High-resolution Mapping of Forest Carbon Stocks in the Colombian Amazon

Supplementary Material

(I) Airborne LiDAR

The CAO Alpha LiDAR recorded up to four discrete laser returns per pulse, and was operated at 2000 m above ground level with 1.12-m spot spacing, 30-degree field of view, and 50-kHz pulse repetition frequency, for which the aircraft maintained a ground speed ≤ 95 knots. CAO-Alpha had a beam divergence customized to 0.56 mrad, which with these flying parameters, resulted in continuous laser coverage without gaps between laser spots on the ground. In addition, all flights were planned with 100% repeat coverage (50% overlap of each swath to each adjacent swath) and therefore LiDAR point density averaged 2 points per 1.12-m spot.

(II) Field validation

A summary of the allometric equations used, and species encountered is provided in Tables S1 and S2, respectively.

(III) Model fitting techniques

The ACD validation model (eq. 3) and H-D model (Table S1) were fit using non-linear Maximum Likelihood Analysis in R, and by incorporating a third equation parameter in the form of a non-arithmetic error term (i.e., $y = ax^b + x^k * \varepsilon$) to account for heteroscedasticity common to previously published ACD-MCH and H-D relationships. This fitting technique is analogous to fitting a linear model to log-transformed x and y data, thereby avoiding the need for log-transformation and back-transformation (Baskerville, 1972;Mascaro et al., 2011).

(IV) Additional information about the regional stratification approach

For the final regional stratification, a total of 147 Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) images were processed through CLASlite. This dataset included 72 images for 2010, 31 for 1990, 20 for 2000, and 24 for 2005. Employing a semi-automated approach to masking clouds, smoke, haze and shadows, we constructed cloud-free regional maps at 30 m resolution.

Median ACD values determined from LiDAR-scale ACD for each land-cover class are listed in Table S3. If a class in the final stratification map did not contain sufficient LiDAR coverage (e.g., less than the targeted 1% or less than 100 ha), we assigned the median ACD value of a broader class on the preceding node of the stratification decision tree (Figure 2c of main text). For example, if the high TRI stratum for a particular catchment did not have sufficient coverage, we assigned the median ACD value of the same TRI stratum for all catchments.

For the stratification approach, catchment boundaries were derived from SRTM data (Hydrology Toolbox, ArcGIS 10, ESRI Inc., USA), which resulted in additional ACD sub-stratification by more than 60 Mg C ha^{-1} in some cases. This addition – supported by a stratification approach – allowed for capturing discrete geographic changes in carbon stocks that may otherwise have been missed in the regional analyses, similar to the localized effects of terrain variation as expressed in the TRI.

(V) Regression equation used for continuous fields map of ACD

Following the results of the correlation analyses (see Methods of main text), we conducted multiple least squares regression analyses using elevation (ELEV), slope, aspect and a terrain ruggedness index (TRI) derived from NASA Shuttle Radar Topography Mission (SRTM) data, and photosynthetic vegetation coverage fraction (PV) and soil cover fraction derived from CLASlite. Through iterations of regression analyses using all of these variables, as well as their interaction terms, we determined that only PV and ELEV influenced the fit of the model at the scale of the entire study region. The final least squares regression of these variables yielded the following model:

$$ACD = -3611.7799353 - 0.1721757 \times ELEV + 81.2756420 \times PV - 0.4393574 \times PV^2$$

with an adjusted $r^2 = 0.30$ ($P < 0.0001$) and a standard error of 34.45 Mg C ha^{-1}. Additionally, we performed a 4-fold cross validation analysis on this model which also found a mean residual standard error of 36.07 Mg C ha^{-1} for the test data. This equation was used estimate ACD at the regional level based on a continuous function, for comparison to the map based on the stratification approach.

(VI) Sources of error in linking LiDAR-based and plot-based estimates of ACD

Standard plot protocol in the field (e.g., Condit, 1998) dictates that trees are considered to be inside a plot if more than 50% of their main stem is contained within the plot boundary. However, LiDAR energy is returned by the 3-D components of forest canopies, including tree crowns and branches. Thus a plot within the LiDAR coverage includes portions of crowns that overhang the edge of the plot, and excludes portions that extent beyond the plot edge. In effect, this disagreement between LiDAR and field estimated ACD produces a false error in typical LiDAR calibrations, including those of the type underlying the universal LiDAR model. Plot size also has a considerable effect, with errors decreasing as plot size increases according to the inverse square root of the plot area.

Supplemental Figures

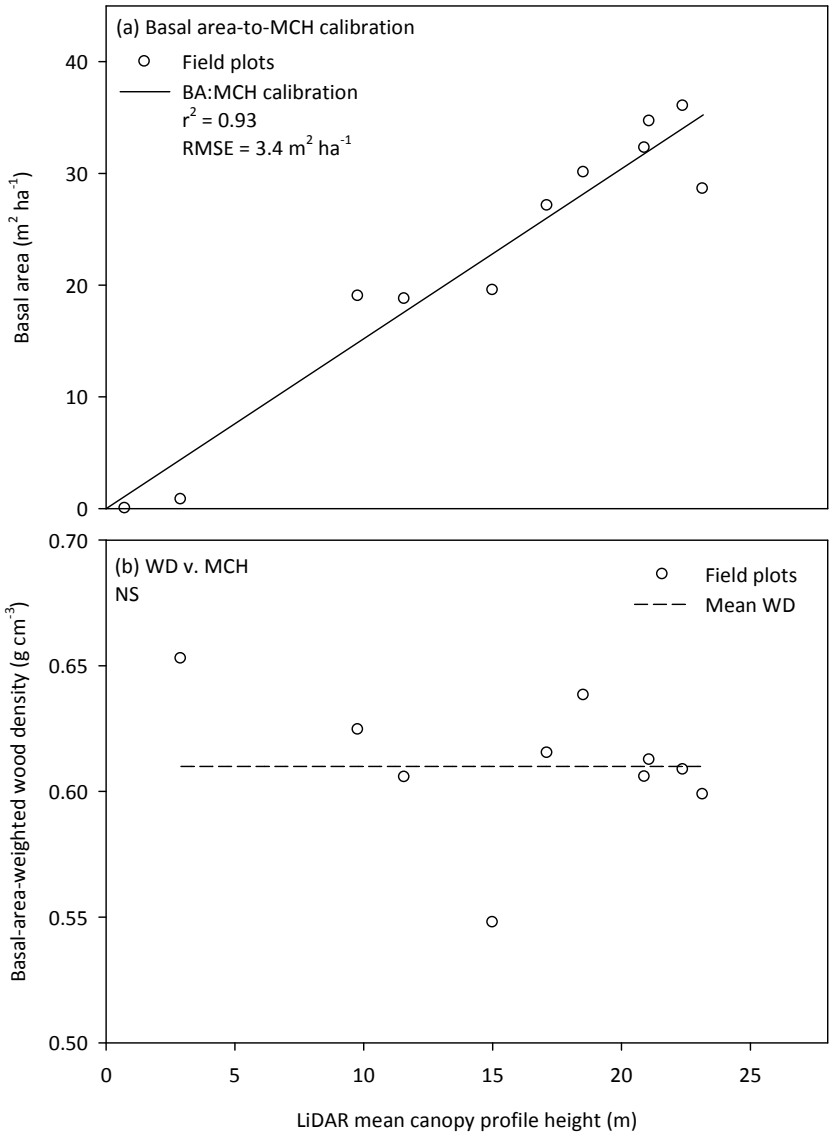

Figure S1. (a) Relationship between field-estimated basal area and LiDAR-derived mean canopy profile height (termed the Stocking Coefficient). (b) Relationship between basal-area-weighted wood density and LiDAR derived mean canopy profile height.

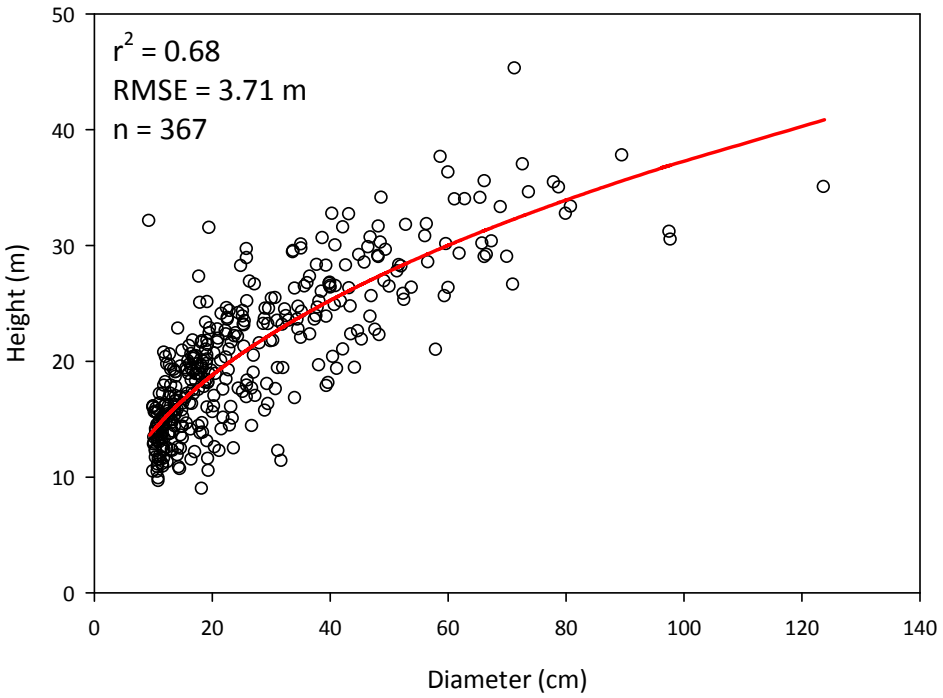

Figure S2. Height to diameter relationship among 367 trees measured in the field plots. All trees > 50 cm dbh were measured for height, as well as several trees of smaller diameters. For field ACD validation, heights of the remaining smaller trees were estimated using the model as shown (model parameters in Table S1).

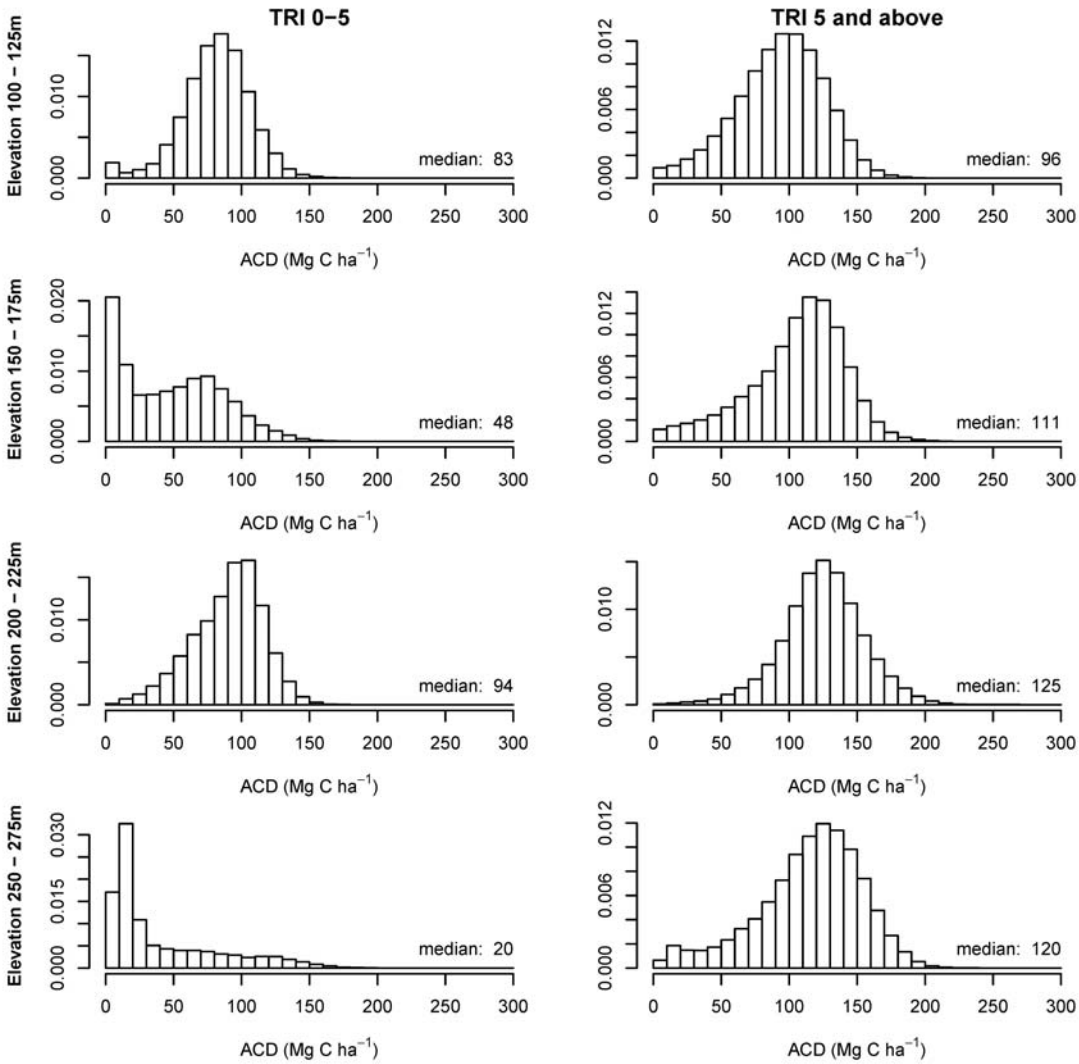

Figure S3. Differences in the distribution of forest aboveground carbon density (ACD) at different elevations for landscapes with low (0-5) and high (5+) values of the terrain ruggedness index (TRI; Riley et al., 1999). Median ACD values for each distribution are shown in the lower right of each panel.

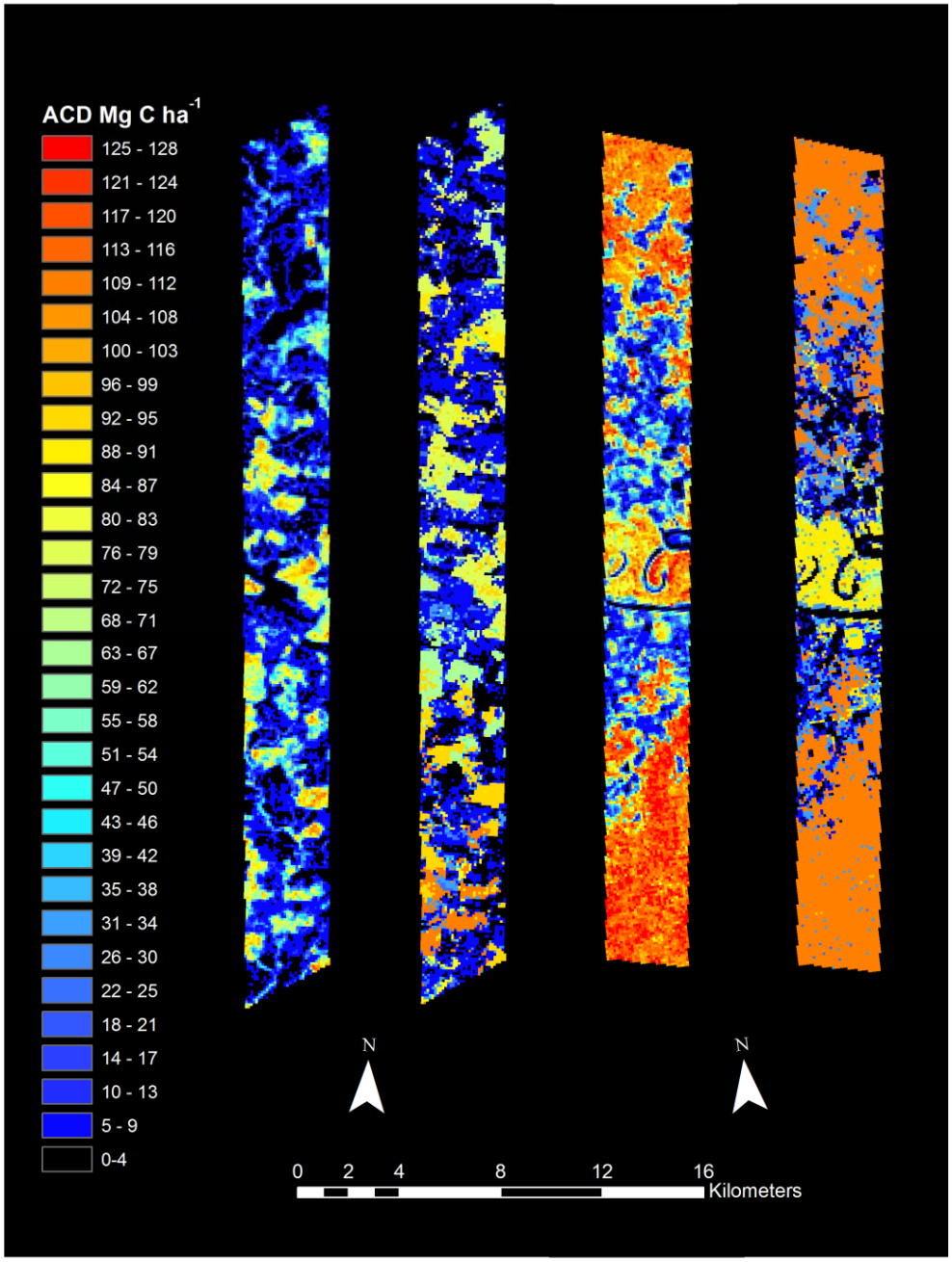

Figure S4. Side-by-side comparison of LiDAR-based ACD (left) and regionally-mapped ACD (right) according to the stratification approach.

Table S1. Allometric models used to estimate aboveground biomass (AGB; kg) or height (H; m). Diameters (D, cm) were measured at breast height (1.3 m from the base) or above buttress. Wood densities (ρ; g cm^{-3}) were taken from a global wood density database (Chave et al., 2009) based on species-, genus-, or family-level identification (see Table S2).

Parameter	Equation	r^2	Reference
AGB	$0.0776*(D^2*H*\rho)^{0.94}$	0.96[1]	Chave et al. (2005)
H	$5.2497*D^{0.4258}$	0.68	This study
AGB	$\pi*(0.5*D)^2*\rho*H/10$	n/a[2]	Asner et al. (2010)
AGB	$\pi*(0.5*D)^2*(1.17*\rho-0.21)*H/10*0.5$	n/a[2]	Asner et al. (2010)

[1] coefficient of determination for ln(y)

[2] Palm and dead tree biomass was estimated using the formula for volume of a cylinder, corrected for wood density, and in the case of dead trees for trunk taper and decay typical of standing dead Amazonian trees (Chao et al., 2009).

Table S2. Summary of all stems encountered in the field validation plots. Wood densities were taken from Chave et al. (2009) according to either family or genus-level identification. When a value was not available from Chave et al. (2009), a default regional value of 0.58 was applied (ter Steege et al., 2006).

Family	Genus	Species	Number of Stems	Wood Density (g cm^{-3})	WD Determination	Reference
ANACARDIACEAE			2	0.56	Family	Chave
ANACARDIACEAE	*Tapirira*	spp.	6	0.37	Genus	Chave
ANNONACEAE			37	0.56	Family	Chave
ANNONACEAE	*Duguetia*	spp.	1	0.73	Genus	Chave
ANNONACEAE	*Xylopia*	spp.	36	0.59	Genus	Chave
APOCYNACEAE			33	0.57	Family	Chave
APOCYNACEAE	*Aspidosperma*	spp.	15	0.75	Genus	Chave
APOCYNACEAE	*Couma*	*macrocarpa*	1	0.53	Genus	Chave
APOCYNACEAE	*Couma*	spp.	3	0.53	Genus	Chave
APOCYNACEAE	*Hymatanthus*	spp.	1	0.55	Genus	Chave
ARALIACEAE	*Schefflera*	spp.	2	0.39	Genus	Chave
ARECACEAE			1	0.56	Family	Chave
ARECACEAE	*Astrocaryum*	spp.	1	0.51	Genus	Chave
ARECACEAE	*Euterpe*	*precatoria*	9	0.39	Genus	Chave
ARECACEAE	*Iriartea*	spp.	1	0.27	Genus	Chave
ARECACEAE	*Mauritiella*	spp.	8	0.58	Region	Default
ARECACEAE	*Oenocarpus*	*bacaba*	1	0.68	Genus	Chave
ARECACEAE	*Oenocarpus*	*bataua*	45	0.68	Genus	Chave
ARECACEAE	*Oenocarpus*	spp.	10	0.68	Genus	Chave
ARECACEAE	*Socratea*	*exhorriza*	2	0.23	Genus	Chave
BIGNONIACEAE	*Callychlamys*	spp.	1	0.58	Region	Default
BIXACEAE	*Bixa*	spp.	2	0.35	Genus	Chave
BOMBACACEAE			9	0.48	Family	Chave
BOMBACACEAE	*Pachira*	spp.	2	0.48	Genus	Chave
BOMBACACEAE	*Scleronema*	spp.	9	0.61	Genus	Chave
BURSERACEAE			21	0.52	Family	Chave
BURSERACEAE	*Dacryodes*	spp.	1	0.57	Genus	Chave
BURSERACEAE	*Protium*	spp.	8	0.57	Genus	Chave
CAESALPINIACEAE			36	0.68	Family	Chave
CAESALPINIACEAE	*Hymenaea*	spp.	1	0.80	Genus	Chave
CAESALPINIACEAE	*Macrolobium*	spp.	19	0.62	Genus	Chave
CAESALPINIACEAE	*Tachigali*	spp.	16	0.58	Genus	Chave
CARYOCARIACEAE			1	0.70	Family	Chave
CARYOCARIACEAE	*Caryocar*	spp.	4	0.69	Genus	Chave
CECROPIACEAE			4	0.34	Family	Chave

Family	Genus	Species	Number of Stems	Wood Density (g cm^{-3})	WD Determination	Reference
CECROPIACEAE	*Cecropia*	spp.	2	0.34	Genus	Chave
CECROPIACEAE	*Pourouma*	spp.	13	0.39	Genus	Chave
CELASTRACEAE			5	0.66	Family	Chave
CELASTRACEAE	*Goupia*	*glabra*	2	0.73	Genus	Chave
CELASTRACEAE	*Goupia*	spp.	1	0.73	Genus	Chave
CELASTRACEAE	*Lagupia*	spp.	1	0.58	Region	Default
CHRYSOBALANACEAE			67	0.78	Family	Chave
CHRYSOBALANACEAE	*Licania*	spp.	4	0.82	Genus	Chave
CLUSIACEAE			8	0.65	Family	Chave
CLUSIACEAE	*Caraipa*	spp.	4	0.66	Genus	Chave
CLUSIACEAE	*Clusia*	spp.	3	0.68	Genus	Chave
CLUSIACEAE	*Tovomita*	spp.	7	0.70	Genus	Chave
CLUSIACEAE	*Vismia*	spp.	3	0.49	Genus	Chave
COMBRETACEAE			1	0.60	Family	Chave
COMBRETACEAE	*Buchenavia*	spp.	4	0.75	Genus	Chave
COMBRETACEAE	*Conceveiba*	spp.	1	0.41	Genus	Chave
EBENACEAE	*Dyospiros*	spp.	1	0.68	Genus	Chave
ELAEOCARPACEAE			5	0.55	Family	Chave
ELAEOCARPACEAE	*Sloanea*	spp.	3	0.61	Genus	Chave
EUPHORBIACEAE			10	0.51	Family	Chave
EUPHORBIACEAE	*Conceveiba*	spp.	7	0.41	Genus	Chave
EUPHORBIACEAE	*Hevea*	spp.	73	0.48	Genus	Chave
EUPHORBIACEAE	*Mabea*	spp.	14	0.61	Genus	Chave
EUPHORBIACEAE	*Senefeldera*	spp.	9	0.78	Genus	Chave
FABACEAE			45	0.68	Family	Chave
FABACEAE	*Clatrotropis*	*macrocarpa*	1	0.79	Genus	Chave
FABACEAE	*Clatrotropis*	spp.	75	0.79	Genus	Chave
FABACEAE	*Ormosia*	spp.	2	0.58	Genus	Chave
FABACEAE	*Swartzia*	spp.	1	0.85	Genus	Chave
HUMIRIACEAE			8	0.77	Family	Chave
ICACINACEAE			12	0.58	Family	Chave
LAURACEAE			50	0.56	Family	Chave
LAURACEAE	*Ocotea*	spp.	5	0.54	Genus	Chave
LECYTHIDACEAE			113	0.70	Family	Chave
LECYTHIDACEAE	*Eschweilera*	spp.	12	0.83	Genus	Chave
MELASTOMATACEAE			3	0.67	Family	Chave
MELASTOMATACEAE	*Miconia*	spp.	1	0.63	Genus	Chave
MIMOSACEAE			5	0.68	Family	Chave
MIMOSACEAE	*Inga*	spp.	13	0.58	Genus	Chave
MIMOSACEAE	*Parkia*	spp.	17	0.46	Genus	Chave

Family	Genus	Species	Number of Stems	Wood Density (g cm^{-3})	WD Determination	Reference
MIMOSACEAE	*Zygia*	spp.	16	0.82	Genus	Chave
MORACEAE			65	0.54	Family	Chave
MORACEAE	*Ficus*	spp.	1	0.41	Genus	Chave
MORACEAE	*Pseudolmedia*	spp.	2	0.67	Genus	Chave
MYRISTICACEAE			33	0.51	Family	Chave
MYRISTICACEAE	*Iryanthera*	spp.	30	0.59	Genus	Chave
MYRISTICACEAE	*Virola*	spp.	34	0.48	Genus	Chave
MYRTACEAE			33	0.77	Family	Chave
NYCTAGINACEAE			2	0.52	Family	Chave
OLACACEAE			3	0.76	Family	Chave
OLACACEAE	*Minquartia*	spp.	4	0.79	Genus	Chave
POLYGONACEAE	*Coccoloba*	spp.	2	0.69	Genus	Chave
RUBIACEAE			56	0.64	Family	Chave
SAPINDACEAE			6	0.69	Family	Chave
SAPINDACEAE	*Allophyllus*	spp.	4	0.52	Genus	Chave
SAPINDACEAE	*Cupania*	spp.	2	0.61	Genus	Chave
SAPOTACEAE			151	0.70	Family	Chave
SAPOTACEAE	*Manilkara*	spp.	3	0.89	Genus	Chave
SAPOTACEAE	*Micropholis*	spp.	20	0.66	Genus	Chave
SAPOTACEAE	*Pouteria*	spp.	6	0.69	Genus	Chave
STERCULIACEAE			5	0.48	Family	Chave
STERCULIACEAE	*Sterculia*	spp.	5	0.40	Genus	Chave
STERCULIACEAE	*Theobroma*	spp.	4	0.53	Genus	Chave
TILIACEAE			14	0.48	Family	Chave
TILIACEAE	*Apeiba*	spp.	24	0.25	Genus	Chave
TILIACEAE	*Mollia*	spp.	12	0.49	Genus	Chave
VERBENACEAE	*Vitex*	spp.	1	0.57	Genus	Chave
VIOLACEAE			4	0.65	Family	Chave
VIOLACEAE	*Rinorea*	spp.	1	0.68	Genus	Chave
VOCHYSIACEAE			19	0.55	Family	Chave
VOCHYSIACEAE	*Erisma*	spp.	42	0.57	Genus	Chave
VOCHYSIACEAE	*Qualea*	spp.	3	0.65	Genus	Chave
VOCHYSIACEAE	*Vochysia*	spp.	2	0.49	Genus	Chave
Unknown			499	0.58	Region	Default
Total stems			**2068**			
Unweighted mean WD				**0.59**		
% Family determination					**41.92**	
% Genus determination					**33.46**	
% Region determination					**24.61**	

Table S3. Summary of vegetation classes used in final regional stratification. Elevation (m) a.s.l. (ELEV), fractional cover (%) of photosynthetic vegetation (PV), terrain ruggedness index (TRI), and catchment (CM) are shown. Mean, median, and standard deviation of LiDAR-based aboveground carbon density (ACD) are given in Mg C ha^{-1}. Total extent of LiDAR coverage (ha) and total extent of each class in the regional ACD map (ha) are provided, as well as the relative coverage of LiDAR (%) within each class. An asterisk (*) indicates that ACD statistics were calculated from a broader class due to insufficient LiDAR coverage (see methods).

CLASS NUMBER		ELEV	PV	TRI	CM	Mean ACD	Median ACD	St. Dev. ACD	LiDAR (ha)	Map (ha)	Cover (%)
Non-forest											
1			(0,20]			3.7	0.9	7.1	459	24188	1.90
2			(20,40]			5.1	1.7	9.8	4026	186898	2.15
3			(40,60]			5.7	2.3	9.5	21526	820605	2.62
4			(60,80]			16.4	9.3	20.9	39356	1361584	2.89
5			(80,100]			33.7	29.7	25.1	3574	181242	1.97
Deforestation regrowth											
6	5 Years					30.1	22.0	29.3	582	22980	2.53
7	10 Years					30.8	23.2	26.9	2230	61282	3.64
Disturbance regrowth											
8	All ages					53.7	47.1	39.1	1022	33775	3.03
Forest											
9*		< 100	[80,84)			100.0	102.5	18.3	24	4759	0.50
10*		< 100	≥ 97			100.0	102.5	18.3	11	2884	0.38
11		[100,125)	[80,84)			60.6	55.5	29.7	105	5622	1.87
12		[100,125)	≥ 97			57.1	61.4	27.1	51	1855	2.75
13		[125,150)	[80,84)			80.5	80.6	27.6	696	5840	11.92
14		[125,150)	≥ 97			83.8	79.3	32.0	40	1403	2.85
15		[150,175)	[80,84)			75.9	84.0	33.7	402	6383	6.30
16		[150,175)	≥ 97			96.2	105.7	34.7	17	884	1.92
17		[175,200)	[80,84)			41.4	35.2	27.6	1189	18794	6.33
18		[175,200)	≥ 97			69.4	65.6	28.4	141	2408	5.86
19		[200,225)	[80,84)			30.4	25.1	23.4	1951	44712	4.36
20*		[200,225)	≥ 97			100.9	112.0	36.0	44	10656	0.41
21		[225,250)	[80,84)			33.2	29.1	23.2	1952	50351	3.88
22		[225,250)	≥ 97			80.6	80.8	15.6	513	21967	2.34
23		[250,275)	[80,84)			32.3	27.3	22.4	971	48426	2.01
24		[250,275)	≥ 97			84.1	85.8	20.8	156	22024	0.71
25		[275,300)	[80,84)			32.7	24.4	26.3	591	29354	2.01
26		[275,300)	≥ 97			89.0	88.8	12.5	514	11693	4.40
27		[300,325)	[80,84)			28.0	20.1	26.6	448	16571	2.70
28		[300,325)	≥ 97			86.3	85.3	14.7	856	15786	5.42

29	[325,350)	[80,84)			23.4	17.0	23.5	560	11912	4.70
30	[325,350)	≥ 97			91.5	94.4	23.2	212	16718	1.27
31	[350,375)	[80,84)			27.5	22.6	20.4	269	7653	3.51
32	[350,375)	≥ 97			77.6	77.6	28.5	125	14596	0.86
33	[375,400)	[80,84)			31.5	25.7	21.0	301	5416	5.56
34	[375,400)	≥ 97			88.1	90.2	15.3	307	10573	2.90
35	[400,500)	[80,84)			33.1	22.8	27.6	769	11165	6.89
36	[400,500)	≥ 97			67.9	67.9	21.8	287	19798	1.45
37	≥ 500	[80,84)			32.4	18.1	28.5	627	38165	1.64
38*	≥ 500	≥ 97			54.6	45.3	34.8	33	133813	0.02
39	< 100	[84,97)	[0,5)		96.0	97.3	21.2	505	29022	1.74
40*	< 100	[84,97)	≥ 5	F	101.3	103.3	16.9	0	50393	0.00
41	< 100	[84,97)	≥ 5	H	101.3	103.3	16.9	1916	87390	2.19
42	[100, 125)	[84,97)	[0,5)		56.9	32.8	49.7	865	42769	2.02
43	[100, 125)	[84,97)	≥ 5	F	121.0	122.5	16.4	908	288315	0.31
44	[100, 125)	[84,97)	≥ 5	H	113.9	122.6	34.5	7587	469893	1.61
45	[125, 150)	[84,97)	[0,5)		96.0	102.2	31.8	2733	29077	9.40
46	[125, 150)	[84,97)	≥ 5	F	136.8	140.1	21.7	11836	487705	2.43
47	[125, 150)	[84,97)	≥ 5	H	127.7	130.2	21.5	34298	893720	3.84
48*	[125, 150)	[84,97)	≥ 5	I	130.0	132.5	21.9	0	1040	0.00
49	[150, 175)	[84,97)	[0,5)		90.0	95.6	22.9	3153	79808	3.95
50*	[150, 175)	[84,97)	≥ 5	C	126.1	126.5	21.9	0	195	0.00
51	[150, 175)	[84,97)	≥ 5	D	66.8	70.9	14.3	212	615	34.47
52	[150, 175)	[84,97)	≥ 5	F	119.9	119.8	26.5	7886	503140	1.57
53*	[150, 175)	[84,97)	≥ 5	G	126.1	126.5	21.9	0	50545	0.00
54	[150, 175)	[84,97)	≥ 5	H	129.0	128.3	18.5	21229	565088	3.76
55*	[150, 175)	[84,97)	≥ 5	I	126.1	126.5	21.9	0	3615	0.00
56	[175, 200)	[84,97)	[0,5)		77.1	79.9	29.0	2276	43818	5.19
57	[175, 200)	[84,97)	≥ 5	C	55.4	56.7	22.1	5766	50453	11.43
58	[175, 200)	[84,97)	≥ 5	D	84.4	86.2	21.7	6027	66423	9.07
59	[175, 200)	[84,97)	≥ 5	F	113.7	117.2	25.3	19106	796953	2.40
60	[175, 200)	[84,97)	≥ 5	G	87.7	92.1	24.5	1079	338113	0.32
61	[175, 200)	[84,97)	≥ 5	H	121.0	123.1	20.0	15372	780440	1.97
62*	[175, 200)	[84,97)	≥ 5	I	104.7	111.2	31.5	0	2615	0.00
63	[200, 225)	[84,97)	[0,5)		54.1	56.5	38.2	2478	143358	1.73
64	[200, 225)	[84,97)	≥ 5	C	45.0	42.7	24.6	3472	115491	3.01
65	[200, 225)	[84,97)	≥ 5	D	70.6	69.2	26.0	4018	203821	1.97
66	[200, 225)	[84,97)	≥ 5	E	72.4	72.4	24.2	1926	43440	4.43
67	[200, 225)	[84,97)	≥ 5	F	116.3	119.3	25.0	22591	759155	2.98
68	[200, 225)	[84,97)	≥ 5	G	104.1	109.4	22.4	3174	399138	0.80
69	[200, 225)	[84,97)	≥ 5	H	115.9	120.5	20.0	17743	771989	2.30
70*	[200, 225)	[84,97)	≥ 5	I	105.7	114.3	31.7	0	676	0.00
71	[225, 250)	[84,97)	[0,5)		79.9	80.5	33.6	1020	53239	1.92

72	[225, 250)	[84,97)	≥ 5	C	52.6	53.3	20.2	6341	297150	2.13
73	[225, 250)	[84,97)	≥ 5	D	55.6	54.3	22.4	1089	98325	1.11
74	[225, 250)	[84,97)	≥ 5	E	107.8	109.7	16.4	15302	267680	5.72
75	[225, 250)	[84,97)	≥ 5	F	111.5	116.3	23.0	18936	671336	2.82
76	[225, 250)	[84,97)	≥ 5	G	105.9	112.6	26.6	2258	214117	1.05
77	[225, 250)	[84,97)	≥ 5	H	111.0	116.3	22.9	20684	927456	2.23
78	[250, 275)	[84,97)	[0,5)		82.6	86.0	20.3	1867	71720	2.60
79	[250, 275)	[84,97)	≥ 5	C	62.7	63.8	22.1	5368	290147	1.85
80	[250, 275)	[84,97)	≥ 5	D	72.9	73.5	41.0	170	21313	0.80
81	[250, 275)	[84,97)	≥ 5	E	103.6	103.9	12.9	2745	126151	2.18
82	[250, 275)	[84,97)	≥ 5	F	100.3	101.8	21.1	12701	473416	2.68
83*	[250, 275)	[84,97)	≥ 5	G	93.8	98.7	28.0	6	125587	0.00
84	[250, 275)	[84,97)	≥ 5	H	102.7	111.5	30.0	6794	338896	2.00
85	[275, 300)	[84,97)	[0,5)		82.7	83.1	12.6	1434	15541	9.23
86	[275, 300)	[84,97)	≥ 5	C	77.0	81.3	20.4	4865	147392	3.30
87*	[275, 300)	[84,97)	≥ 5	D	87.7	91.3	24.2	52	5851	0.89
88	[275, 300)	[84,97)	≥ 5	E	102.1	101.1	11.2	974	16727	5.82
89	[275, 300)	[84,97)	≥ 5	F	91.0	94.3	22.4	12201	342788	3.56
90*	[275, 300)	[84,97)	≥ 5	G	87.7	91.3	24.2	0	44648	0.00
91	[275, 300)	[84,97)	≥ 5	H	86.0	90.4	37.2	1568	70587	2.22
92	[300, 325)	[84,97)	[0,5)		93.1	100.9	23.5	252	4481	5.62
93	[300, 325)	[84,97)	≥ 5	C	80.7	84.2	21.1	2291	93607	2.45
94	[300, 325)	[84,97)	≥ 5	D	57.2	39.3	53.4	76	2065	3.68
95	[300, 325)	[84,97)	≥ 5	E	105.8	106.2	10.6	2497	21913	11.40
96	[300, 325)	[84,97)	≥ 5	F	85.6	93.4	36.4	5625	120422	4.67
97*	[300, 325)	[84,97)	≥ 5	G	87.4	94.5	31.7	0	11814	0.00
98	[300, 325)	[84,97)	≥ 5	H	67.7	66.7	34.7	895	26251	3.41
99	[325, 350)	[84,97)	[0,5)		68.3	71.6	33.3	37	1587	2.33
100	[325, 350)	[84,97)	≥ 5	C	59.4	53.9	31.1	464	59208	0.78
101	[325, 350)	[84,97)	≥ 5	D	52.5	43.5	34.4	114	934	12.21
102	[325, 350)	[84,97)	≥ 5	E	102.1	101.7	9.2	657	14663	4.48
103	[325, 350)	[84,97)	≥ 5	F	76.6	76.7	39.5	3908	40409	9.67
104*	[325, 350)	[84,97)	≥ 5	G	77.3	81.0	37.9	0	6399	0.00
105	[325, 350)	[84,97)	≥ 5	H	73.6	70.4	38.9	549	17635	3.11
106	[350, 375)	[84,97)	[0,5)		62.5	62.6	22.4	111	618	17.96
107	[350, 375)	[84,97)	≥ 5	C	67.1	69.7	24.8	1507	43200	3.49
108	[350, 375)	[84,97)	≥ 5	D	46.5	42.3	21.5	161	674	23.89
109*	[350, 375)	[84,97)	≥ 5	E	70.8	68.8	33.1	0	6391	0.00
110	[350, 375)	[84,97)	≥ 5	F	74.9	69.1	37.5	1939	20144	9.63
111*	[350, 375)	[84,97)	≥ 5	G	70.8	68.8	33.1	0	3541	0.00
112	[350, 375)	[84,97)	≥ 5	H	74.2	72.9	35.5	512	16813	3.05
113	[375, 400)	[84,97)	[0,5)		75.0	81.6	22.6	33	515	6.41
114	[375, 400)	[84,97)	≥ 5	C	66.5	68.0	23.4	1965	29316	6.70

115	[375, 400)	[84,97)	≥ 5	D	48.1	46.5	16.5	162	640	25.31
116*	[375, 400)	[84,97)	≥ 5	E	73.1	71.7	31.4	0	84	0.00
117	[375, 400)	[84,97)	≥ 5	F	81.6	82.1	34.9	1036	11946	8.67
118*	[375, 400)	[84,97)	≥ 5	G	73.1	71.7	31.4	0	1497	0.00
119	[375, 400)	[84,97)	≥ 5	H	86.2	92.1	39.6	647	17295	3.74
120*	[400, 500)	[84,97)	[0,5)		71.2	67.5	34.4	9	2366	0.38
121	[400, 500)	[84,97)	≥ 5	C	62.1	62.4	22.9	1779	78065	2.28
122	[400, 500)	[84,97)	≥ 5	D	49.7	49.8	16.1	599	1347	44.47
123*	[400, 500)	[84,97)	≥ 5	E	71.2	67.5	34.4	0	31	0.00
124	[400, 500)	[84,97)	≥ 5	F	73.2	71.8	35.0	3741	23961	15.61
125*	[400, 500)	[84,97)	≥ 5	G	71.2	67.5	34.4	0	4624	0.00
126	[400, 500)	[84,97)	≥ 5	H	81.1	87.6	40.0	2199	33910	6.48
127*	≥ 500	[84,97)	[0,5)		58.6	52.7	34.3	0	534	0.00
128*	≥ 500	[84,97)	≥ 5	A	58.6	52.7	34.3	0	2048	0.00
129*	≥ 500	[84,97)	≥ 5	B	58.6	52.7	34.3	0	509	0.00
130*	≥ 500	[84,97)	≥ 5	C	58.6	52.7	34.3	0	474621	0.00
131*	≥ 500	[84,97)	≥ 5	D	58.6	52.7	34.3	0	5	0.00
132*	≥ 500	[84,97)	≥ 5	E	58.6	52.7	34.3	0	29	0.00
133	≥ 500	[84,97)	≥ 5	F	44.2	34.3	29.5	1635	25730	6.35
134*	≥ 500	[84,97)	≥ 5	G	58.6	52.7	34.3	0	155346	0.00
135	≥ 500	[84,97)	≥ 5	H	72.0	79.9	33.1	1754	7851	22.34

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