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Comparison of carbon uptake estimates from forest inventory and Eddy-Covariance for a montane rainforest in central Sulawesi

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Introduction

Eddy-Covariance (EC) measurements in tropical forests have always been difficult as turbulent conditions during the night rarely meet the requirements. Thus the Carbon sink of – 970 g (C) m^{-2} y^{-1} estimated by Ibrom et al. (2007) from flux measurements at our site has always been considered too high.

Although the amount of Carbon stored in montane rainforests is large, Carbon flux estimates from these forests remain scarce. Therefore we restarted EC- measurements at the site in 2013.

Objective

- provide an independent estimate of Carbon storage change in aboveground biomass (AGB) for comparison with fluxes.
- Assess changes in forest structure possibly explaining high fluxes.
- Provide a basis for further biometric measurements.

Constraints

- Original inventory designed for biodiversity study, not for an AGB estimate.
- Quality of old data unclear.

Conclusions

- Carbon sequestration estimates based on our inventory were much lower than those from EC measurements.
- New inventories in old-growth rainforests should use a DBH-weighted sampling approach to account for the influence of thinly distributed large trees on AGB estimates.
- The forests structure seems to have been stable for the last decade

➔ The difference between reported fluxes and inventory based estimates indicate missing night time fluxes and call for careful flux filtering and analysis of EC data.

Site

- Central Sulawesi, Indonesia (Fig. 1)
- Elevation 1450 m a.s.l.
- Old-growth montane rainforest
- For 2014-2015 mean temperature was 20.3°C, annual precipitation ~1720 mm (Fig. 2)
- Aboveground biomass (AGB) estimated as 308 ± 18.8 Mg ha^{-1} (Culmsee et al. 2010)

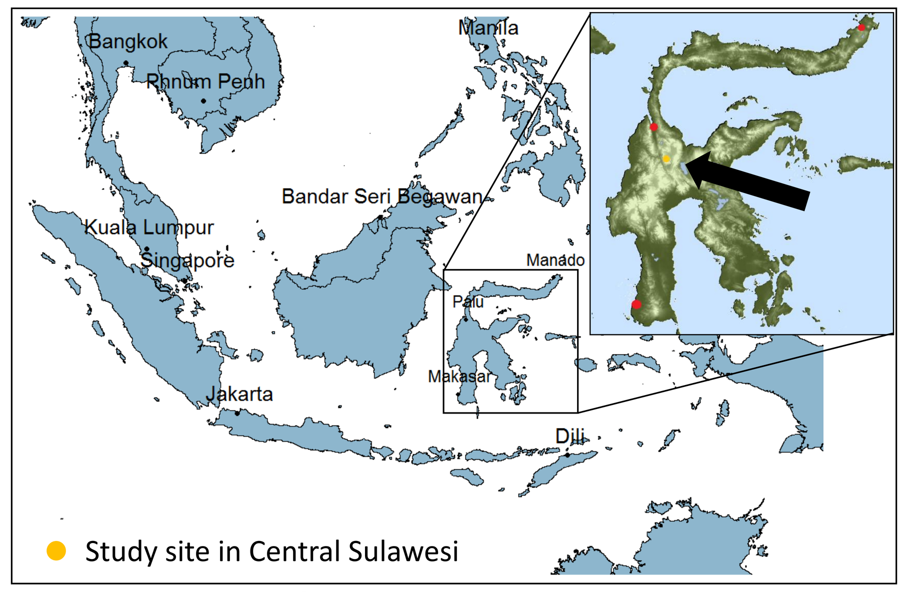

Fig. 1 Study area: Bariri, Sulawesi

Methods

- Re-inventory of 22 forest plots, for the layout see Fig. 3
- Identification of all trees from former inventory through number tags or position
- Identification of new trees with a Diameter at breast height (DBH) > 7 cm
- DBH measurements according to guidelines for tropical forests
- Height measurement of every tree with Vertex 3 (Haglöf) hypsometer
- Estimation of AGB in kg per tree following Culmsee et al. 2010, dry wood density ρ=0.535, D = diameter in cm, H = height in m:

$$AGB_{est} = exp[-2.557 + 0.94 \times ln(\rho \times D^2 \times H)]$$

- Individual trees with DBH in 2015 < DBH in 2005 were discarded

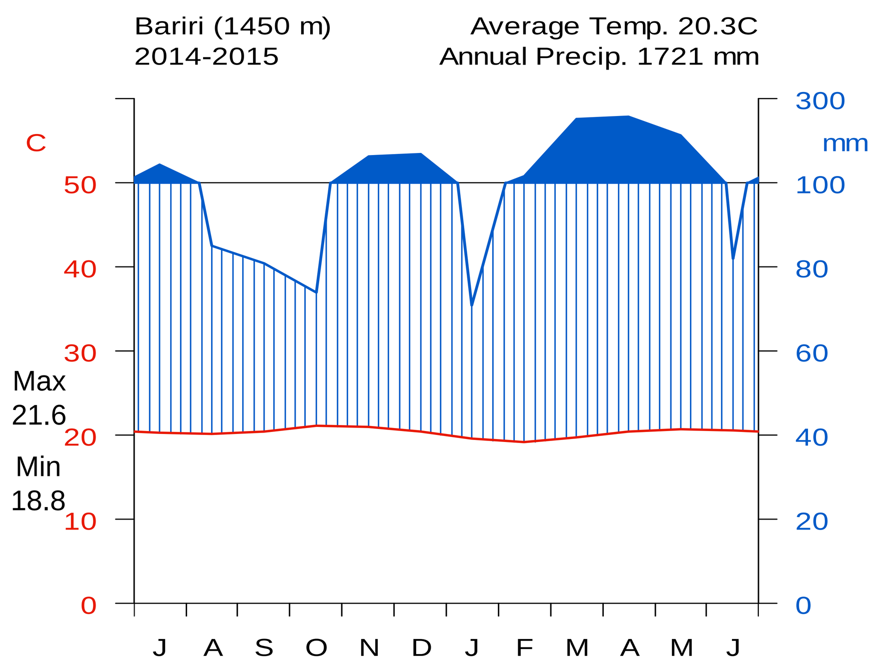

Fig. 2 Meteorological conditions

Results

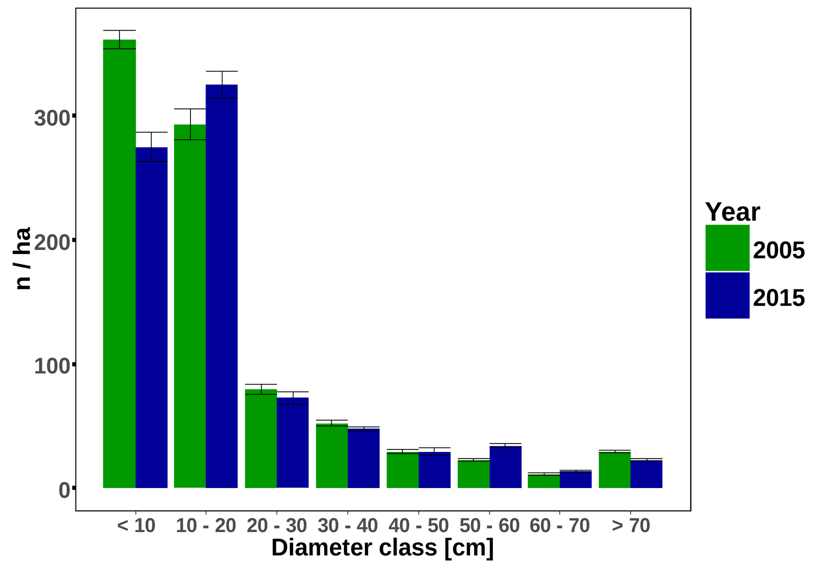

Fig. 4 Number of trees in each DBH class ha^{-1}, bars denote inter-plot variance

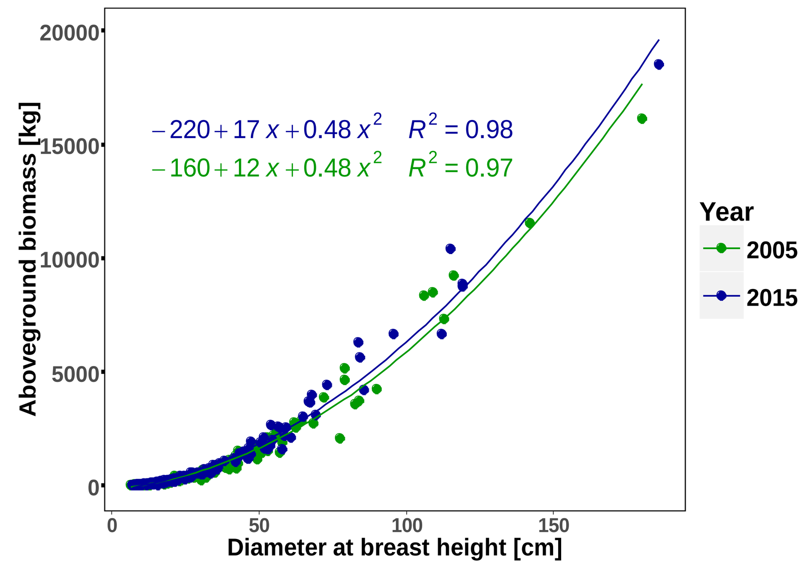

Fig. 5 Relationship between DBH and AGB [kg]

➔ **Diameter distribution:** the structure of the forest did not change dramatically (Fig. 4)

➔ **AGB / DBH relationship:** the relationship seems to be very stable over the years. Inventories in this area could therefore forego error prone height measurements and focus on DBH alone (Fig. 5)

➔ **Aboveground biomass per plot (AGB):** the variability of AGB sums per plot is high due to the influence of few large trees (Fig.6)

➔ **Carbon uptake estimate:** the forest AGB is very stable with an estimated uptake of 1.45 Mg (C) ha^{-1} y^{-1}

➔ **Total aboveground biomass:** the sample design leads to an overestimation of total AGB per hectare (not shown)

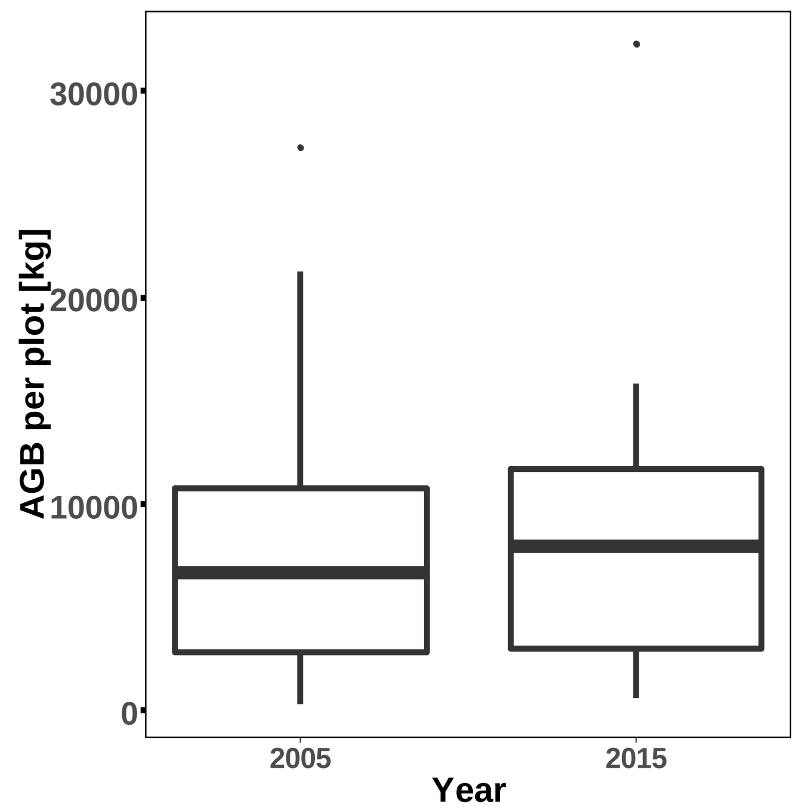

Fig. 6: Variability of AGB sums per plot

Methodological issues

- Plots were established by selecting for center trees 25m apart, as close as possible to a North-South transect (Fig. 3)
- Measurements in 2005 seem to overestimate DBH
- Height measurements in closed forests often difficult
- Sample size relatively small, few large trees dominant
- Inventory did not capture Carbon allocation in non woody biomass and rhizosphere

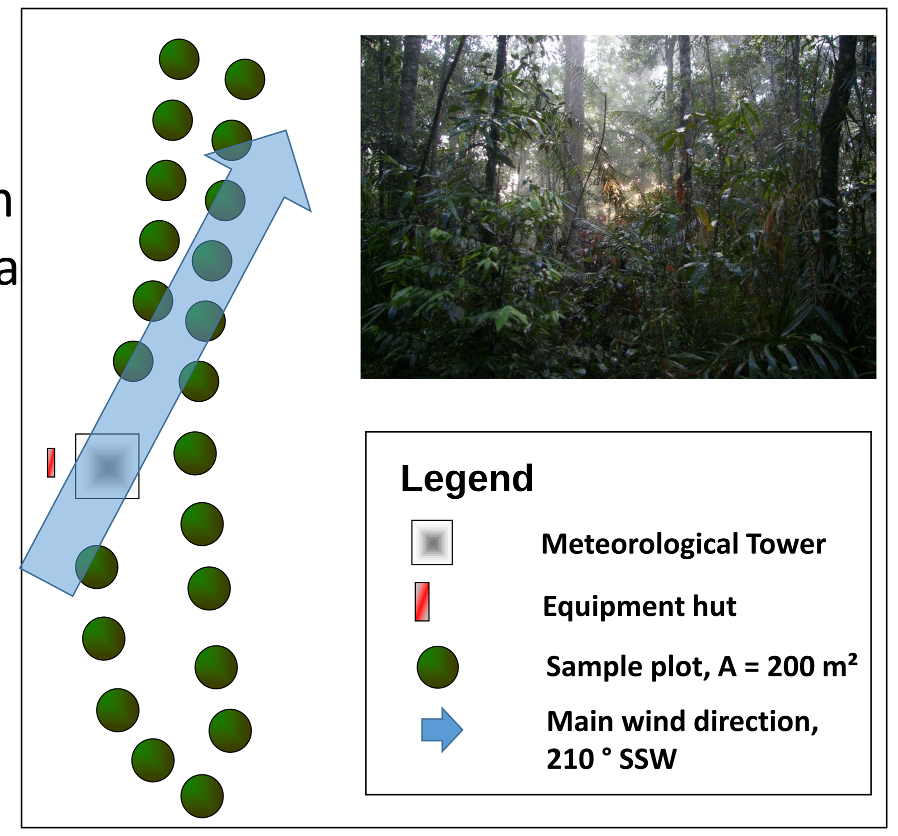

Fig. 3: Layout of sample plots, (distance between consecutive plots is 25m) and an impression of the forest

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