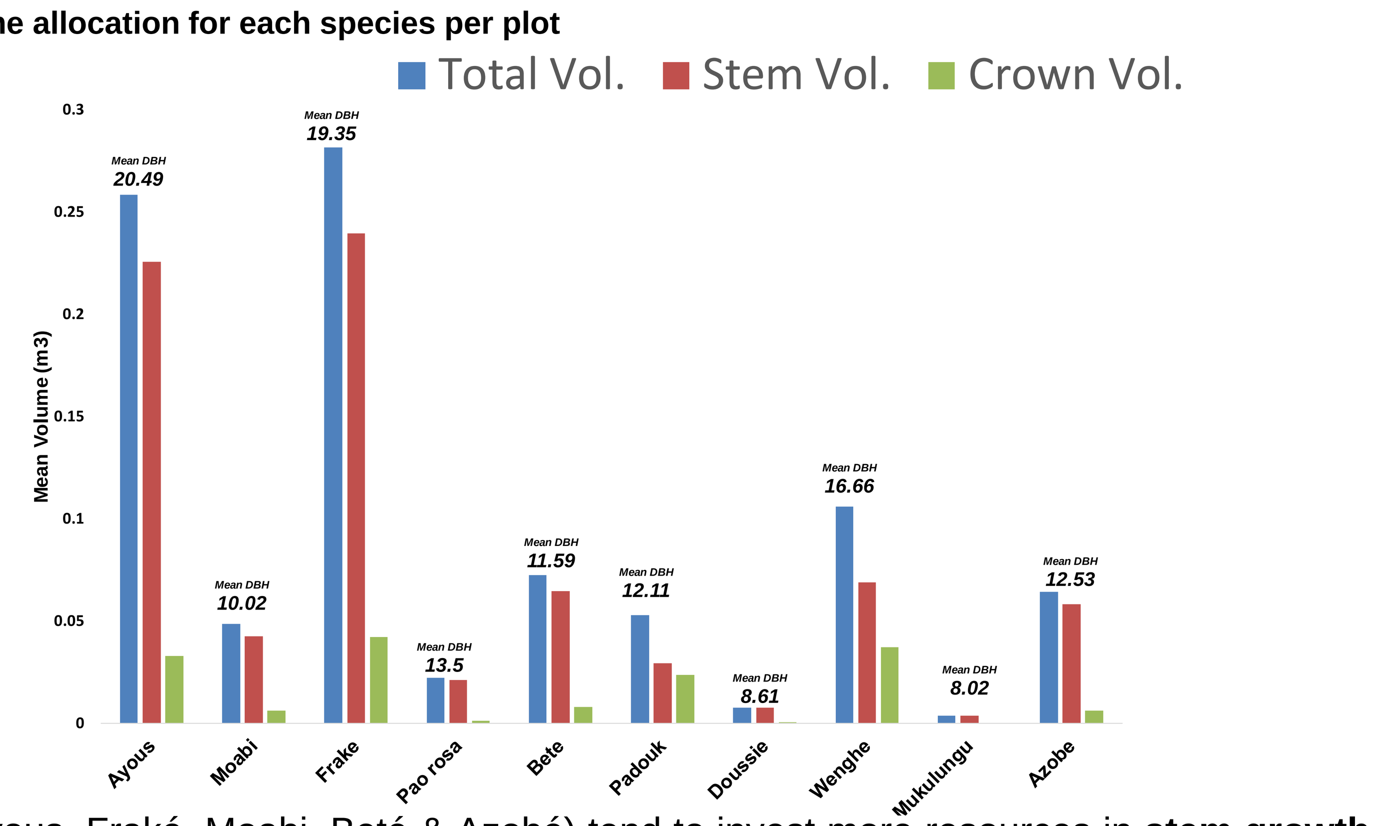
Positive relationship b/t DBH and tree height derived from MLS data for **10** species spread over **221** trees

Overall trend is **consistent** across inter & intra species which **exhibit different growth rate according to plot**

DBH ranges from **5.6 to 35**cm, with tree heights varying b/t **2.1 to 25.8m** among the species in graph A, while DBH spans from **2.5 to 48.8**cm, with tree heights ranging from about 1.7 to 29m



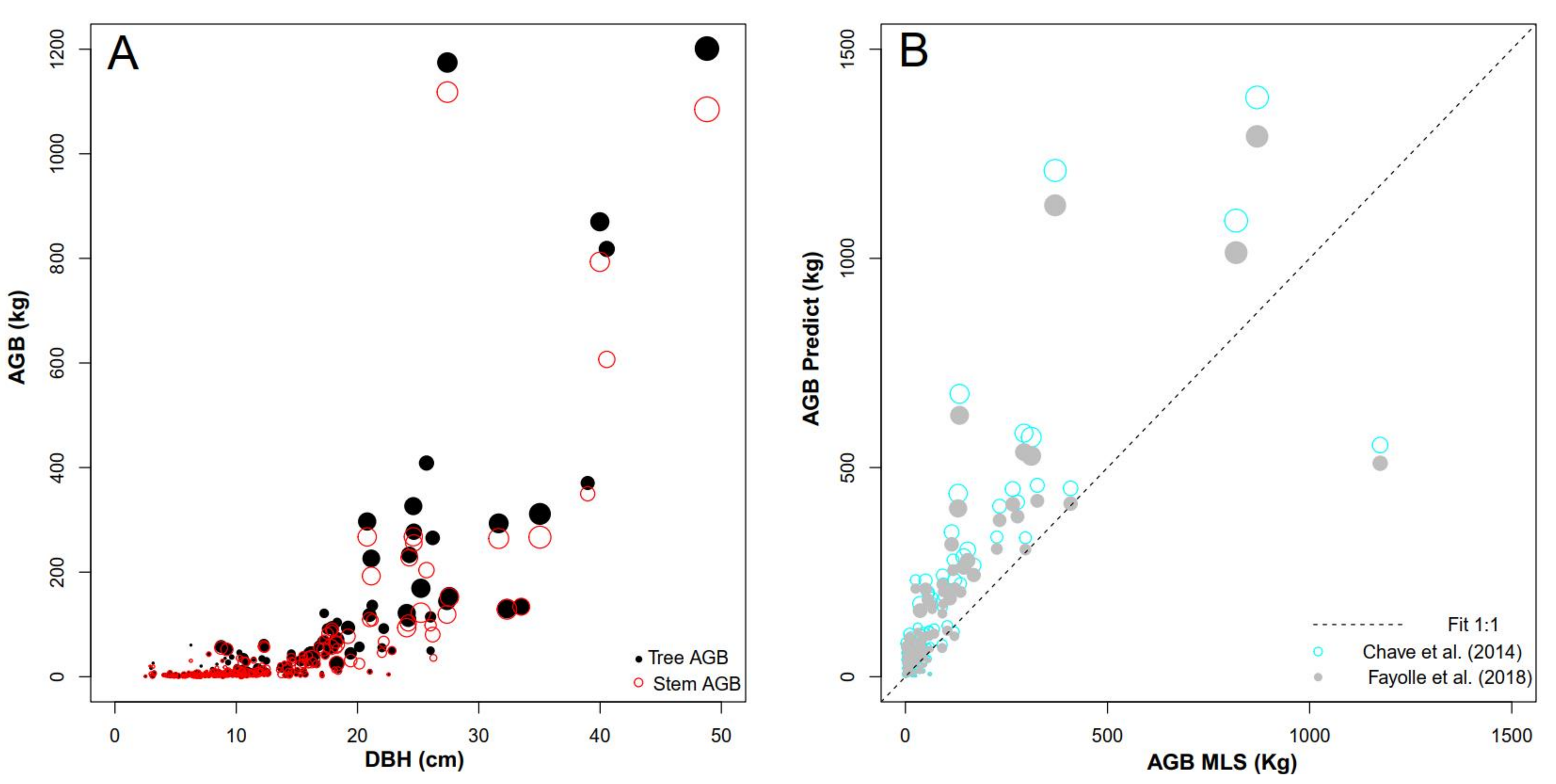
- **Volume allocation for each species per plot**



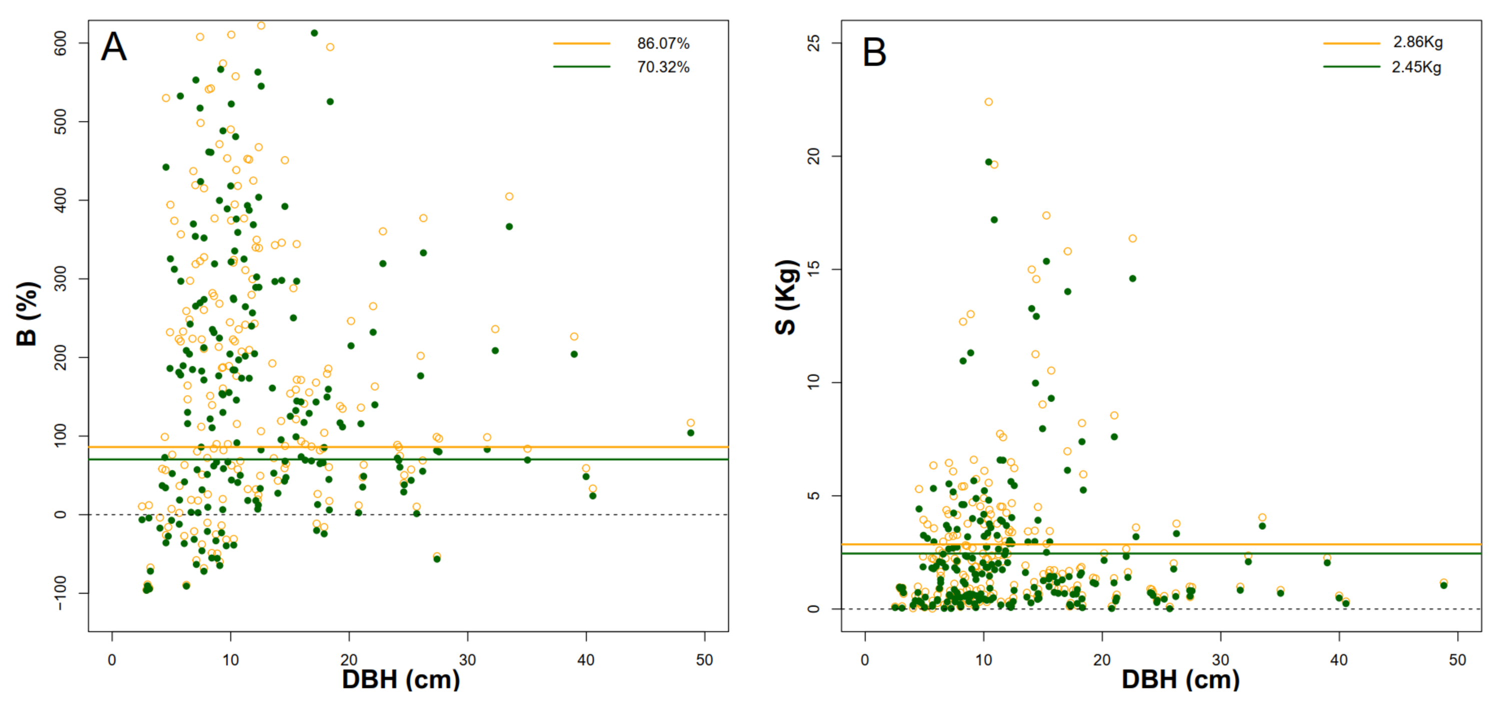
Five species (Ayous, Fraké, Moabi, Beté & Azobé) tend to invest more resources in **stem growth** rather than **crown expansion**, reflecting a typical strategy of **pioneer species**

Conversely, **Three** species (Padouk, Doussie & Wenghé) invest their resources **proportionally** in their stems and crowns, characteristic of sciaphilous species

- **Biomass estimation & comparison with state of art**



- **Bias & relative error variation**



Using Chave et al. (2014) and Fayolle et al . (2018) equations leads to large average bias of **86.07%** and **70.32%**, respectively

Relative errors for these two equations are **2.86kg** and **2.45kg**, respectively

Relationship between AGB and DBH, dot corresponds to an individually tree and stem MLS AGB. The size of symbols is proportional to tree height. A significant and positive correlation of **0.72** was found between **AGB** and **DBH**, reflecting an **empirical dependency** of these **both structural** parameters

Based on AGB derived from MLS data, predictions from pantropical equation of Chave et al (2014) and subregional equation of Fayolle et al (2018) **largely overestimate AGB**, revealing their **inadequacy for planted forests**

However, it is important to check whether this overestimation is a consequence of the impact of **vertical variations** in **WD** on AGB data obtained from the LiDAR data (Momo et al.,2020)

5. Perspective

The next challenges include :
- applying this cutting-edge processing approach to all 29 plots sampled, both for planted and unplanted trees

- it will also be a question of determining the below-ground biomass

- finally, integrating all these results with species growth performance in order to predict potential volumes of wood and biomass that may be available in the long term

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