Allometry

Conférence internationale sur les changements
d'occupation du sol et de biomasse forestière
en Afrique centrale

Libreville, Gabon, 20-21 mars 2014

Projet de renforcement des capacités institutionnelles en matière de REDD+
pour la gestion durable des forêts dans le Bassin du Congo
Institut de Recherches en Écologie Tropicale
Programme UN-REDD / FAO

Overview

- Matieu Henry (FAO): Status of allometric equation on Globallometree
  - Are allometric equations accurate and precise enough to reliably estimate landscape-level forest C stocks?
- Vivien Rossi/Nicolas Picard (CIRAD): How do errors propagate from allometric equations to landscape-level estimates of forest biomass?
- Alfred Ngomanda (IRET):Should one use a local equation (unbiased but based on a small sample) or a pantropical equation (based on a large sample but possibly biased locally)?

Status of allometric equation on Globallometree

Forests produces several services to our societies such as:

Estimated using tree/ stand allometric equations

Model-selection error may introduce 20 to 40% uncertainty (Melson 2010, Ngomanda et al. 2014)

It is important to optimize the phase of field measurements

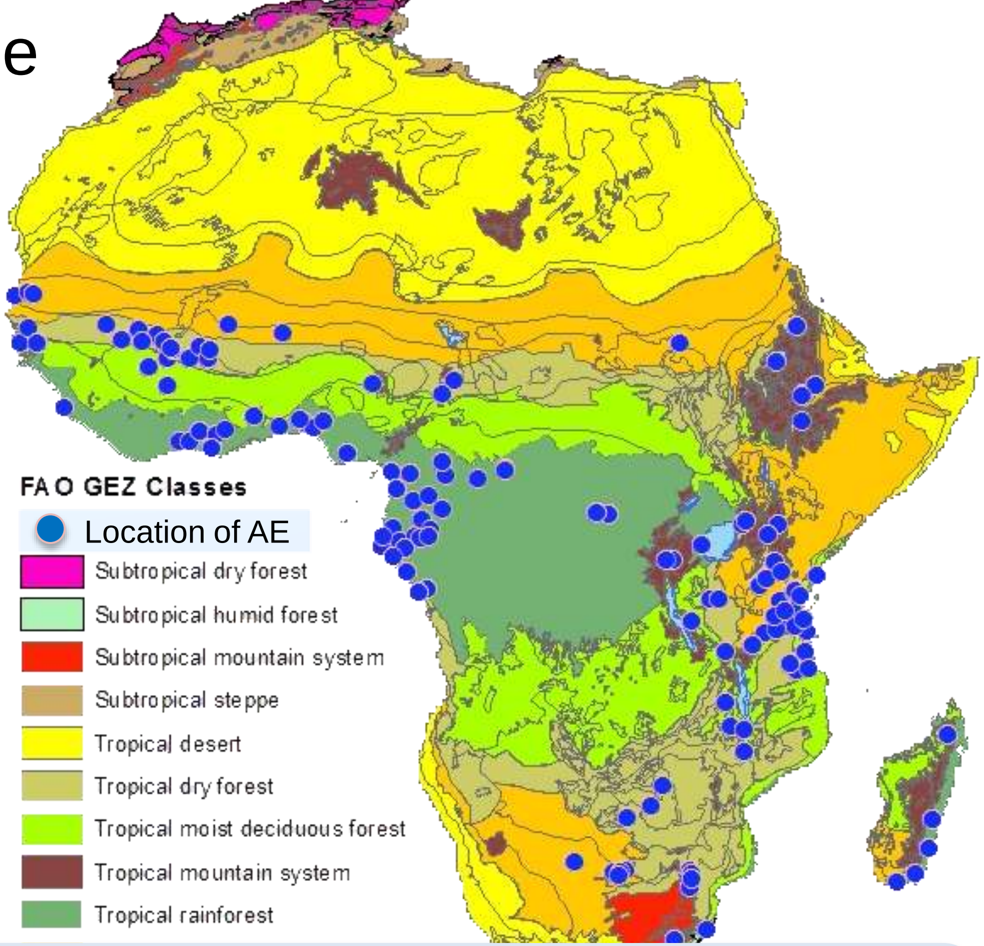
Development of tree allometric equations is very costly

Status of AE on Globallometree

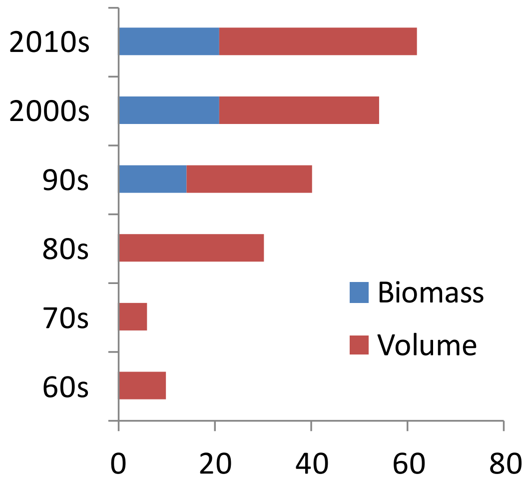
- Total AE: 5520
- Oldest equations for biomass: 1957
- AE for tropical rainforest (22%)

Status of AE in Africa

- 22% of AE are located in Africa
- No equations on biomass in the 70-80's
- No AE for Subtropical steppe



Status of AE in Central Africa



- 1 country use AE to report to FRA:
>underestimation of 30% of the stocks using default values
- AE from 27 studies
- 24% of AE focus on biomass (15 AE for total AGB)
- Biomass AE in 4 countries (1% of total AE)
- Average sample size: volume: 121, biomass:48

- Expected total tree harvested: 3075 +138+101 (3314)
- 86 species considered , no AE for Tropical moist deciduous forest

Basic IPCC equation to assess GHG emission estimates

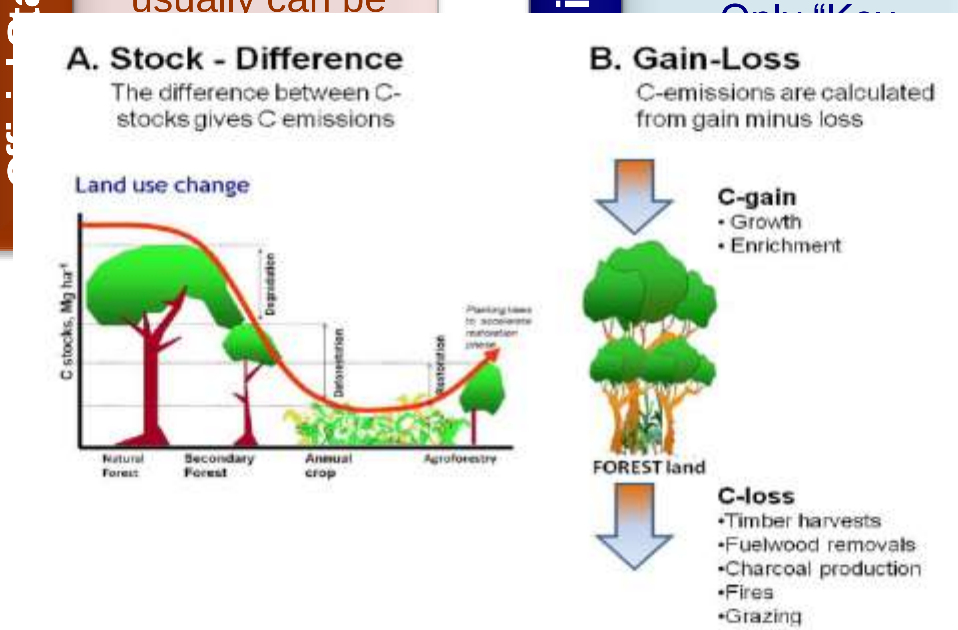
Emission Estimate = **Activity Data** X **Emission Factor**

Emission Estimates

"Key Categories" (usually ~10-15 Sources) account for over 95% of a countries emissions, focus resources on these

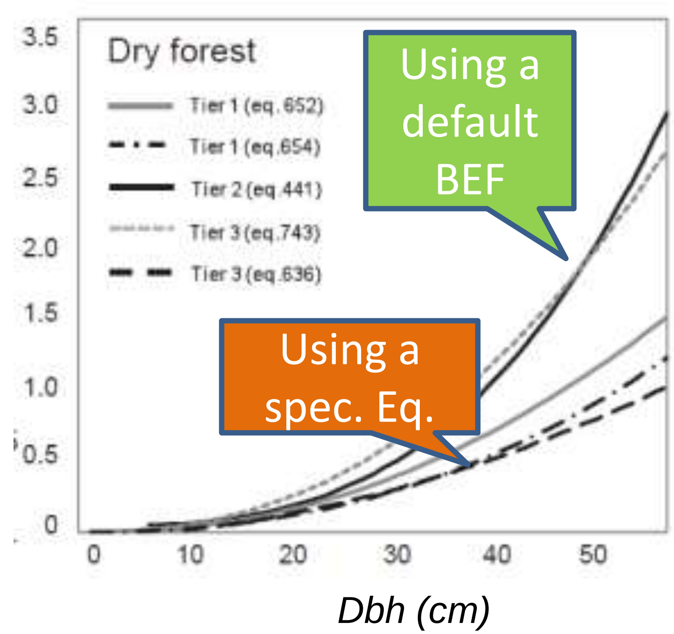
Activity Data usually can be

Most sources can use defaults from IPCC Guidelines–

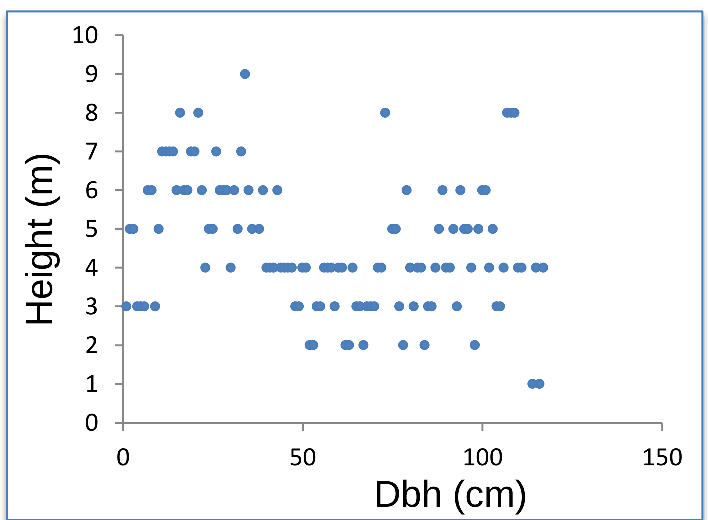


Applicability of existing equations face several constraints

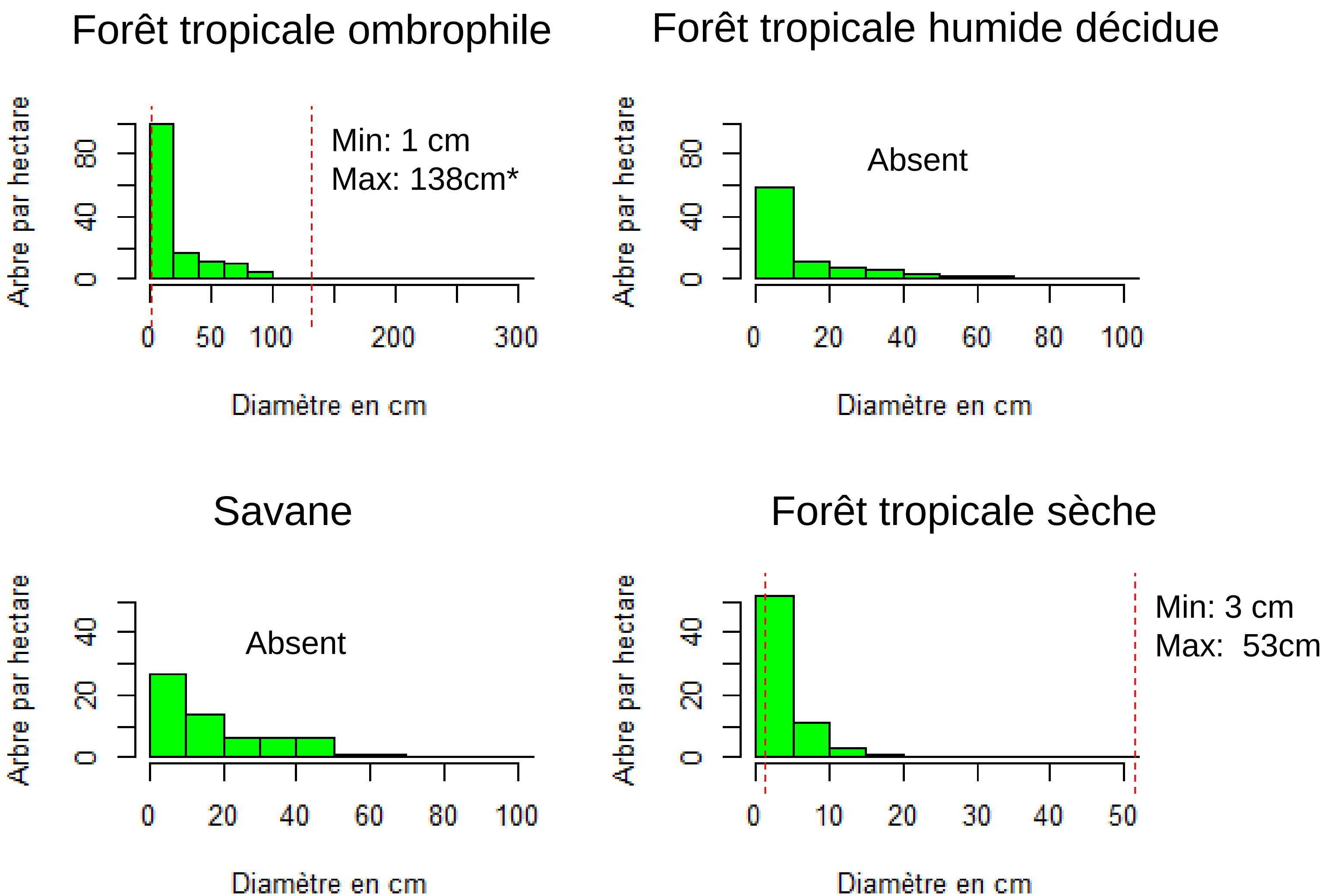
- BEF are rare and often not adapted;
- Interval of validity limits the us of equations (only 26 trees with Dbh>100cm measured in CA)
- Few equations for total aboveground biomass;
- For few tree species, there is no clear relationship between Dbh and other parameters;
- About 20% of tree species not identified;
- Often, measured tree variables during field inventories do not match with AE input variables;
- Inconsistent methods to measure tree characteristics (no consensus);
- Often, inaccurate documentation;
- Are the considered tree species representative ?
- Raw data are rarely accessible.



Henry et al. (2010)



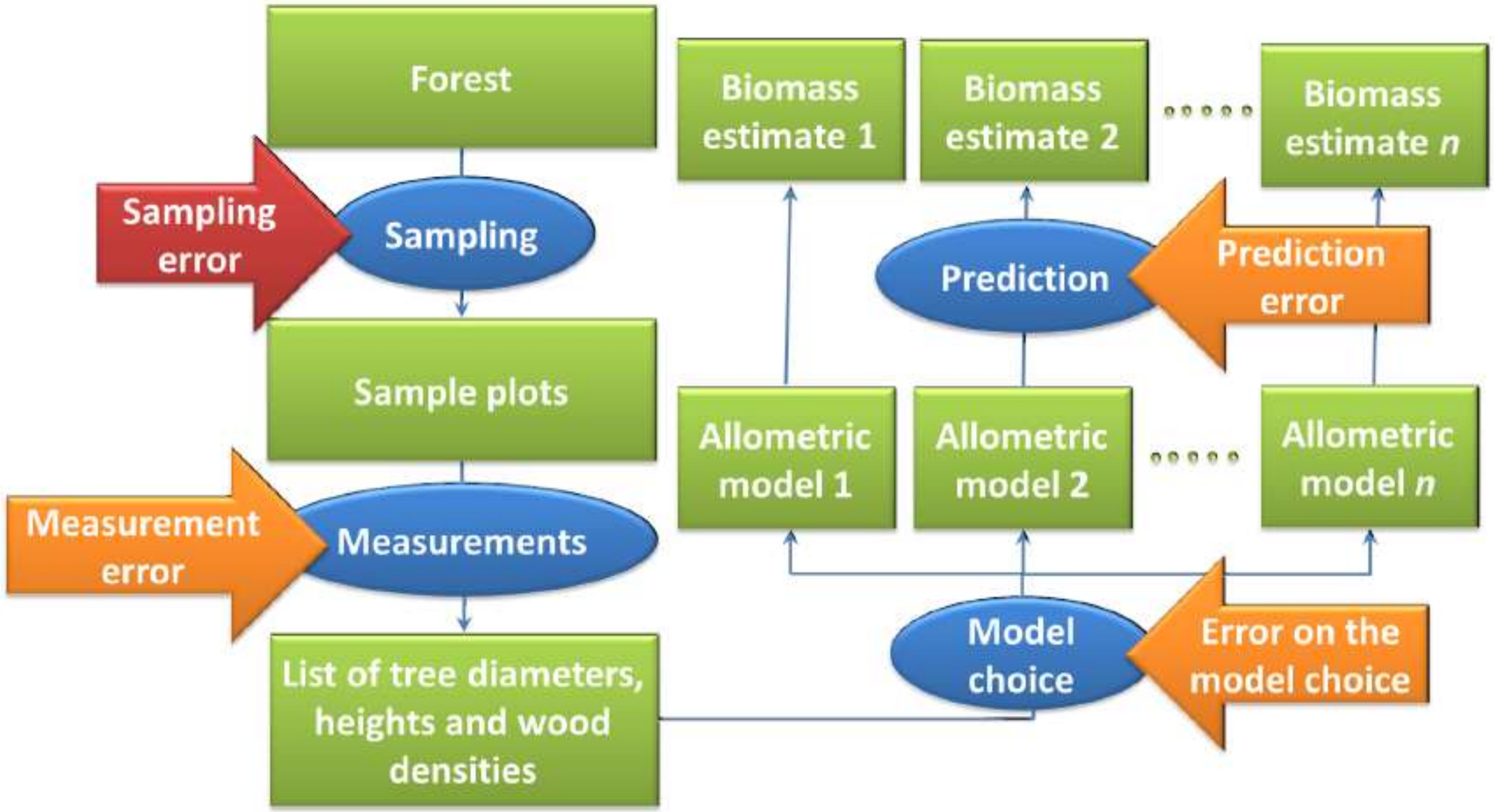
Applicability of regional allometric equations in the context of a national forest inventory



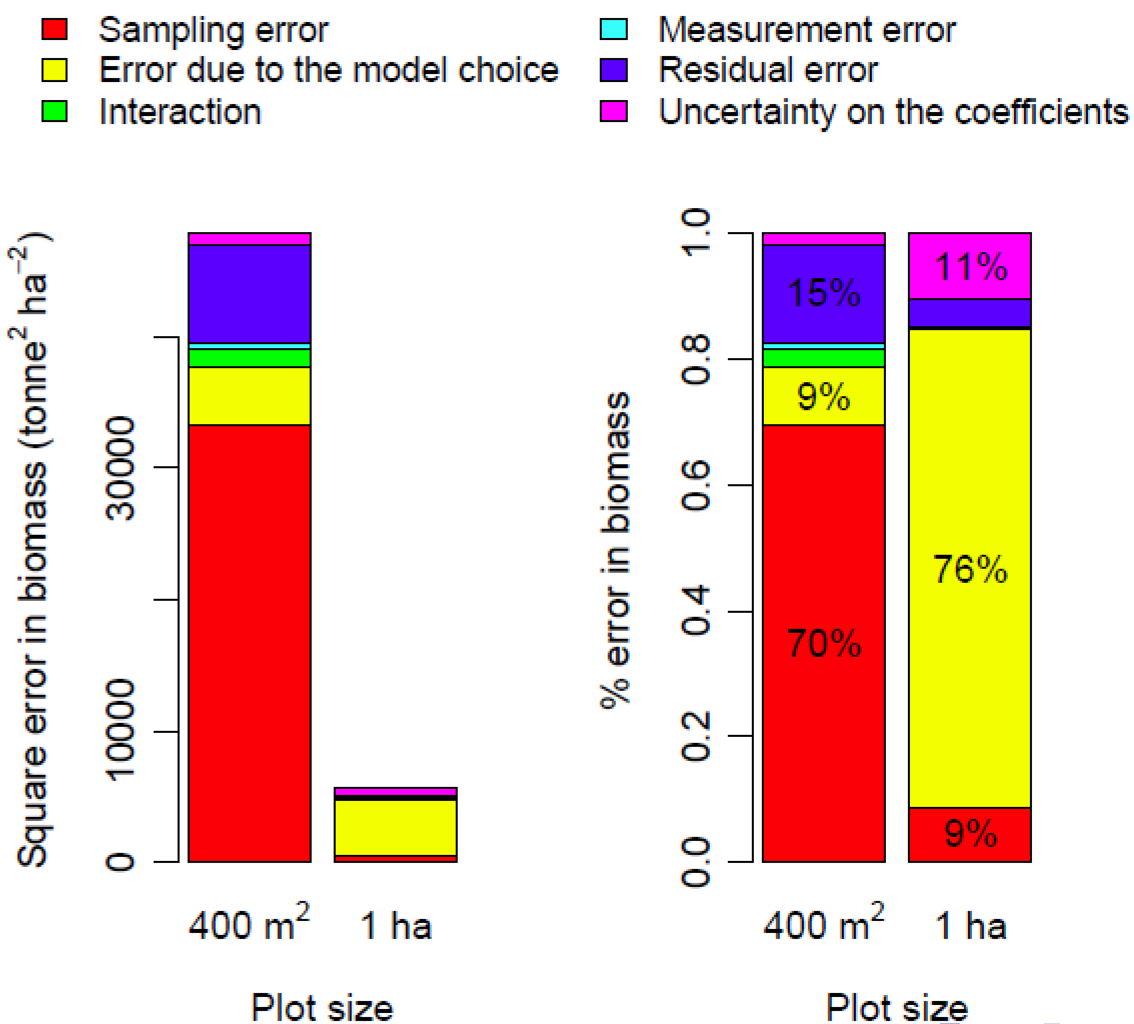
Availability of tree AE in function of forest types and diameter classes

How do errors propagate from allometric equations to landscape-level estimates of forest biomass?

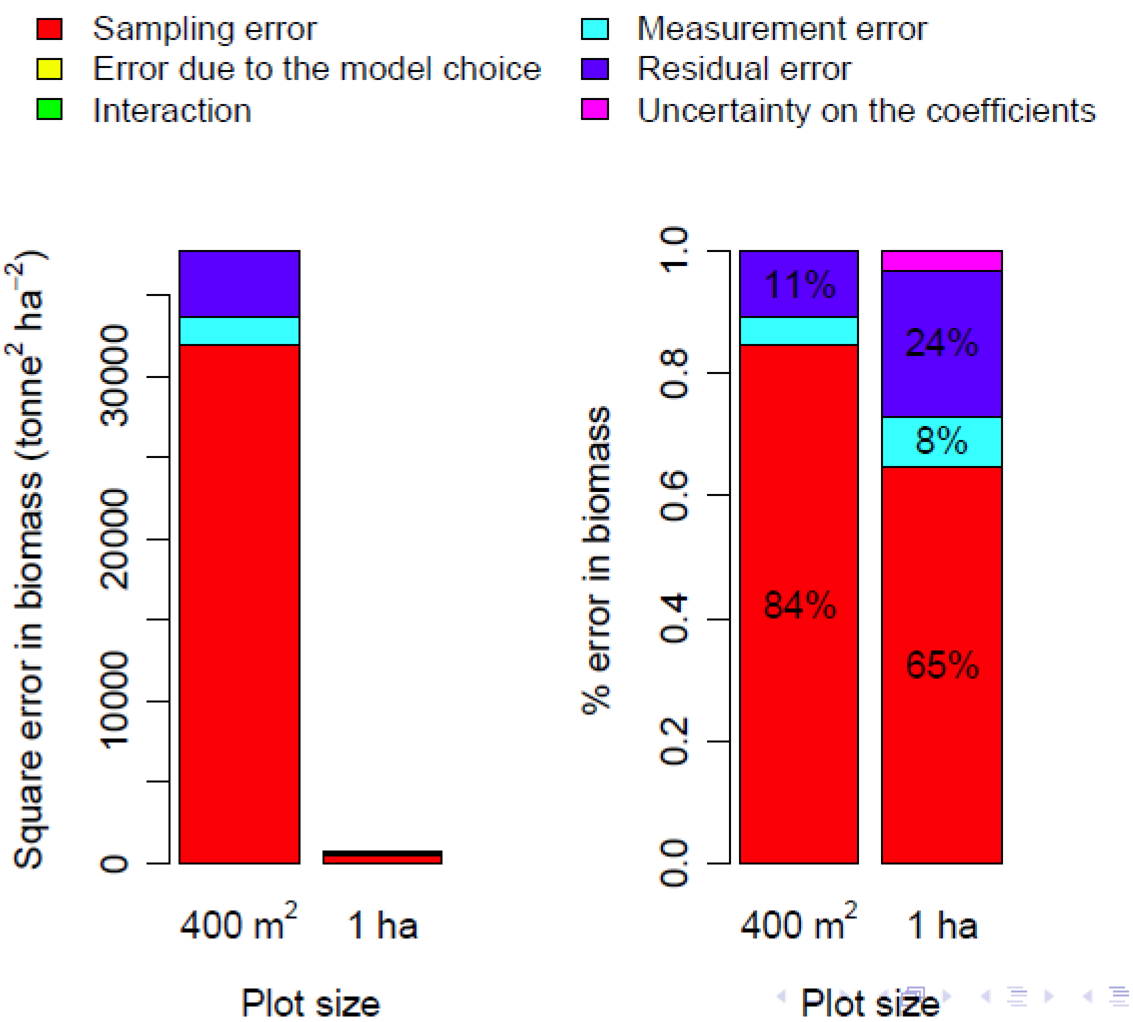
Chain of propagation of errors



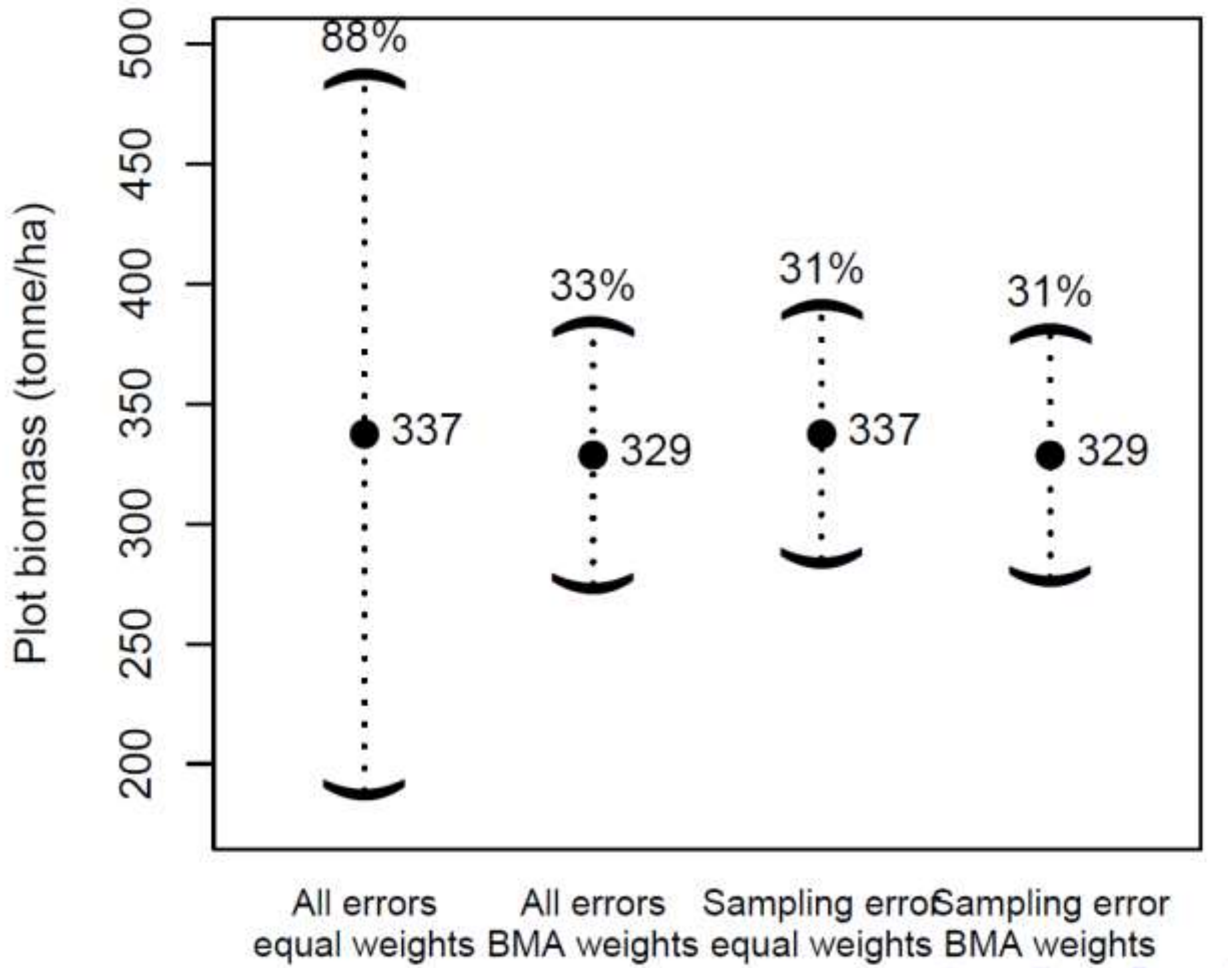
Contribution of the different sources to the total error
All allometric equations are equally likely



Contribution of the different sources to the total error One allometric equation is more likely than the others (according to BMA)



Estimate of the plot-level biomass



Which source of error should be addressed at first?

1. Error due to the model choice
   ☞ Increase the number of study sites
2. Error due to the uncertainty on the model coefficients
   ☞ Increase the sample size at each site
3. Sampling error
4. Residual error of the models
   ☞ introduce additional predictors in the allometric equation

Should we use a local or a pantropical equation to estimate biomass of Central African rainforests?

Oecologia (2005) 145: 87–99
DOI 10.1007/s00442-005-0100-x

ECOSYSTEM ECOLOGY

J. Chave · C. Andalo · S. Brown · M. A. Cairns
J. Q. Chambers · D. Eamus · H. Fölster · F. Fromard
N. Higuchi · T. Kira · J.-P. Lescure · B. W. Nelson
H. Ogawa · H. Puig · B. Riéra · T. Yamakura

Tree allometry and improved estimation of carbon stocks and balance in tropical forests

Model	Forest type	α	β_1	β_2	β_3	df	RSE	r^2	AIC
$\ln(AGB) = \alpha + \beta_1 \ln(D) + \beta_2 \ln(H) + \beta_3 \ln(\rho)$									
I.1	Dry	−2.680	1.805	1.038	0.377	312			
	Moist	−2.994	2.135	0.824	0.809	1344	0.302	0.996	818
	Wet	−2.408	2.040	0.659	0.746	139			
I.2	All types	−2.801	2.115	0.780	0.809	1,804	0.316	0.969	971
$\ln(AGB) = \alpha + \beta_2 \ln(D^2 H\rho)$									
I.3	Dry	−2.235	–	0.916	–	314			
	Moist	−3.080	–	1.007	–	1,346	0.311	0.996	913
	Wet	−2.605	–	0.940	–	141			
I.4	All types	−2.922	–	0.990	–	1,806	0.323	0.967	1,050
$\ln(AGB) = \alpha + \ln(D^2 H\rho)$									
I.5	Dry	−2.843	–	–	–	316			
	Moist	−3.027	–	–	–	1,349	0.316	0.989	972
	Wet	−3.024	–	–	–	143			
I.6	All types	−2.994	–	–	–	1,808	0.324	–	1,053

Parameters α, β_1, β_2, and β_3 are the model's fitted parameters. The best-fit parameters are reported for each model, together with the degrees of freedom (df), residual standard error (RSE), squared coefficient of regression, and Akaike Information Criterion (AIC)

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Tree allometry and improved estimation of carbon stocks and balance in tropical forests

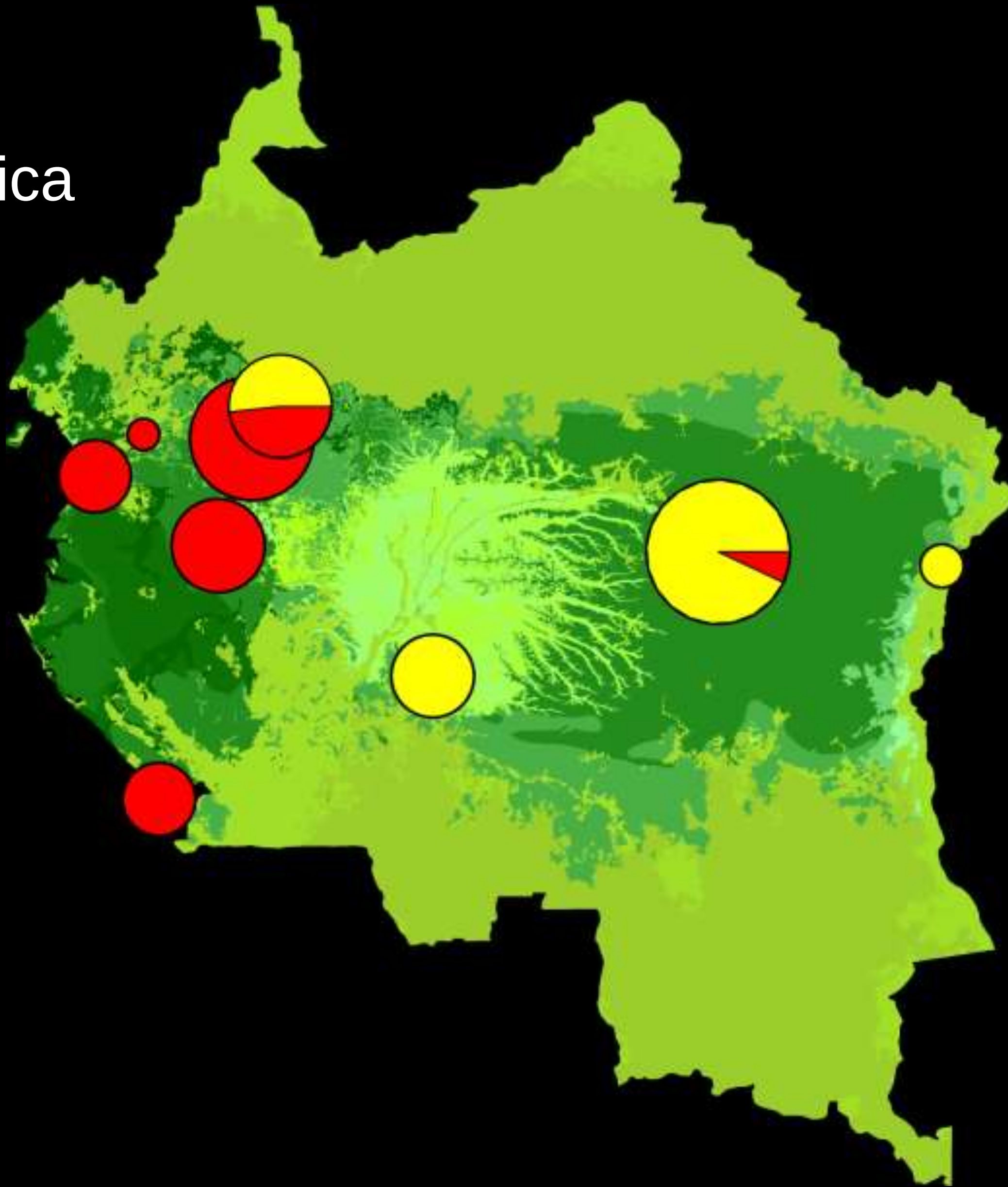
Fig. 1 Location of the study sites. All of the experiments were carried out in the Neotropics and in South-East Asia or Oceania. Notice the absence of study sites in Africa

Henry et al., 2010

Vieilledent et al., 2012

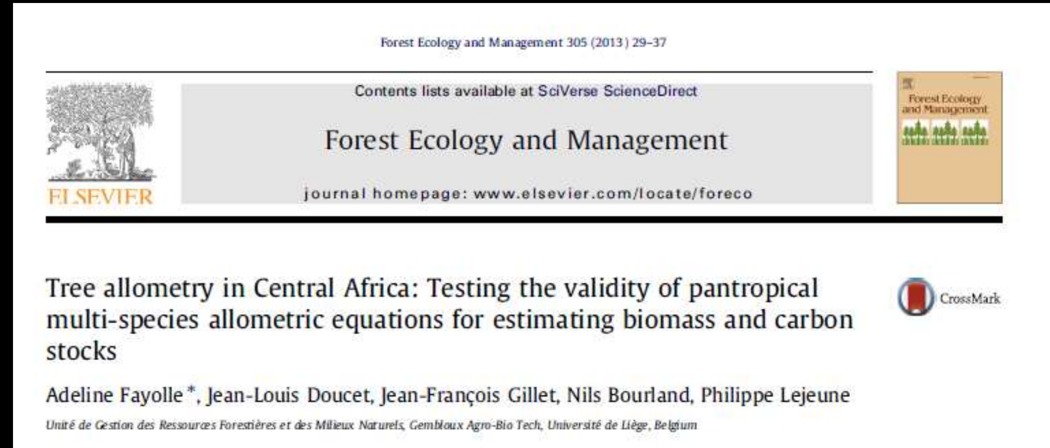
Existing allometric equations in central Africa

- 5 studies in central Africa published since 2010
- 804 trees measured



- **South-eastern Cameroon (Fayolle et al., 2013):**
  - Moist climate, accordingly with Chave et al. (2005);
  - 138 measured trees (dbh range: 5.30 – 192.5 cm)
  - Semi-deciduous forest;

- **North-eastern Gabon (Ngomanda et al., 2014)**
  - Moist climate, accordingly with Chave et al. (2005);
  - 101 measured trees (dbh range: 11.8 – 109.4 cm)
  - Transition between evergreen and semi-deciduous forest


Forest Ecology and Management 305 (2013) 29–37
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Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco
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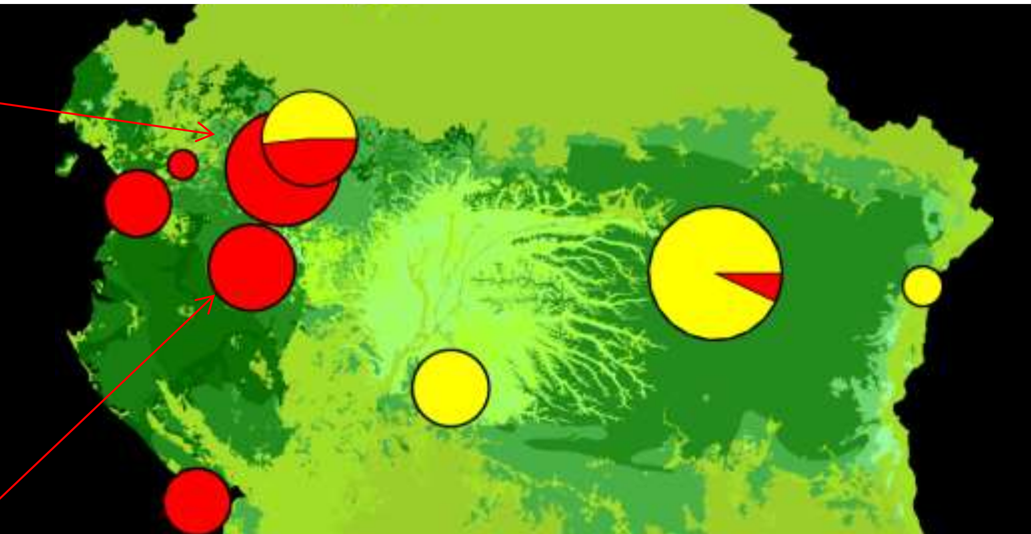
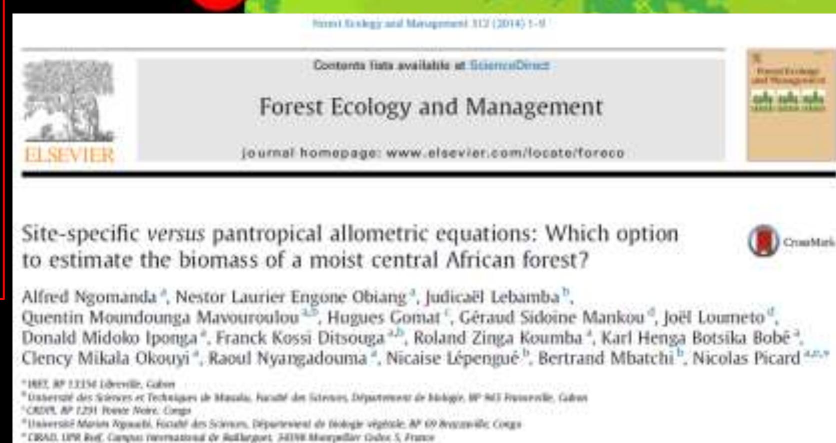
Tree allometry in Central Africa: Testing the validity of pantropical multi-species allometric equations for estimating biomass and carbon stocks

Adeline Fayolle *, Jean-Louis Doucet, Jean-François Gillet, Nils Bourland, Philippe Lejeune
Unité de Gestion des Ressources Forestières et des Milieux Naturels, Gembloux Agro-Bio Tech, Université de Liège, Belgium




Forest Ecology and Management 312 (2014) 1–9
Contents lists available at ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco
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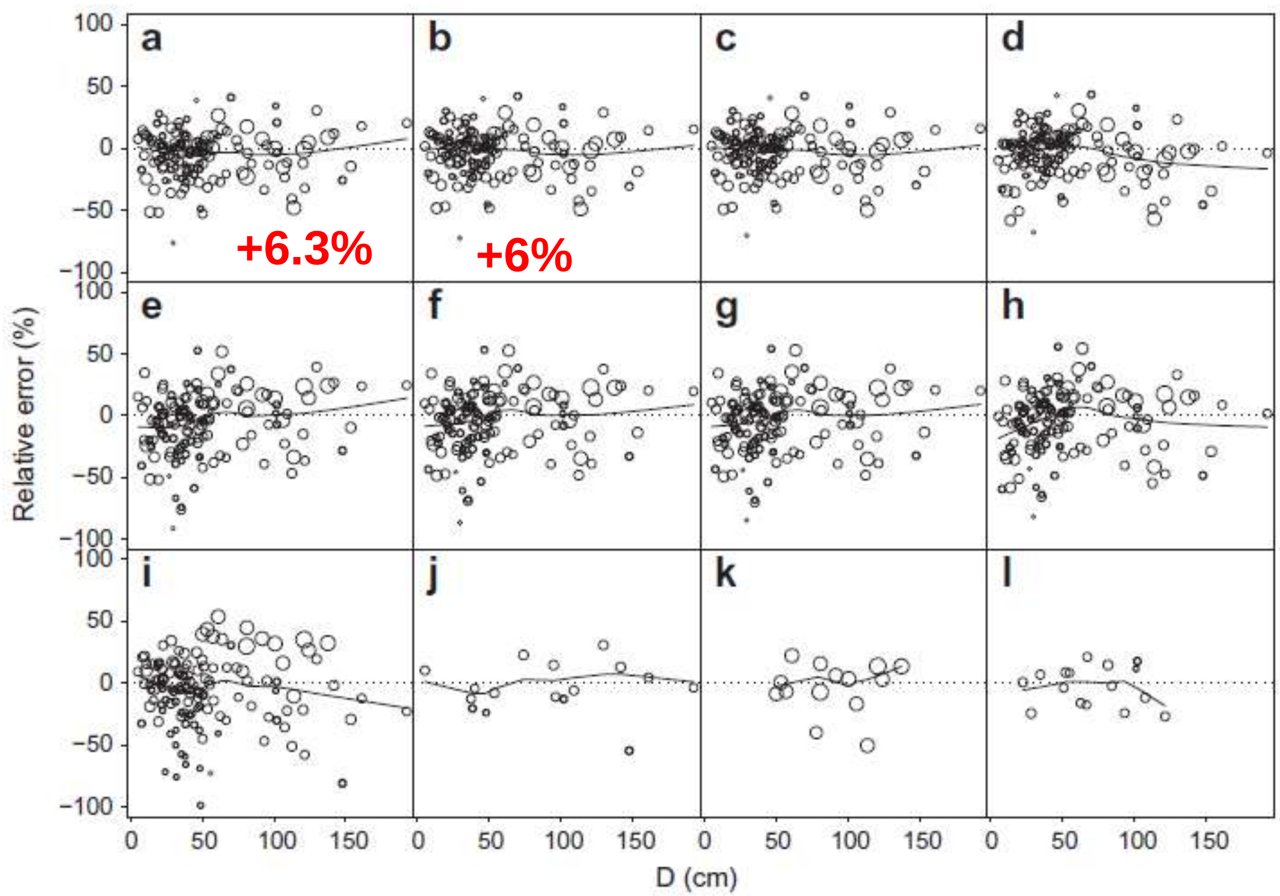
Site-specific *versus* pantropical allometric equations: Which option to estimate the biomass of a moist central African forest?

Alfred Ngomanda [a], Nestor Laurier Engone Obiang [a], Judicaël Lebamba [b], Quentin Moundounga Mavouroulou [a,b], Hugues Gomat [c], Géraud Sidoine Mankou [d], Joël Loumeto [d], Donald Midoko Iponga [a], Franck Kossi Ditsouga [a,b], Roland Zinga Koumba [a], Karl Henga Botsika Bobé [a], Clency Mikala Okouyi [a], Raoul Nyangadouma [a], Nicaise Lépengué [b], Bertrand Mbatchi [b], Nicolas Picard [a,e,*]

Predictions of ABG by local and pantropical allometric equations

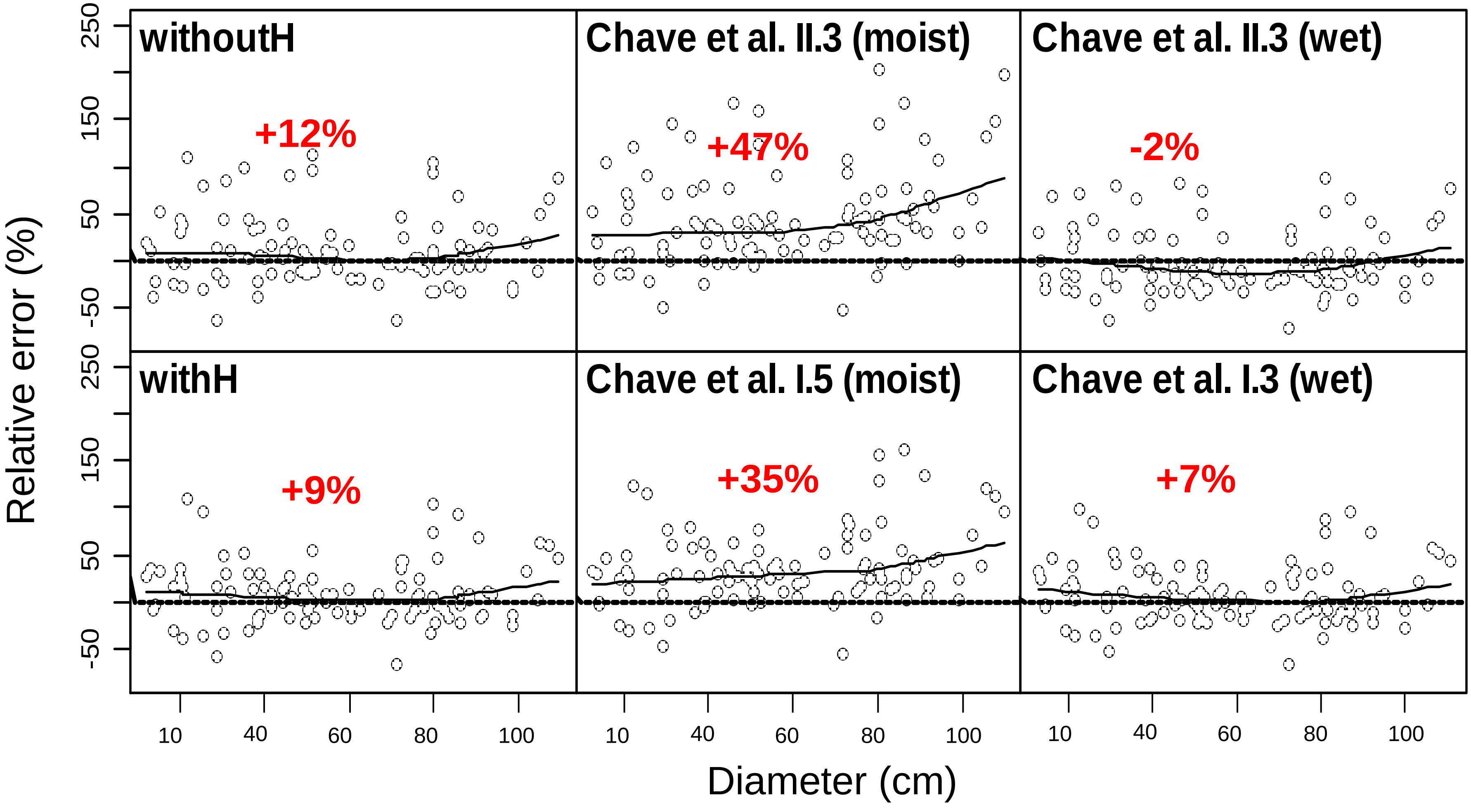
for South-eastern Cameroun (Fayolle et al., 2013)



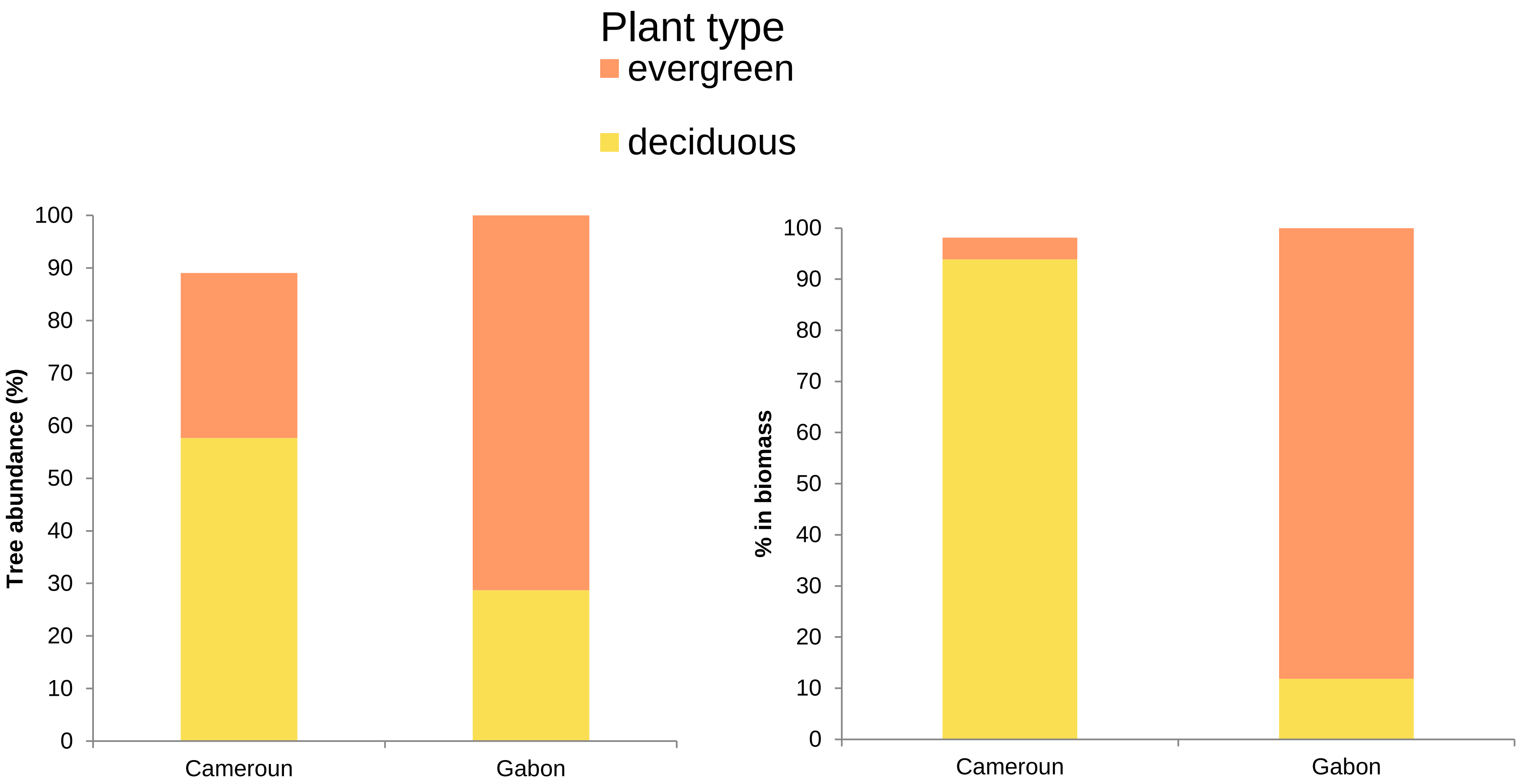
The pantropical equation for moist forests (figure a) is valid in the south-eastern Cameroon (figure b= local model)

Prediction of ABG by local and pantropical allometric equations

The pantropical equation for moist forests over-estimate of about 40% the biomass of north-eastern Gabon (Ngomanda et al., 2014)



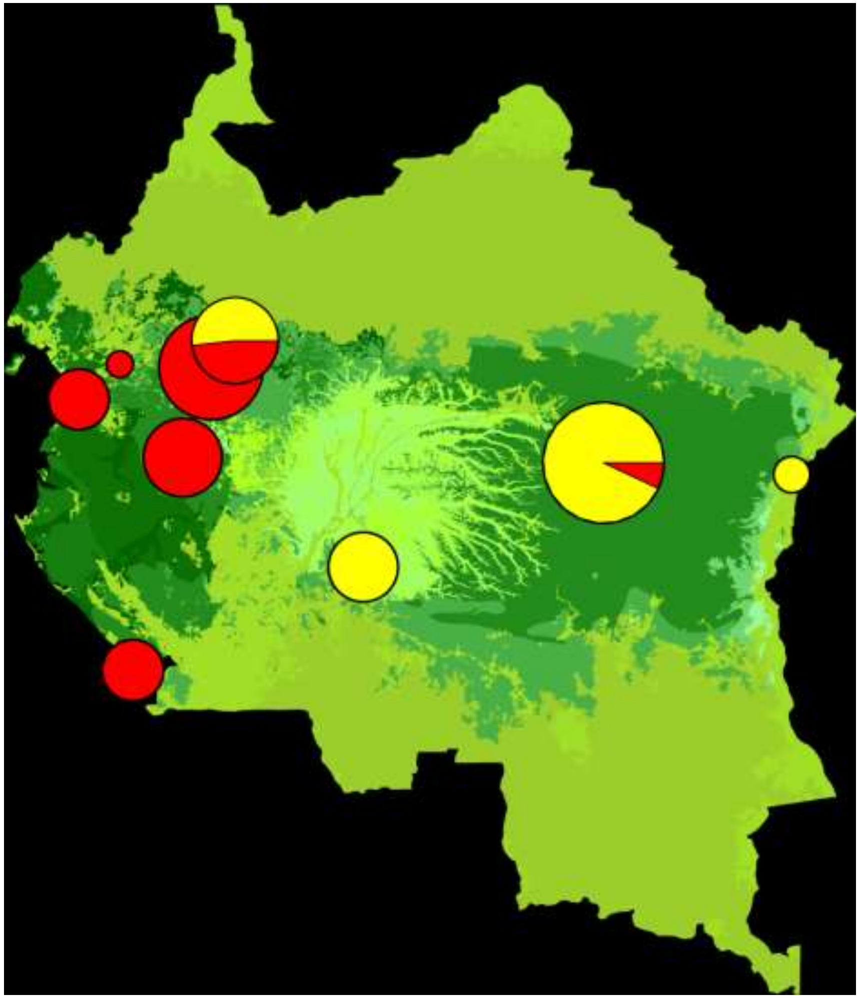
Contribution of different plant types (based on leaf phenology) to the biomass



Difference in biomass allometry between south-eastern Cameroon and north-eastern Gabon is in agreement with vegetation types

Is it necessary to measure additional tree biomasses?

- Provide accurate and precise allometric equations to reliably estimate landscape-level forest C stocks
- **Vegetation zones** rather than **climatic zones** should be used as a stratification factor for sampling of additional tree biomass and build of regional allometric equation



The importance of diameter-height relationships

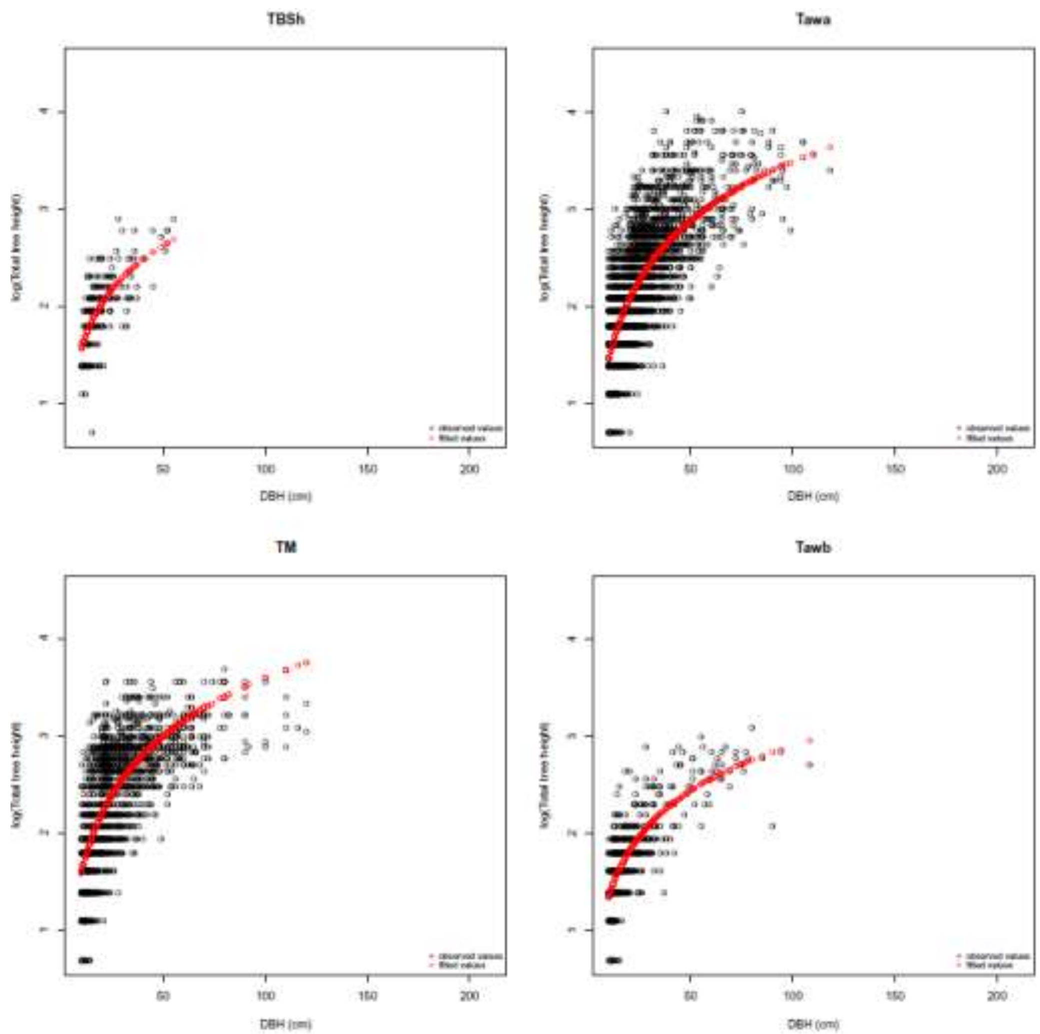
Current available Dbh/Height relationship

Biogeosciences, 9, 3381–3403, 2012
www.biogeosciences.net/9/3381/2012/
doi:10.5194/bg-9-3381-2012

Biogeosciences

Tree height integrated into pantropical forest biomass estimates

T. R. Feldpausch[1], J. Lloyd[1,2], S. L. Lewis[1,3], R. J. W. Brienen[1], M. Gloor[1], A. Monteagudo Mendoza[4],
G. Lopez-Gonzalez[1], L. Banin[1,5], K. Abu Salim[6], K. Affum-Baffoe[7], M. Alexiades[8], S. Almeida[9,†], I. Amaral[10],



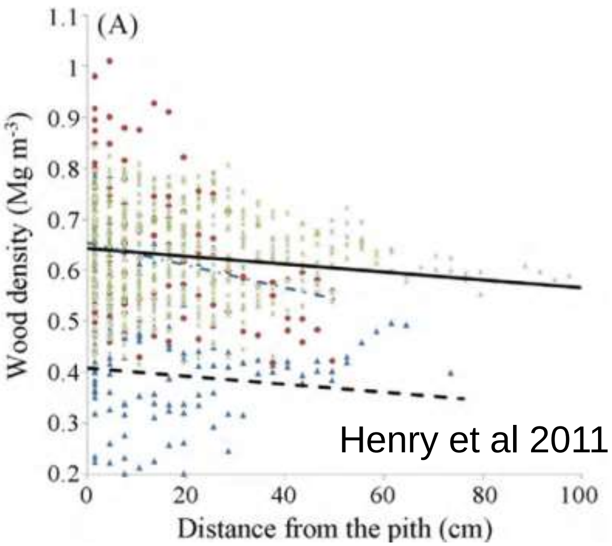
But does not consider ecological zones/ forest types

& overestimate tree height for big trees

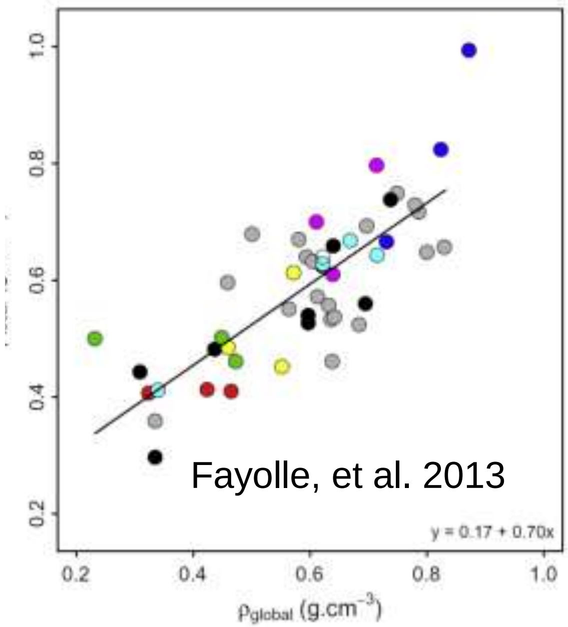
Further improvement is necessary

The importance of wood density

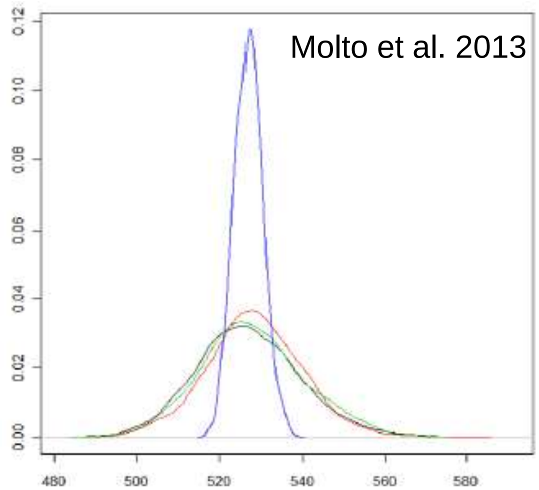
Variation within trees



Comparison between local and global values



Probability distribution of biomass in one plot in Paracou, French Guyana (T/ha)



There is a lot of variability of wood density values that would result from several factors (history, physiology, ontogeny, etc.)

When assessing biomass at plot or landscape scale, knowing the wood density of each tree would not result in significant reduction of the error.

Black : all uncertainty sources considered
Green: without WD uncertainty
Red: without height uncertainty
Blue: without model uncertainty

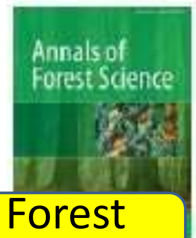
Towards an improvement of forest biomass assessment

CAPACITY BUILDING & COUNTRY SUPPORT

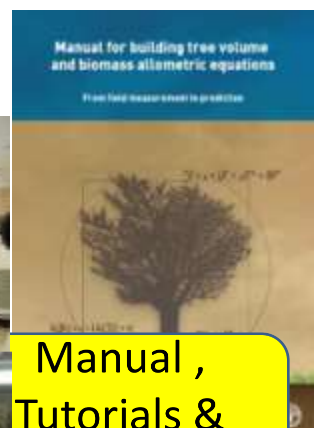
NEW METHODS AND TECHNOLOGIES
SCIENTIFIC RESEARCH

Trainings

Field measurements

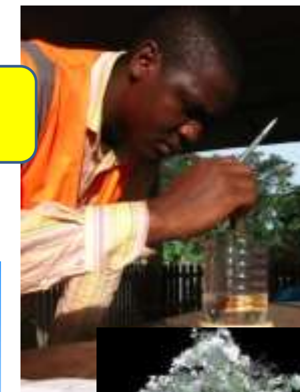


Forest science



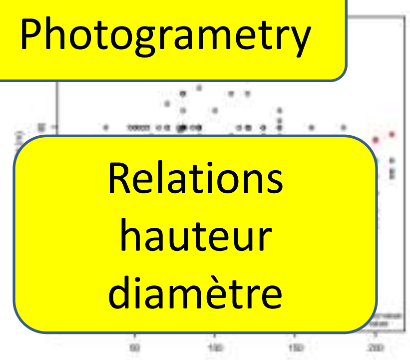
Manual , Tutorials & software

Wood density



Photogrammetry

Ground LiDAR



Relations hauteur diamètre

References

Fayolle A, J-L Doucet, J-F Gillet, N Bourland, P Lejeune (2013) Tree allometry in Central Africa: Testing the validity of pantropical multi-species allometric equations for estimating biomass and carbon stocks. Forest Ecology and Management 305:29-37.
Feldpausch TR, et al. (2012) Tree height integrated into pantropical forest biomass estimates. Biogeosciences 9:3381-3403. doi: 10.5194/bg-9-3381-2012
Henry M, A Besnard, WA Asante, J Eshun, S Adu-Bredu, R Valentini, M Bernoux, L Saint-André (2010) Wood density, phytomass variations within and among trees, and allometric equations in a tropical rainforest of Africa Forest Ecology and Management 260:1375–1388
Henry M, A Bombelli, C Trotta, A Alessandrini, L Birigazzi, G Sola, G Vieilledent, P Santenoise, F Longuetaud, R Valentini, N Picard, L Saint-André (2013) GlobAllomeTree: international platform for tree allometric equations to support volume, biomass and carbon assessment. iForest - Biogeosciences and Forestry 0:326-330. doi: 10.3832ifor0901-006
Henry M, N Picard, R Manlay, R Valentini, M Bernoux, L Saint-André (2011) Estimating tree biomass of sub-Saharan African forests: a review of available allometric equations. Silva Fennica Monographs 45:1-94
IPCC (2003) Good Practice Guidance for Land Use, Land-Use Change and Forestry, IPCC National Greenhouse Gas Inventories Programme,, Kanagawa, Japan
IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Melson SL, ME Harmon, JS Fried, JB Domingo (2011) Estimates of live-tree carbon stores in the Pacific Northwest are sensitive to model selection. Carbon Balance and Management 6
Ngomanda A, NL Engone Obiang, J Lebamba, Q Moundounga Mavouroulou, H Gomat, GS Mankou, J Loumeto, D Midoko Iponga, F Kossi Ditsouga, R Zinga Koumba, KH Botsika Bobé, C Mikala Okouyi, R Nyangadouma, N Lépengué, B Mbatchi, N Picard (2014) Site-specific versus pantropical allometric equations: Which option to estimate the biomass of a moist central African forest? Forest Ecology and Management 312:1-9. doi: http://dx.doi.org/10.1016/j.foreco.2013.10.029
Picard N, L Saint André, M Henry (2012) Manual for building tree allometric equations: from the field to the prediction, Food and Agriculture Organization of the United Nations, Centre de Coopération Internationale en Recherche Agronomique
Vieilledent G, AS Vaudry R, Rakotonarivo OS, Randrianasolo HZ, Razafindrabe HN, Rakotoarivony CB, Ebeling