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Supplementary Information S1. Consequences for biomass estimates

Using the largest set of secondary plot data at hand (1478 plots) in combination with the most accurate allometric equation available, we show that AGB of 20 year old secondary forest varied dramatically across sites (from ca 20 to 225 Mg/ha, with an average of 121.8 Mg/ha), with potentially large consequences for carbon estimates. Carbon storage estimates of tropical forest are frequently based on the total area of forest multiplied by average carbon density values[1] or on remote sensing estimates of forest cover, height, and height-carbon density equations[2,3]. For example, according to the latest estimates[1], the total cover of natural forests in tropical Latin American countries (from Mexico through Bolivia/Brazil) is 8.25 million km^2. FAO[1] assumes that these natural forests contain an average above-and belowground biomass (ABGB) of 150 Mg/ha in Central America and 247 Mg/ha in South America. As a result, the estimated amount of biomass stored in forests in Latin American tropical countries is 196.1 Gg.

However, as much as 1.70 million km^2 of the total forest area (20.6%) is naturally regenerating forest that are neither old-growth nor plantations. FAO assumes that these regenerating forests contain a considerable biomass. However, assuming that all regenerating forests are 20 year old with an average AGB of 121.8 Mg/ha (this study) and a belowground root: aboveground shoot ratio of 0.24 (Central America) or 0.2 (South America, FAO 2010), this would correspond to an ABGB of 151 and 126 Mg/ha respectively. When taking the area and ABGB of regenerating secondary forest into account, then the total forest biomass in natural forests (old-growth and secondary) is 183.2 Gg. Hence, 12.9 Gg, or 6.6% less biomass is stored in natural forests compared to the FAO calculations. When an average age of 10 years is assumed for secondary forests, which is a more likely scenario because many secondary forests are slashed soon again[4], and using the average AGB for 10-year old secondary forests of 70.6 Mg/ha, then 172.7 Gg, or 23.5 Gg (12.0%) less biomass would be stored in natural forests compared to the FAO calculations. This improved estimate of the carbon storage potential of secondary forest can be further improved by 1) more detailed remote-sensing estimates of the areal extent of secondary forests, 2) maps of forest age, 3) equations relating biomass recovery to forest age and environment (e.g., Figs 1,2) and 4) including robust data on belowground carbon storage.

1 FAO. Global Forest Resources Assessment 2010. (FAO Forestry Paper 163. Food and Agriculture Organization of the United Nations, Rome, 2010).
2 Saatchi, S. S. *et al.* Benchmark map of forest carbon stocks in tropical regions across three continents. *Proceedings of the National Academy of Sciences of the United States of America* **108**, 9899-9904, doi:10.1073/pnas.1019576108 (2011).
3 Baccini, A. *et al.* Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. *Nat. Clim. Chang.* **2**, 182-185, doi:10.1038/nclimate1354 (2012).
4 van Breugel, M. *et al.* Succession of ephemeral secondary forests and their limited role for the conservation of floristic diversity in a human-modified tropical landscape. *Plos One* **8**, doi:10.1371/journal.pone.0082433 (2013).

Supplementary Information S1 Table 1. Consequences for different biomass estimates of secondary forests for the amount of biomass stored in natural forest in tropical Central America and South America. The columns "forest area" indicate the area in natural forests (old-growth and secondary forests) according to the FAO[1]. The columns "biomass density NF" indicates how much above- and belowground biomass (ABGB) there is per ha in old-growth forest (OGF) according to FAO, and in secondary forest (SF) of 20 and 10 years according to our new estimates. When the forest area is multiplied by the corresponding biomass density, total forest biomass per forest type is given for old-growth forest (OGF, according to FAO data), secondary forest (SF_{FAO}, according to FAO data), if all secondary forests would be 20 years (SF_{20}, our new estimate), or if all secondary forests would be 10 years (SF_{10}, our new estimate). The last columns provide the total forest biomass of natural forests, when the biomass of old-growth and secondary forests are summed.

Region	Forest area			Biomass density NF			Forest biomass per forest type				Forest biomass natural forests		
	Old-growth forest (km^2)	Secondary forest (km^2)	Natural forest (km^2)	ABGB OGF (Mg/ha)	ABGB SF_{20} (Mg/ha)	ABGB SF_{10} (Mg/ha)	OGF (Gg)	SF_{FAO} (Gg)	SF_{20} (Gg)	SF_{10} (Gg)	OGF+SF_{FAO} (Gg)	OGF+SF_{20} (Gg)	OGF+SF_{10} (Gg)
Central America	387,920	417,220	805,140	149.5	151.0	87.5	5.80	6.24	6.30	3.65	12.04	12.10	9.45
South America	6,157,440	1,283,590	7,441,030	247.4	146.2	84.7	152.34	31.76	18.76	10.87	184.09	171.10	163.21
Total	6,545,360	1,700,810	8,246,170				158.13	37.99	25.06	14.53	196.13	183.20	172.66

Supplementary Information S2. Evaluation of aboveground biomass build-up using different allometric equations.

Aboveground tree biomass estimates vary depending on the allometric equation used. Live aboveground biomass was therefore calculated for each tree using three (sets of) frequently used allometric equations (Supplementary Information S1 Table 1) : 1) Brown[1], 2) Chave 2005[2], and 3) Chave 2014[3]. The Brown equations are based on stem diameter only, the Chave 2005 and 2014 equations are based on a combination of stem diameter and wood density. Brown and Chave 2005 both present different equations for different forest types; dry forest (<1500 mm/yr), moist forest (1500 to 3500 [Chave] or 4000 mm/yr [Brown]) and wet forest (>3500 [Chave] or >4000 [Brown] mm/yr). Chave 2014 provides an improved allometric equation based on a larger dataset (including many secondary forest trees from wet and dry forests), and uses a correction factor *E* that corrects for site aridity. Recovery of aboveground forest biomass was modelled using a logarithmic relationship with stand age.

After 20 years, the three different equations resulted in small differences in absolute AGB estimates for dry forests, larger differences in AGB estimates for moist forest, and large differences for wet forest (Extended Data Fig. 6). AGB estimates of the Chave 2014 equation led to lower biomass estimates compared to the other two equations. For example, for moist forests, that cover the largest area of forest in the tropics, the AGB estimate of Chave 2005 is 21% higher, and of Brown 2005 is 26% higher than the new equation of Chave 2014. Henceforth we use the Chave 2014 estimates, because it is the most recent equation based on the largest dataset so far, it includes many secondary forest trees, and it is ecologically most relevant because it takes wood density and *E* into account.

Supplementary Information S2 Table 1. Allometric equations of Brown[1], Chave 2005[2] and Chave 2014[3] used to calculate above-ground biomass (AGB, in kg) of trees in different forest types. E= site-specific bioclimatic stress variable (see [3]) , ρ= wood density (in g cm^{-3}), dbh = diameter at breast height (in cm), BA = basal area. Note that we did not use the Brown wet equation because we did not include forests with rainfall > 4000 mm/yr

Reference	Forest type	Rainfall (mm)	Equation
Chave 2014	all	-	$AGB = \exp[-1.803 - 0.976 \times E + 0.976 \times \ln(\rho) + 2.673 \times \ln(dbh) - 0.0299 \times [\ln(dbh)]^2]$
Chave 2005	dry	<1500	$AGB = \rho \times \exp[-0.667 + 1.784 \times \ln(dbh) + 0.207 \times [\ln(dbh)]^2 - 0.0281 \times [\ln(dbh)]^3]$
Chave 2005	moist	1500-3500	$AGB = \rho \times \exp[-1.499 + 2.148 \times \ln(dbh) + 0.207 \times [\ln(dbh)]^2 - 0.0281 \times [\ln(dbh)]^3]$
Chave 2005	wet	>3500	$AGB = \rho \times \exp[-1.239 + 1.980 \times \ln(dbh) + 0.207 \times [\ln(dbh)]^2 - 0.0281 \times [\ln(dbh)]^3]$
Brown	dry	700-900	$AGB = 10^{(-0.535 + \log_{10}(BA))}$
Brown	dry	900-1500	$AGB = 0.2035 \times dbh^{2.3196}$
Brown	moist	1500-4000	$AGB = \exp[-2.289 + 2.649 \times \ln(dbh) - 0.021 \times [\ln(dbh)]^2]$
Brown	wet	>4000	$AGB = 21.297 - 6.953 \times dbh + 0.740 \times dbh^2$

1 Pearson, R., Walker, S. & Brown, S. Source book for land use, land-use change and forestry projects. *World Bank, Washington* (2005).
2 Chave, J. *et al.* Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* **145**, 87-99, doi:10.1007/s00442-005-0100-x (2005).
3 Chave, J. *et al.* Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology* **20**, 3177-3190, doi:10.1111/gcb.12629 (2014).