Nogueira, E.M., Yanai, A.M.; Fonseca, F.O.; Fearnside, P.M. 2015. Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biology* 21: 1271–1292.

doi: 10.1111/gcb.12798.

ISSN: 1365-2486

Title: Carbon stock loss from deforestation through 2013 in Brazilian Amazonia

Running head: Amazon carbon loss

Authors: Euler Melo Nogueira[1*], Aurora M Yanai[1], Frederico O R Fonseca[1], Philip Martin Fearnside[1*]

Author affiliation:

1. Department of Environmental Dynamics, National Institute for Research in Amazonia (INPA), Av. André Araújo n^{o} 2936, CEP 69 067-375, Manaus, Amazonas, Brazil

Correspondence: Philip Martin Fearnside; Tel.: + 55 92 3643 1822, Fax: + 55 92 3642 3028; e-mail: pmfearn@inpa.gov.br, philip.fearnside@gmail.com

Keywords: Global warming, Greenhouse gases, Amazon forest, Tropical forest, REDD.
Type of Paper: Primary Research Article
Word count: abstract: 299, main text: 5736 (excluding abstract and references)
Reference count: 117; **Number of Figures/Tables:** 8

Abstract

The largest carbon stock in tropical vegetation is in Brazilian Amazonia. In this ~5 million km^2 area, over 750,000 km^2 of forest and ~240,000 km^2 of non-forest vegetation types had been cleared through 2013. We estimate current carbon stocks and cumulative gross carbon loss from clearing of primary vegetation in Brazil's "Legal Amazonia" and "Amazonia biome" regions. Biomass of "pre-modern" vegetation (prior to major increases in disturbance beginning in the 1970s) was estimated by matching vegetation classes mapped at a scale of 1:250,000 and 29 biomass means from 41 published studies for vegetation types classified as forest (2317 1-ha plots) and as either non-forest or contact zones (1830 plots and sub-plots of varied size). Total biomass (above and below-ground, dry weight) underwent a gross reduction of 18.3% in Legal Amazonia (13.1 Pg C) and 16.7% in the Amazonia biome (11.2 Pg C) through 2013, excluding carbon loss from the effects of fragmentation, selective logging, fires, mortality induced by recent droughts and clearing of forest regrowth. In spite of the loss of carbon from clearing, large amounts of carbon were stored in stands of remaining vegetation in 2013, equivalent to around 149 Mg C ha^{-1} when weighted by the total area covered by each vegetation type in Legal Amazonia. Native vegetation in Legal Amazonia in 2013 originally contained 58.6 Pg C, while that in the Amazonia biome contained 56 Pg C. Emissions per unit area from clearing could potentially be larger in the future because previously cleared areas were mainly covered by vegetation with lower mean biomass than the remaining vegetation. Estimates of original biomass are essential for estimating losses to forest degradation. This study offers estimates of cumulative biomass loss, as well as estimates of pre-modern carbon stocks that have not been represented in recent estimates of deforestation impacts.

References

Abdala GC, Caldas LS, Haridasan M, Eiten G (1998) Above and belowground organic matter and root:shoot ratio in a cerrado in central Brazil. Brazilian Journal of Ecology, **2**, 11–23.

Achard F, Beuchle R, Mayaux P *et al.* (2014) Determination of forest deforestation rates and related carbon losses from 1990 to 2010. Global Change Biology, **20**, 2540–2554 doi:10.1111/gcb.12605.

Aguiar APD, Ometto JP, Nobre C *et al.* (2012) Modeling the spatial and temporal heterogeneity of deforestation-driven carbon emissions: the INPE-EM framework applied to the Brazilian Amazon. Global Change Biology, **18**, 3346–3366.

Alves LF, Vieira SA, Scaranello MA, Camargo PB, Santos FAM, Joly CA, Martinelli LA (2010) Forest structure and live aboveground biomass variation along an elevational gradient of tropical Atlantic moist forest (Brazil). Forest Ecology and Management, **260**, 679–691.

Asner GP, Knapp DE, Broadbent EN, Oliveira PJC, Keller M, Silva JN (2005) Selective logging in the Brazilian Amazon. Science, **310**, 480–482.

Assis AM, Pereira OJ, Thomaz LD (2004) Fitossociologia de uma floresta de restinga no Parque Estadual Paulo César Vinha, Setiba, município de Guarapari (ES). Revista Brasileira de Botânica, **27**, 349–361.

Assis MA, Prata EMB, Pedroni F *et al.* (2011) Florestas de restinga e de terras baixas na planície costeira do sudoeste do Brasil: vegetação e heterogeneidade ambiental. Biota Neotropica, **11**, 103–121.

Assunção J, Gandour CC, Rocha R (2012) Deforestation Slowdown in the Legal Amazon: Prices or Policies? Climate Policy Initiative (CPI) Working Paper, Pontífica Universidade Católica (PUC), Rio de Janeiro, RJ, Brazil. 37 pp. Available at: http://climatepolicyinitiative.org/wp-content/uploads/2012/03/Deforestation-Prices-or-Policies-Working-Paper.pdf. Accessed 28/10/2014.

Baccini A, Goetz SJ, Walker WS *et al.* (2012) Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nature Climate Change, **2**, 182–185.

Barbosa RI, dos Santos JRS, da Cunha MS, Pimentel TP, Fearnside PM (2012) Root biomass, root : shoot ratio and belowground carbon stocks in the open savannahs of Roraima, Brazilian Amazonia. Australian Journal of Botany, **60**, 405–416.

Barbosa RI, Fearnside PM (1999) Incêndios na Amazônia brasileira: Estimativa da emissão de gases do efeito estufa pela queima de diferentes ecossistemas de Roraima na passagem do evento “El Niño” (1997/98). Acta Amazonica, **29**, 513–534.

Barbosa RI, Fearnside PM (2005) Above-ground biomass and the fate of carbon after burning in the savannas of Roraima, Brazilian Amazonia. Forest Ecology and Management, **216**, 295–316.

Barbosa RI, Ferreira CAC (2004) Biomassa acima do solo de um ecossistema de “campina” em Roraima, norte da Amazônia Brasileira. Acta Amazonica, **34**, 577–586.

Barlow J, Peres CA, Lagan BO, Haugaasen T (2003) Large tree mortality and the decline of forest biomass following Amazonian wildfires. Ecology Letters, **6**, 6–8.

Bongers F, Engelen D, Klinge H (1985) Phytomass structure of natural plant communities on spodosols in southern Venezuela: the Bana woodland. Vegetatio, **63**, 13–34.

Brando PM, Balch JK, Nepstad DC *et al.* (2014) Abrupt increases in Amazonian tree mortality due to drought-fire interactions. Proceedings of the National Academy of Sciences of the United States of America, **111**, 6347–6352.

Brazil, IBAMA (2011) Monitoring Deforestation of Brazilian Biomes Project (PMDBBS), Monitoramento do Bioma Cerrado 2009-2010. Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), Ministério do Meio Ambiente, Brasília, DF, Brazil. 65 pp. http://siscom.ibama.gov.br/monitorabiomas/cerrado/index.htm. Accessed 04/10/2013.

Brazil, IBAMA (2013) Monitoring Deforestation of Brazilian Biomes Project (PMDBBS). Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), Brasília, DF, Brazil. http://siscom.ibama.gov.br/monitorabiomas/cerrado/index.htm. Accessed 04/10/2013.

Brazil, IBGE (1992) Manual Técnico da Vegetação Brasileira (Manuais Técnicos em Geociências n$^{o.}$1). Fundação Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro, RJ, Brazil. 92 pp.

Brazil, IBGE (2012) Manual Técnico da Vegetação Brasileira. 2ª. Edição Revista e Ampliada. Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro, RJ, Brazil. 274 pp.

Brazil, IBGE (2013) Divisão Municipal do Território Brasileiro. Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro, RJ, Brazil. ftp://geoftp.ibge.gov.br/malhas_digitais/municipio_2010/. Accessed 28/11/2013.

Brazil, INPE (2013) Metodologia para o Cálculo da Taxa Anual de Desmatamento na Amazônia Legal. National Institute for Space Research (INPE), Coordenadoria Geral de Observação da Terra Programa Amazônia (Projeto PRODES). Ministério da Ciência e Tecnologia, São José dos Campos, SP, Brazil. 37 pp. http://www.obt.inpe.br/prodes/metodologia_TaxaProdes.pdf. Accessed 27/10/2014.

Brazil, INPE (2014) Amazon Deforestation Monitoring Project (PRODES). National Institute for Space Research, São José dos Campos, SP, Brazil. http://www.dpi.inpe.br/prodesdigital/prodes.php. Accessed 22/09/2014.

Brazil, MCT (2006) Emissões de gases de efeito estufa da queima de biomassa no cerrado não-antrópico utilizando dados orbitais. Primeiro Inventário Brasileiro de Emissões Antrópicas de Gases de Efeito Estufa. Relatório de Referência. Ministério da Ciência e Tecnologia (MCT), Brasília, DF, Brazil, 51 pp.

Brazil, MCT (2010) Segunda Comunicação Nacional do Brasil à Convenção-Quadro das Nações Unidas sobre Mudança do Clima (Volume 2). Coordenação-Geral de Mudanças Globais do Clima, Ministério da Ciência e Tecnologia (MCT), Brasília, DF, Brazil. 280 pp. http://www.mct.gov.br/upd_blob/0213/213909.pdf (Accessed 13/05/2014).

Brazil, MMA (2013) Download de dados geográficos. Ministry of the Environment. Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. http://mapas.mma.gov.br/i3geo/datadownload.htm. Accessed 04/10/2013.

Brazil, MMA (2014) Brazil's submission of the forest reference emission level for deforestation in the Amazonia biome for results-based payments for REDD+ under the UNFCCC. Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. 58 pp. http://www.mma.gov.br/redd/images/Publicacoes/submission_frel_brazil.pdf. Accessed 27/10/2014.

Brazil, Projeto RadamBrasil (1973–1983) Levantamento de Recursos Naturais. Ministério das Minas e Energia, Departamento Nacional de Produção Mineral, Rio de Janeiro, RJ, Brazil.

Brazil, Projeto SIVAM (2002) Relatório metodológico de trabalho. Revisão 3. Diretoria de Geociência. Rio de Janeiro, Brazil. 330 pp.

Brown IF, Martinelli LA, Thomas W, Moreira MZ, Ferreira CA, Victoria RA (1995) Uncertainty in the biomass of Amazonian forests: An example from Rondônia, Brazil. Forest Ecology and Management, **75**, 175–189.

Cardoso EL, Crispim SMA, Rodrigues CAG, Barioni Júnior W (2000) Composição e dinâmica da biomassa aérea após a queima em savana gramíneo-lenhosa no Pantanal. Pesquisa Agropecuária Brasileira, **35**, 2309–2316.

Castro EA, Kauffman JB (1998) Ecosystem structure in the Brazilian Cerrado: A vegetation gradient of aboveground biomass, root mass and consumption by fire. Journal of Tropical Ecology, **14**, 263–283.

César O, Monteiro R (1995) Florística e fitossociologia de uma floresta de restinga em Picinguaba (Parque Estadual da Serra do Mar), Município de Ubatuba - SP. Naturalia, **20**, 89–105.

Clark DB, Kellner JR (2012) Tropical forest biomass estimation and the fallacy of misplaced concreteness. Journal of Vegetation Science, **23**, 1191–1196.

da Silva RP (2007) Alometria, estoque e dinâmica da biomassa de florestas primárias e secundárias na região de Manaus (AM). PhD Thesis. Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil.

de Araújo LS, dos Santos JR, Keil M, Pardi Lacruz MS, Kramer JCM (2001) Razão entre bandas do SIR-C/ X SAR para estimativa de biomassa em áreas de contato floresta e cerrado. In: *Anais X Simpósio Brasileiro de Sensoriamento Remoto (SBSR)*, (eds. Epiphanio JCN, Banon GJF) pp. 1513–1520, Foz do Iguaçu, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP. Brazil. Available at: http://urlib.net/dpi.inpe.br/lise/2001/09.12.16.47 (accessed 23 05 2014).

de Carvalho AL, Nelson BW, Bianchini MC, Plagnol D, Kuplich TM, Daly DC (2013) Bamboo-dominated forests of the southwest Amazon: Detection, spatial extent, life cycle length and flowering waves. PLoS ONE, **8**, e54852.

de Lima MIC (2008) Projeto RADAM: Uma Saga Amazônica. Paka-Tatu, Belém, Pará, Brazil.132 pp.

de Menezes MPM, Berger U, Mehlig U (2008) Mangrove vegetation in Amazonia: a review of studies from the coast of Pará and Maranhão States, north Brazil. Acta Amazonica, **38**, 403–420.

de Miranda SC, Bustamante M, Palace M, Hagen S, Keller M, Ferreira LG (2014) Regional variations in biomass distribution in Brazilian savanna woodland. Biotropica, **46**, 125–138.

de Moraes RM, Delitti WBC, Struffaldi-de-Vuono Y (1999) Litterfall and litter nutrient content in two Brazilian Tropical Forests. Brazilian Journal of Botany, **22**, 9–16.

de Oliveira ÁCA (2000) Efeitos do Bambu *Guadua weberbaueri* Pilger sobre a Fisionomia e Estrutura de uma Floresta no Sudoeste da Amazônia. Masters Thesis. Universidade Federal do Amazonas (UFAM), Manaus, AM, Brazil.

Delitti WBC, Meguro M, Pausas JG (2006) Biomass and mineralmass estimates in a "cerrado" ecosystem. Revista Brasileira de Botânica, **29**, 531–540.

Dias ATC, de Mattos EA, Vieira SA, Azeredo JV, Scarano FR (2006) Aboveground biomass stock of native woodland on a Brazilian sandy coastal plain: Estimates based on the dominant tree species. Forest Ecology and Management, **226**, 364–367.

Emilio T, Quesada CA, Costa FRC *et al.* (2014) Soil physical conditions limit palm and tree basal area in Amazonian forests. Plant Ecology & Diversity, **7**, 215–229.

Eva HD, Achard F, Beuchle R *et al.* (2012) Forest cover changes in tropical south and central America from 1990 to 2005 and related carbon emissions and removals. Remote Sensing, **4**, 1369–1391.

FAO (2010) *Global Forest Resources Assessment 2010.* FAO Forestry Paper 163, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Fearnside PM (1997) Greenhouse gases from deforestation in Brazilian Amazonia: Net committed emissions. Climatic Change, **35**, 321-360.

Fearnside PM (2000) Global warming and tropical land-use change: greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation. Climatic Change, **46**, 115–158.

Fearnside PM (2013) What is at stake for Brazilian Amazonia in the climate negotiations. Climatic Change, **118**, 509-519.

Feldpausch TR, Banin L, Phillips OL *et al.* (2011) Height-diameter allometry of tropical forest trees. Biogeosciences, **8**, 1081–1106.

Fernandes MEB, do Nascimento AAM, Carvalho ML (2007) Estimativa da produção anual de serapilheira dos bosques de mangue no furo grande, Bragança-Pará. Revista Árvore, **31**, 949–958.

Foley JA, Asner GP, Costa MH *et al.* (2007) Amazonia revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and the Environment, **5**, 25–32.

188 Fromard F, Puig H, Mougin E, Marty G, Betoulle JL, Cadamuro L (1998) Structure, above-ground
189 biomass and dynamics of mangrove ecosystems: new data from French Guiana. Oecologia, **115**,
190 39–53.
191 Fonseca A, Souza Jr C, Veríssimo A (2014) Boletim do desmatamento da Amazônia Legal, Sistema de
192 Alerta de Desmatamento (SAD) setembro de 2014. Instituto do Homem e Meio Ambiente da
193 Amazônia (IMAZON), Belém, Pará, Brazil. 10 pp.
194 http://www.imazon.org.br/publicacoes/transparencia-florestal/transparencia-florestal-amazonia-
195 legal/boletim-do-desmatamento-da-amazonia-legal-setembro-de-2014-sad. Accessed 27/10/2014.
196 Gehring C, Park S, Denich M (2004) Liana allometric biomass equations for Amazonian primary and
197 secondary forest. Forest Ecology and Management, **195**, 69–83.
198 Gonçalves ASC, Fernandes MEB, Carvalho ML (2006) Variação anual da produção de serapilheira em
199 bosques de mangue no Furo Grande, Bragança, Pará. Boletim Museu Paraense Emílio Goeldi,
200 Ciências Naturais, **1**, 35–42.
201 Hansen MC, Potapov PV, Moore R *et al.* (2013) High-resolution global maps of 21st-century forest
202 cover change. Science, **342**, 850–853.
203 Harris NL, Brown S, Hagen SC *et al.* (2012) Baseline map of carbon emissions from deforestation in
204 tropical regions. Science, **336**, 1573–1576.
205 Heckenberger MJ, Kuikuro A, Kuikuro UT, Russell JC, Schmidt M, Fausto C, Franchetto B (2003)
206 Amazonia 1492: Pristine forest or cultural parkland? Science, **301**, 1710–1714.
207 Heckenberger, MJ, Russel C, Toney JR, Schmidt, MJ (2007) The legacy of cultural landscapes in the
208 Brazilian Amazon: Implications for biodiversity. Philosophical Transactions of the Royal Society
209 B: Biological Sciences, **362**, 197-208.
210 Heinsdijk D (1964) O Diâmetro dos troncos e o estrato superior das florestas tropicais (Capítulos II e
211 III do Relatório FAO nº 601, entre os Rios Tapajós e Xingu - 1957). Food and Agriculture
212 Organization of the United Nations (FAO), Rome, Italy. 56 pp.
213 Higuchi N, dos Santos J, Ribeiro RJ, Minette YB (1998) Biomassa da parte aérea da vegetação da
214 floresta tropical úmida de terra-firme da Amazônia brasileira. Acta Amazonica, **28**, 153–166.
215 Houghton RA, Lawrence KT, Hackler JL, Brown S (2001) The spatial distribution of forest biomass in
216 the Brazilian Amazon: A comparison of estimates. Global Change Biology, **7**, 731–746.
217 Houghton RA, Skole DL, Nobre CA, Hackler JL, Lawrence KT, Chomentowski WH (2000) Annual
218 fluxes of carbon from deforestation and regrowth in the Brazilian Amazon. Nature, **403**, 301–304.
219 IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4). In:
220 Agriculture, Forestry and Other Land Use (eds Eggleston HS, Buendia L, Miwa K, Ngara T,
221 Tanabe K), National Greenhouse Gas Inventories Programme, Intergovernmental Panel on Climate
222 Change (IPCC) and Institute for Global Environmental Strategies, Kanagawa, Japan.
223 IPCC (2007). Summary for policymakers. In: Climate Change 2007: The physical science basis.
224 Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel
225 on Climate Change. (eds Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor
226 M, Miller HL), p. 3. Cambridge University Press, Cambridge, UK and New York, NY, USA.
227 Junk WJ, Piedade MTF (1993) Biomass and primary-production of herbaceous plant communities in
228 the Amazon floodplain. Hydrobiologia, **263**, 155–162.
229 Kauffman JB, Cummings DL, Ward DE (1994) Relationships of fire, biomass and nutrient dynamics
230 along a vegetation gradient in the Brazilian cerrado. Journal of Ecology, **82**, 519–531.
231 Keith H, Mackey BG, Lindenmayer DB (2009) Re-evaluation of forest biomass carbon stocks and
232 lessons from the world's most carbon-dense forests. Proceedings of the National Academy of
233 Sciences of the United States of America, **106**, 11635–11640.
234 Klinge H, Herrera R (1983) Phytomass structure of natural plant communities on spodosols in
235 southern Venezuela: The tall Amazon Caatinga forest. Vegetatio, **53**, 65–84.

Lilienfein J, Wilcke W, Zimmermann R, Gerstberger P, Araújo GM, Zech W (2001) Nutrient storage in soil and biomass of native Brazilian Cerrado. Journal of Plant Nutrition and Soil Science, **164**, 487–495.

Lima AJN, Suwa R, Ribeiro GHPM *et al.* (2012) Allometric models for estimating above- and below-ground biomass in Amazonian forests at São Gabriel da Cachoeira in the upper Rio Negro, Brazil. Forest Ecology and Management, **277**, 163–172.

Loarie SR., Asner, GP, Field CB (2009) Boosted carbon emissions from Amazon deforestation. Geophysical Research Letters, **36**, L14810.

Malhi Y, Wood D, Baker TR *et al.* (2006) The regional variation of aboveground live biomass in old-growth Amazonian forests. Global Change Biology, **12**, 1–32.

Medeiros TCC, Sampaio EVSB (2008) Allometry of aboveground biomasses in mangrove species in Itamaracá, Pernambuco, Brazil. Wetlands Ecology and Management, **16**, 323–330.

Mitchard ETA, Feldpausch TR, Brienen RJW *et al.* (2014) Markedly divergent estimates of Amazon forest carbon density from ground plots and satellites. Global Ecology and Biogeography, **23**, 935–946.

Mitchard ETA, Saatchi SA, Baccini A, Asner GP, Goetz SJ, Harris NL, Brown S (2013) Uncertainty in the spatial distribution of tropical forest biomass: a comparison of pan-tropical maps. Carbon Balance and Management, **8**, 10.

Nelson BW, Mesquista R, Pereira JLG, Souza SGA, Batista GT, Couto LB (1999) Allometric regressions for improved estimate of secondary forest biomass in the central Amazon. Forest Ecology and Management, **117**, 149–167.

Nepstad DC, Veríssimo A, Alencar A *et al.* (1999) Large-scale impoverishment of Amazonian forests by logging and fire. Nature, **398**, 505–508.

Nogueira EM (2008) Wood density and tree allometry in forests of Brazil`s 'arc of deforestation': Implications for biomass and emission of carbon from land-use change in Brazilian Amazonia. PhD Thesis. National Institute for Research in the Amazon (INPA), Manaus, AM, Brazil.

Nogueira EM, Fearnside PM, Nelson BW, Barbosa RI, Keizer EWH (2008a) Estimates of forest biomass in the Brazilian Amazon: New allometric equations and adjustments to biomass from wood-volume inventories. Forest Ecology and Management, **256**, 1853–1867.

Nogueira EM, Fearnside PM, Nelson BW, França MB (2007) Wood density in forests of Brazil's 'arc of deforestation': Implications for biomass and flux of carbon from land-use change in Amazonia. Forest Ecology and Management, **248**, 119–135.

Nogueira EM, Nelson BW, Fearnside PM (2006) Volume and biomass of trees in central Amazonia: Influence of irregularly shaped and hollow trunks. Forest Ecology and Management, **227**, 14–21.

Nogueira EM, Nelson BW, Fearnside PM, França MB, de Oliveira ACA (2008b) Tree height in Brazil's 'arc of deforestation': Shorter trees in south and southwest Amazonia imply lower biomass. Forest Ecology and Management, **255**, 2963–2972.

Nordhaus I, Wolff M, Diele K (2006) Litter processing and population food intake of the mangrove crab *Ucides cordatus* in a high intertidal forest in northern Brazil. Estuarine, Coastal and Shelf Science, **67**, 239–250.

Numata I, Cochrane MA, Roberts DA, Soares JV, Souza Jr CM, Sales MH (2010) Biomass collapse and carbon emissions from forest fragmentation in the Brazilian Amazon. Journal of Geophysical Research, **115**, G03027, doi:10.1029/2009JG001198

Ometto JP, Aguiar AP, Assis T, Soler L, Valle P, Tejada G, Lapola DM, Meir P (2014) Amazon forest biomass density maps: tacking the uncertainty in carbon emission estimates. Climatic Change, **124**, 545–560.

Ottmar RD, Vihnanek RE, Miranda HS, Sato MN, Andrade SMA (2001) Stereo photo series for quantifying Cerrado fuels in central Brazil – Volume I. Gen. Tech. Rep. PNW-GTR-519. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA. 87 pp.

Paiva AO, Rezende AV, Pereira RS (2011) Estoque de carbono em cerrado *sensu stricto* do Distrito Federal. Revista Árvore, **35**, 527–538.
Pan Y, Birdsey RA, Fang J (2011) A large and persistent carbon sink in the world's forests. Science, **333**, 988–993.
Peña-Claros M, Poorter L, Alarcón A *et al.* (2012) Soil effects on forest structure and diversity in a moist and a dry tropical forest. Biotropica, **44**, 276–283.
Pires JM, Prance GT (1985) The Vegetation types of the Brazilian Amazon. In: *Key Environments Amazonia* (eds Prance GT, Lovejoy TE), pp. 109–145. Pergamon Press, Oxford, UK.
Pires LA, Britez RM, Martel G, Pagano SN (2006) Produção, acúmulo e decomposição da serapilheira em uma restinga da Ilha do Mel, Paranaguá, PR, Brasil. Acta Botanica Brasilica, **20**, 173–184.
Potapov P, Yaroshenko A, Turubanova S *et al.* (2008) Mapping the world´s intact forest landscapes by remote sensing. Ecology and Society, **13**, 51.
Proisy C, Couteron P, Fromard F (2007) Predicting and mapping mangrove biomass from canopy grain analysis using Fourier-based textural ordination of IKONOS images. Remote Sensing of Environment, **109**, 379–392.
Quesada CA, Phillips OL, Schwarz M *et al.* (2012) Basin-wide variations in Amazon forest structure and function are mediated by both soils and climate. Biogeosciences, **9**, 2203–2246.
Rezende AV (2002) Diversidade, estrutura, dinâmica e prognose do crescimento de um cerrado *sensu stricto* submetido a diferentes distúrbios por desmatamento. PhD Thesis. Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil.
Ribas LM (2007) Concentração e aporte de elementos da serapilheira do manguezal do estuário do Rio Paraíba do Sul, estado do Rio de Janeiro, Brasil. Masters Thesis. Universidade Federal do Norte Fluminense (UENF), Niteroi, RJ, Brazil.
Ribeiro SC, Fehrmann L, Soares CPB, Jacovine LAG, Klein C, Gaspar RO (2011) Above- and belowground biomass in a Brazilian Cerrado. Forest Ecology and Management, **262**, 491–499.
Rizzini CT (1997) Tratado de Fitogeografia do Brasil: Aspectos ecológicos, sociológicos e florísticos, 2 ed. Editora Hucitec Edusp, São Paulo, SP, Brazil. 747 pp.
Saatchi SS, Harris NL, Brown S *et al.* (2011) 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.
Saatchi SS, Houghton RA, Alvalá RCS, Soares JV, Yu Y (2007) Distribution of aboveground live biomass in the Amazon Basin. Global Change Biology, **13**, 816–837.
Santos JR (1988) Biomassa aérea da vegetação de cerrado: estimativa e correlação com dados do sensor Thematic Mapper do Satélite Landsat. PhD Thesis. Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil.
Santos JR, Pardi LaCruz MS, Araujo LS, Keil M (2002) Savanna and tropical rainforest biomass estimation and spatialization using JERS-1 data. International Journal of Remote Sensing, **23**, 1217–1229.
Schietti J, Emilio T, Rennó CD *et al.* (2014) Vertical distance from drainage drives floristic composition changes in an Amazonian rainforest. Plant Ecology & Diversity, **7**, 241–253.
Schöngart J, Wittmann F, Worbes M (2010) Biomass and net primary production of central Amazonian floodplain forests. In: *Amazonian Floodplain Forests: Ecophysiology, Biodiversity and Sustainable Management* (eds Junk WJ, Piedade MTF, Wittmann F, Schöngart J, Parolin P), pp. 347–388, Ecological Studies 210. Springer Verlag, Berlin, Germany.
Silva CAR, Lacerda LD, Ovalle AR, Rezende CE (1998) The dynamics of heavy metals through litterfall and decomposition in a red mangrove forest. Mangroves and Salt Marshes, **2**, 149–157.
Silva CAR, Lacerda LD, Silva LFF, Rezende CE (1991) Forest structure and biomass distribution in a red mangrove stand in Sepetiba Bay, Rio de Janeiro. Revista Brasileira de Botânica, **14**, 21–25.
TerraClass (2010) Levantamento de informações de uso e cobertura da terra na Amazônia-2010 (Sumário Executivo). Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Instituto Nacional

de Pesquisas Espaciais (INPE), São José dos Campos, SP, Brazil. 7 pp. http://www.inpe.br/cra/projetos_pesquisas/terraclass2010.php (accessed 03/06/2014)

Torezan JMD, Silveira M (2000) The biomass of bamboo (*Guadua weberbaueri* Pilger) in open forest of the southwestern Amazon. Ecotropica, **6**, 71–76.

Veloso HP, Rangel Filho ALR, Lima JCA (1991) Classificação da Vegetação Brasileira, Adaptada a um Sistema Universal. Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janeiro, RJ, Brazil. 123 pp.

Woodhouse IH, Mitchard ETA, Brolly M, Maniatis D, Ryan CM (2012) Radar backscatter is not a 'direct measure' of forest biomass. Nature Climate Change, **2**, 556–557.

Xaud HAM, Martins FSRV, dos Santos JR (2013) Tropical forest degradation by mega-fires in the northern Brazilian Amazon. Forest Ecology and Management, **294**, 97–106.

Zarin D (2012) Carbon from tropical deforestation. Science, **336**, 1518–1519.

Supporting information

Table S1. Details on collection sites, sampling methods, number and size of plots for each source dataset used in Tables 1 and 2.

Table S2. Notes for Tables 1 and 2.

Table S3. Total biomass and carbon stocks (dry weight in Pg) by vegetation physiognomy in the Amazonia biome.

Figure S1. Variability of total biomass shown in Figure 2.

Figure S2. Distribution of original total biomass (above- and below-ground; dry weight in Mg ha^{-1}) in areas cleared through 2013 in Brazil's "Legal Amazonia" and "Amazonia biome" regions.

Table 1. Dry above-ground biomass and carbon stock estimates (Mg ha^{-1}) for *campinaranas* (vegetation on white-sand soils), savannas and pioneer formations from 38 published studies (see Table S1 in Supplementary Material for details about collection sites, sampling method, number and size of plots for each source dataset used). Means for each vegetation type are shown in bold.

Vegetation type (Legend from Brazil, IBGE, 1992)	**Herbaceous ± SD or (±SE)**		**Trees and Shrubs ± SD or (±SE)**		**Necromass (litter) ± SD or (±SE)**		**Total live and dead biomass ± SD or (±SE)**		**Carbon ± SD or (±SE)**		**Source**	**Note**
Forested shade-loving *campinarana* (Ld)	-	-	264.35	1.63	-	-	-	-	-	-	Lima *et al.* (2012, Table 2)	[1]
	1.96	-	180.36	-	9.75	-	192.05	-	86.04	-	Bongers *et al.* (1985, Tables 3, 9 and 10) "Tall *Bana*"	[2], [3]
	3.46	-	273.48	-	13.12	9.34	289.88	-	129.86	-	Klinge & Herrera (1983, Tables 5 and 16)	[3], [4]
Mean	**2.71**	**-**	**239.40**	**-**	**11.44**	**-**	**253.54** [a]	**-**	**113.59**	**-**		[3]
Treed shade-loving *campinarana* (La)	0.83	-	13.70	-	1.37	-	15.90	-	7.12	-	Barbosa & Ferreira (2004, Tables 4 and 6)	[3], [5]
	-	-	-	-	-	-	38.80	-	17.38	-	Barbosa & Fearnside (1999, Table 3)	[3], [6]
	2.47	-	37.32	-	31.80	-	71.57	-	32.06	-	Bongers *et al.* (1985, Tables 3, 9 and 10) "Low *Bana*"	[2], [3]
Mean	**1.65**	**-**	**25.51**	**-**	**16.58**	**-**	**42.09**	**-**	**18.86**	**-**		
Grassy-woody shade-loving *campinarana* (Lg)	1.92	-	3.88	-	1.85	-	7.65	-	2.96	-	Bongers *et al.* (1985, Tables 3, 9 and 10) "Open *Bana*"	[2], [3]
Mean	**1.92**	**-**	**3.88**	**-**	**1.85**	**-**	**7.65**	**-**	**2.96**	**-**		
Seasonal forested savanna (Sd)	2.02	1.29	39.41	18.97	9.86	4.84	51.29	21.46	22.98	9.61	Ottmar *et al.* (2001) "*Cerrado Denso*"	[3], [7]
Mean	**2.02**	1.29	**39.41**	18.97	**9.86**	4.84	**51.29**	21.46	**22.98**	9.61		
Seasonal treed savanna (Sa)	-	-	15.10	-	9.21	-	-	-	-	-	Paiva *et al.* (2011, Table 3)	[8]
	-	-	67.64	-	6.32	12.3*	73.96	-	33.13	-	Ribeiro *et al.* (2011)	
	-	-	-	-	-	-	9.43	1.31	4.23	0.59	Brazil, MCT (2006, Table 2) "*Cerrado sensu stricto*"	[3], [9]
	1.52	0.42	9.56	1.30	0.65	-	11.73	1.12	5.22	0.52	Barbosa & Fearnside (2005, Tables 3 and 5) "Sa"	[10]
	-	-	-	-	-	-	-	-	11.60	-	Rezende (2002, p. 216)	[11]

	-	-	-	-	-	-	14.11	3.41	6.32	1.53	Santos *et al.* (2002, Table 1) "Savanna woodland"	[3], [12]
	-	-	-	-	-	-	12.40	-	5.56	-	de Araújo *et al.* (2001)	[13]
	1.35	-	19.32	-	2.06	-	22.73	-	10.18	-	Lilienfein *et al.* (2001, Tables 2 and 4)	[3], [14]
	2.50	0.61	26.15	12.45	8.41	2.93	37.06	15.56	16.60	6.97	Ottmar *et al.* (2001) "*Sensu stricto*"	[3], [7], [15], [16], [17]
	-	-	-	-	-	-	39.79	-	17.83	-	Abdala *et al.* (1998)	[3], [18]
	4.80	-	12.80	-	7.20	-	24.80	(2.50)	11.11	(1.12)	Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, aberto*"	[3], [19]
	2.30	-	16.10	-	6.60	-	25.00	(2.90)	11.20	(1.30)	Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, denso*"	[3], [19]
	8.11	-	-	-	1.82	0.61	-	-	-	-	Kauffman *et al.* (1994, Table 1) "*Cerrado sensu stricto*"	[20]
	-	-	-	-	-	-	27.38	6.68	12.26	2.99	Santos (1988, pp. 143-144)	[3], [21]
Mean	**3.43**	**-**	**23.81**	**-**	**5.28**	**-**	**27.13**	**-**	**12.10**	**-**		
Seasonal parkland savanna (Sp)	-	-	19.50	-	-	-	-	-	-	-	Delitti *et al.* (2006, Tables 4 and 8) "*Campo cerrado*"	-
	3.65	0.86	3.64	0.16	0.74	-	8.04	0.47	3.42	0.18	Barbosa & Fearnside (2005, Tables 3 and 5) "Sp"	[10], [22]
	-	-	-	-	-	-	7.42	1.73	3.19	0.74	Santos *et al.* (2002, Table 1) "Shrub and/or treed savanna"	[3], [12]
	3.99	2.86	13.04	7.95	5.14	2.94	22.17	8.06	9.53	3.47	Ottmar *et al.* (2001) "*Cerrado ralo*"	[3], [7], [16]
	7.27	-	-	-	1.33	0.62	-	-	-	-	Kauffman *et al.* (1994, Table 1) "*Campo cerrado*"	[20]
Mean	**4.97**	**-**	**12.06**	**-**	**2.40**	**-**	**12.54**	**-**	**5.38**	**-**		
Seasonal grassy-woody savanna (Sg)	4.59	-	1.06	0.68	0.66	-	6.31	0.88	2.30	-	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Arg"	[23]
	5.89	-	0.60	1.08	0.85	-	7.34	1.96	2.68	-	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Lts"	[23]
	5.34	-	2.76	1.59	0.77	-	8.87	2.43	3.42	-	Barbosa *et al.* (2012, Tables 1, 2 and 4) "GP-Lts"	[23]
	7.65	-	-	-	1.36	-	9.01	2.86	3.26	-	Barbosa *et al.* (2012, Tables 1, 2 and 4) "WG-Hyd"	[23]
	-	-	-	-	-	-	4.77	1.84	1.85	0.71	Santos *et al.* (2002, Table 1) "Grassland savanna"	[3], [12]

	-	-	-	-	-	-	7.18	1.42	2.78	0.55	Brazil, MCT (2006, Table 1) "*Campo sujo*"	[3], [7]
	2.77	0.50	0.04	0.00	0.50	-	3.31	0.45	1.19	0.16	Barbosa & Fearnside (2005, Tables 3 and 5) "Sg Clean field"(*Campo limpo)*	[10], [22]
	2.31	0.98	0.60	0.01	0.35	-	3.26	0.71	1.24	0.24	Barbosa & Fearnside (2005; Tables 3 and 5) "Sg Dirty field" (*Campo sujo*)	[10], [22]
	8.84	4.74	0.04	0.11	0.95	0.70	9.84	5.18	3.56	1.88	Ottmar *et al.* (2001) "*Campo limpo*"	[3], [7], [16]
	5.58	2.62	2.52	2.09	2.71	1.21	10.81	3.08	4.18	1.19	Ottmar *et al.* (2001) "*Campo sujo*"	[3], [7]
	2.90	-	-	-	2.60	-	-	-	-	-	Castro & Kauffman (1998, Table 1) "*Campo limpo*"	[19]
	2.20	-	1.70	(0.30)	5.30	-	9.20	(0.80)	3.56	(0.31)	Castro & Kauffman (1998, Table 1) "Campo sujo"	[3], [19]
	2.31	0.96	-	-	1.26	0.41	3.57	1.06	1.29	0.38	Cardoso *et al.* (2000, Figure 2)	[3], [24]
	7.13	-	-	-	-	-	-	-	-	-	Kauffman *et al.* (1994, Table 1) "*Campo limpo*"	-
	7.32	-	-	-	-	-	-	-	-	-	Kauffman *et al.* (1994, Table 1) "*Campo sujo*"	-
Mean	**4.99**	-	**1.16**	-	**1.57**	-	**6.95**	-	**2.61**	-		
Steppe-like seasonal treed savanna (Ta)	1.52	0.42	7.64	0.25	1.08	-	10.25	0.26	4.40	0.11	Barbosa & Fearnside (2005, Tables 4 and 6) "Ta"	[10]
Mean	**1.52**	0.42	**7.64**	0.25	**1.08**	-	**10.25**	0.26	**4.40**	0.11		
Steppe-like seasonal parkland savanna (Tp)	3.17	1.53	2.32	0.08	0.64	-	6.13	0.85	2.52	0.32	Barbosa & Fearnside (2005, Tables 4 and 6) "Tp"	[10]
Mean	**3.17**	1.53	**2.32**	0.25	**0.64**	-	**6.13**	0.85	**2.52**	0.32		
Steppe-like seasonal grassy-woody savanna (Tg)	1.38	0.49	0.09	0.01	0.16	-	1.63	0.43	0.68	0.17	Barbosa & Fearnside (2005, Tables 4 and 6) "Tg Clean field" (*Campo limpo*)	[10]
	2.28	1.00	1.32	0.21	0.45	-	4.05	0.65	1.72	0.26	Barbosa & Fearnside (2005, Table 4 and 6) "Tg Dirty field" (*Campo sujo*)	[10]
Mean	**1.83**	**-**	**0.70**	**-**	**0.30**	**-**	**2.84**	**-**	**1.20**	**-**		
Pioneer vegetation in areas with riverine	-	-	-	-	-	-	18.00	3.00	8.06	1.35	Schöngart *et al.* (2010, Table 18.10)	[25], [26]

influence (Pa)												
	-	-	-	-	-	-	21.35	-	9.56	-	Junk & Piedade (1993)	[26], [27]
Mean	**-**	**-**	**-**	**-**	**-**	**-**	**19.68**	**-**	**8.81**	**-**		
Pioneer vegetation in areas with marine influence (Pm) [b, c]	-	-	-	-	7.68	-	-	-	-	-	Assis *et al.* (2011, p. 108)	[28]
	-	-	166.30	-	-	-	-	-	-	-	Alves *et al.* (2010, Table 3 "*Restinga* forest")	[29]
	-	-	3.55	-	1.59	-	5.14	-	-	-	Dias *et al.* (2006, Table 2 "*Restinga* open woodland")	[30]
	-	-	-	-	5.54	-	-	-	-	-	Pires *et al.* (2006; p.177)	[31]
	-	-	-	-	3.93	-	-	-	-	-	de Moraes *et al.* (1999, Table 2)	[28]
Mean	**-**	**-**	**84.92**	**-**	**4.69**	**-**	**89.61** [a]	**-**	**40.14**	**-**		[26]
Pioneer vegetation in areas with riverine and marine influence (Pf) [c]	-	-	104.78	-	-	-	-	-	-	-	Medeiros & Sampaio (2008, Table 5)	-
	-	-	-	-	11.36	-	-	-	-	-	de Menezes *et al.* (2008, Table 4)	[28], [32]
	-	-	-	-	7.40	-	-	-	-	-	Fernandes *et al.* (2007)	[28]
	-	-	195.38	109.27	-	-			-	-	Proisy *et al.* (2007, Table 1)	[33]
	-	-	-	-	6.17	-	-	-	4.07	-	Ribas (2007, p. 30)	[28]
	-	-	-	-	7.29	-	-	-	-	-	Gonçalves *et al.* (2006)	[28]
	-	-	-	-	16.38	-	-	-	-	-	Nordhaus *et al.* (2006)	[28]
	-	-	201.45	-	-	-	-	-	-	-	Fromard *et al.* (1998, Table 4)	[34]
	-	-	-	-	8.69	-	-	-	-	-	Silva *et al.* (1998)	[28]
	-	-	65.37	-	-	-	-	-	-	-	Silva *et al.* (1991, Table 1)	-
Mean	**-**	**-**	**141.75**	**-**	**9.55**	**-**	**151.29** [a]	**-**	**73.03**	**-**		[35]

[a] The estimates of mean biomass can sometimes differ from the simple mean of the values listed in the table. In these cases the value was calculated so as to take advantage of the estimates that only report the biomass of some of the components of the vegetation (*e.g.*, the total biomass can be obtained from the sum of the means of the components).

[b] "Seasonally flooded coastal forest at sea level" (also known as *restinga*) refers to vegetation mosaics growing on poor sandy soil along the Brazilian coast, which include forests and open woodlands (César & Monteiro, 1995; Rizzini, 1997; Assis *et al.*, 2004).

[c] Despite estimates having been carried out in Amazonia for "pioneer vegetation in areas with riverine influence" (Pa) and in "pioneer vegetation in areas with riverine-marine influence" (Pf) (*e.g.*, Fernandes *et al.*, 2007; Proisy *et al.*, 2007; de Menezes *et al.*, 2008; Schöngart *et al.*, 2010), we used additional estimates obtained in other regions of Brazil (*e.g.*, the states of Pernambuco, São Paulo and Rio de Janeiro), especially for "pioneer vegetation in areas with marine influence" (Pm).

* Standard deviation value is express in %.

See Table S2 in Supplementary Material for notes [1] to [35].

Table 2. Dry below-ground-biomass and carbon stock estimates (Mg ha^{-1}) for *campinaranas* (vegetation on white-sand soils), savannas and pioneer formations from 17 published studies (see Table S1 in Supplementary Material for details about collection sites, sampling method, number and size of plots for each source dataset used). Means for each vegetation type are shown in bold.

Vegetation type (Legend from Brazil, IBGE, 1992)	**Root mass [a] (only ≥ 2 mm) (± SD or SE)**		**Total root mass [b] (± SD or SE)**		**Carbon (± SD or SE)**		**Max. Depth (m)**	**Source**	**Note**
Forested shade-loving *campinarana* (Ld)	33.75	1.20	-	-	-	-	2.20	Lima *et al.* (2012, Table 2)	
	-	-	127.50	-	63.75	-	0.68	Bongers *et al.* (1985, Tables 3, 9 and 10) "Tall *Bana*"	[2], [36]
	-	-	134.84	75.19	67.42	-	-	Klinge & Herrera (1983, Tables 5 and 16)	[36]
Mean	**33.75**	**-**	**131.17**	**75.19**	**65.58**	**-**	-		
Treed shade-loving *campinarana* (La)	-	-	23.08	-	11.54	-	-	Barbosa & Ferreira (2004, Tables 4 and 6)	[36], [5]
	-	-	21.30	-	10.65	-	-	Barbosa & Fearnside (1999, Table 3)	[36], [6]
	-	-	69.00	-	34.50	-	0.39	Bongers *et al.* (1985, Tables 3, 9 and 10) "Low *Bana*"	[2], [36]
Mean	**-**	**-**	**37.79**	**-**	**18.90**	**-**	**-**		
Grassy-woody shade-loving *campinarana* (Lg)	-	-	42.00	-	21.00	-	0.22	Bongers *et al.* (1985, Tables 3, 9 and 10) "Open *Bana*"	[2], [36]
Mean	**-**	**-**	**42.00**	**-**	**21.00**	**-**	**-**		
Seasonal forested savanna (Sd)	**-**	**-**	108.52	-	54.26	-	-	Ottmar *et al.* (2001) "*Cerrado Denso*"	[36], [37]
Mean	**-**	**-**	**108.52**	**-**	**54.26**	**-**	**-**		
Seasonal treed savanna (Sa)	-	-	46.63	-	22.38	-	2.00	Paiva *et al.* (2011, Table 3)	[8]
	-	-	37.50	23.0*	18.75	-	1.00	Ribeiro *et al.* (2011)	[36]
	-	-	-	-	18.60	-	-	Rezende (2002, p. 216)	[11]
	12.76	-	30.36	-	15.18	-	2.00	Lilienfein *et al.* (2001, Tables 2 and 4)	[36]
	-	-	43.10	-	21.55	-	6.00	Abdala *et al.* (1998)	[36]
	-	-	46.60	-	23.30	-	2.00	Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, aberto*"	[36]
	-	-	52.90	-	26.45	-	2.00	Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, denso*"	[36]
Mean	**12.76**	**-**	**42.85**	**-**	**20.89**	**-**	**-**		

Seasonal parkland savanna (Sp)	-	-	15.10	-	7.55	-	-	Barbosa & Fearnside (2005, Tables 3 and 5) "Sp"	[36], [38]
	-	-	13.95	-	6.97	-	-	Santos *et al.* (2002, Table 1) "Shrub and/or treed savanna"	[36], [12], [38]
	-	-	41.66	-	20.83	-	-	Ottmar *et al.* (2001) "*Cerrado ralo*"	[36], [38]
Mean	-	-	**23.57**	-	**11.79**	-	-		
Seasonal grassy-woody savanna (Sg)	1.14	-	21.40	2.47	6.69	0.29	1.00	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Arg"	
	0.47	-	22.62	2.21	6.25	1.12	1.00	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Lts"	
	1.65	-	22.14	4.90	7.21	1.85	1.00	Barbosa *et al.* (2012, Tables 1, 2 and 4) "GP-Lts"	
	0.00	-	29.52	7.15	7.10	1.65	1.00	Barbosa *et al.* (2012, Tables 1, 2 and 4) "WG-Hyd"	
	-	-	16.30	-	4.79	-	2.00	Castro & Kauffman (1998, Table 1) "*Campo limpo*"	[39]
	-	-	30.10	-	8.84	-	2.00	Castro & Kauffman (1998, Table 1) "*Campo sujo*"	[39]
Mean	-	-	**23.68**	-	**6.81**	-	**1.33**		
Steppe-like seasonal treed savanna (Ta)	-	-	19.26	-	9.63	-	-	Barbosa & Fearnside (2005, Tables 4 and 6) "Ta"	[36], [38]
Mean	-	-	**19.26**	-	**9.63**	-	-		
Steppe-like seasonal parkland savanna (Tp)	-	-	11.52	-	5.76	-	-	Barbosa & Fearnside (2005, Tables 4 and 6) "Tp"	[36], [38]
Mean	-	-	**11.52**	-	**5.76**	-	-		
Steppe-like seasonal grassy-woody savanna (Tg)	-	-	4.98	-	2.49	-	-	Barbosa & Fearnside (2005, Tables 4 and 6) "Tg Clean field" (*Campo limpo*)	[36], [40]
	-	-	12.38	-	6.19	-	-	Barbosa & Fearnside (2005, Table 4 and 6) "Tg Dirty field" (*Campo sujo*)	[36], [40]
Mean	-	-	**8.68**	-	**4.34**	-	-	-	-
Pioneer vegetation in areas with riverine influence (Pa)	-	-	7.56	-	3.39	-	-	Schöngart *et al.* (2010, Table 18.10)	[36], [26], [41]
	-	-	8.97	-	4.02	-	-	Junk & Piedade (1993)	[36], [26], [41]
Mean	-	-	**8.26**	-	**3.70**	-	-	-	-
Pioneer vegetation in areas with	-	-	37.64	-	16.86	-	-		[26], [41]

marine influence (Pm)										
Mean	-	-	**37.64**	-	**16.86**	-	-	-		
Pioneer vegetation in areas with riverine and marine influence (Pf)	-	-	75.65	-	36.51	-	-	-		[42], [35]
Mean	-	-	**75.65**	-	**36.51**	-	-	-		

[a] Includes only roots with diameter ≥2 mm, in accord with the recommendation of the IPCC (2006, p. 1.9) that fine roots should not be included as part of the "below-ground biomass" because it is difficult to distinguish them empirically from soil organic matter.

[b] Includes the biomass of roots of all sizes, including fine roots with diameter < 2 mm.

* Standard deviation value is express in %.

See Table S2 in Supplementary Material for notes [2] to [42].

Table 3. Dry biomass and carbon stock estimates (Mg ha^{-1}) for 29 vegetation types in Brazilian Amazonia.

Vegetation type (Legend from Brazil, IBGE, 1992)	Above-ground **biomass** (mean ± SD)	Above-ground **carbon** (mean ± SD)*	Below-ground **biomass** (mean ± SD)	Below-ground **carbon** (mean ± SD)*	Above- and below-ground **biomass** (mean ± SD)	Above- and below-ground **carbon** (mean ± SD.)*	**N° of plots**	**Source**	**Notes**
Dense-canopy rainforest, montane (Dm)	299.66 ± 61.71	145.33 ± 29.93	61.65 ± 12.69	29.90 ± 6.16	361.30 ± 74.40	175.23 ± 36.09	27	Nogueira *et al.* (2008a)	
Dense-canopy rainforest, submontane (Ds)	319.59 ± 76.72	155.00 ± 37.21	65.75 ± 15.78	31.89 ± 7.65	385.33 ± 92.50	186.89 ± 44.86	533	Nogueira *et al.* (2008a)	
Dense-canopy rainforest on non-flooding lowlands (Db)	318.90 ± 58.15	154.67 ± 28.20	65.61 ± 11.96	31.82 ± 5.80	384.50 ± 70.11	186.48 ± 34.00	517	Nogueira *et al.* (2008a)	
Dense-canopy rainforest on river floodplain (Da)	299.26 ± 63.52	145.14 ± 30.81	61.57 ± 13.07	29.86 ± 6.34	360.83 ± 76.59	175.00 ± 37.15	144	Nogueira *et al.* (2008a)	
Open-canopy rainforest, submontane (As)	280.24 ± 64.38	135.92 ± 31.22	55.78 ± 12.81	27.06 ± 6.22	336.02 ± 77.19	162.97 ± 37.44	618	Nogueira *et al.* (2008a)	
Open-canopy submontane forest dominated by bamboo in southwestern Amazonia (Asb)	175.95 ± 32.22	85.33 ± 15.62	32.00 ± 6.34	15.52 ± 3.07	207.95 ± 38.51	100.85 ± 18.68	10	Nogueira *et al.* (2008b)	(a)
Open-canopy rainforest on non-flooding lowlands (Ab)	303.10 ± 57.66	147.00 ± 27.97	60.33 ± 11.48	29.26 ± 5.57	363.43 ± 69.14	176.26 ± 33.53	265	Nogueira *et al.* (2008a)	
Open-canopy rainforest on river floodplain (Aa)	298.39 ± 60.66	144.72 ± 29.42	59.40 ± 12.08	28.81 ± 5.86	357.79 ± 72.74	173.53 ± 35.28	146	Nogueira (2008)	
Seasonal semi-deciduous submontane forest (Fs)	263.27 ± 94.29	127.69 ± 45.73	52.41 ± 18.77	25.42 ± 9.10	315.68 ± 113.06	153.10 ± 54.83	33	Nogueira *et al.* (2008a)	
Seasonal, semi-deciduous, lowland forest (Fb)	257.99 ± 77.44	125.13 ± 37.56	51.36 ± 15.41	24.91 ± 7.48	309.35 ± 92.85	150.03 ± 45.03	12	Nogueira *et al.* (2008a)	
Seasonal, semi-deciduous, alluvial forest (Fa)	236.35 ± 42.76	114.63 ± 20.74	47.05 ± 8.51	22.82 ± 4.13	283.40 ± 51.27	137.45 ± 24.87	9	This, study, unpublished	(b)
Seasonal, deciduous, submontane forest (Cs)	241.90 ± 68.16	117.32 ± 33.06	48.15 ± 13.57	23.35 ± 6.58	290.06 ± 81.72	140.68 ± 39.64	3	This, study, unpublished	(b)
Contact between rainforest and seasonal forest (ON)	259.05 ± 64.12	125.64 ± 31.10	51.57 ± 12.76	25.01 ± 6.19	310.62 ± 76.89	150.65 ± 37.29	128	Nogueira *et al.* (2008a)	
Contact between *campinarana* and rainforest (LO)	320.78 ± 64.36	155.58 ± 31.22	63.85 ± 12.81	30.97 ± 6.21	384.63 ± 77.18	186.55 ± 37.43	274	Nogueira *et al.* (2008a)	
Contact between savanna and rainforest (SO)	262.10 ± 93.73	127.12 ± 45.46	52.17 ± 18.66	25.30 ± 9.05	314.28 ± 112.39	152.42 ± 54.51	77	Nogueira *et al.* (2008a)	
Contact between savanna and seasonal forest (SN)	252.44 ± 76.76	122.43 ± 37.23	50.25 ± 15.28	24.37 ± 7.41	302.69 ± 92.04	146.81 ± 44.64	74	Nogueira *et al.* (2008a)	
Forested shade-loving *campinarana* (Ld)	253.54 ± 69.17	113.59 ± 30.99	131.17 ± 5.19	65.58 ± 2.59	384.71 ± 74.36	179.17 ± 33.58	38	This study, Tables 1 and 2	(c)

Treed shade-loving *campinarana* (La)	42.09 ± 27.98	18.86 ± 12.53	37.79 ± 27.04	18.90 ± 13.52	79.88 ± 53.60	37.75 ± 25.39	25	This study, Tables 1 and 2	(d)
Grassy-woody shade-loving *campinarana* (Lg)	7.65 ± 5.73	2.96 ± 2.22	42.00 ± 14.14	21.00 ± 7.07	49.65 ± 19.87	23.96 ± 9.29	2	This study, Tables 1 and 2	
Seasonal forested savanna (Sd)	51.29 ± 21.46	22.98 ± 9.61	108.52	54.26	159.80	77.24	4	This study, Tables 1 and 2	
Seasonal treed savanna (Sa)	27.13 ± 18.49	12.10 ± 7.90	42.85 ± 7.92	20.89 ± 3.69	69.98 ± 21.20	32.99 ± 9.10	175	This study, Tables 1 and 2	(d), (e)
Seasonal parkland savanna (Sp)	12.54 ± 8.34	5.38 ± 3.60	23.57 ± 15.68	11.79 ± 7.84	36.12 ± 24.02	17.17 ± 11.44	137	This study, Tables 1 and 2	
Seasonal grassy-woody savanna (Sg)	6.95 ± 2.70	2.61 ± 1.03	23.68 ± 5.26	6.81 ± 1.33	30.63	9.42	531	This study, Tables 1 and 2	(d)
Steppe-like seasonal treed savanna (Ta)	10.25 ± 0.26	4.40 ± 0.11	19.26	9.63	29.51	14.03	34	This study, Tables 1 and 2	
Steppe-like seasonal parkland savanna (Tp)	6.13 ± 0.85	2.52 ± 0.32	11.52 ± 1.60	5.76 ± 0.80	17.65	8.28	38	This study, Tables 1 and 2	
Steppe-like seasonal grassy-woody savanna (Tg)	2.84 ± 1.71	1.20 ± 0.74	8.68 ± 5.23	4.34 ± 2.62	11.52 ± 6.94	5.54 ± 3.36	54	This study, Tables 1 and 2	
Pioneer vegetation in areas with riverine influence (Pa)	19.68 ± 2.37	8.81 ± 1.06	8.26 ± 0.99	3.70 ± 0.45	27.94 ± 3.36	12.52 ± 1.51	21	This study, Tables 1 and 2	
Pioneer vegetation in areas with marine influence (Pm)	89.61	40.14	37.64	16.86	127.24	57.01	77	This study, Tables 1 and 2	
Pioneer vegetation in areas with riverine and marine influence (Pf)	151.29	73.03	75.65	36.51	226.94	109.54	141	This study, Tables 1 and 2	

* In forests the carbon content was considered to be 48.5% for dry biomass (da Silva, 2007, Table 6:13b). In non-forest formations these estimates vary in accord with Tables 1 and 2.
(a) The biomass of trees and palms with DBH ≥ 5 cm was obtained from Nogueira *et al.* (2008b). The biomasses of the other components, as explained in the methodology section, were added from the inventories of de Oliveira (2000).
(b) These estimates were obtained using data on wood volume from Brazil, Projeto RadamBrasil (1973-1983) using the same methodology as that used in Nogueira *et al.* (2008a).
(c) For forested shade-loving *campinarana* (Ld)the mean above-ground biomass was obtained as the sum of the means of the components ("Herbaceous", "Trees and shrubs" and "Necromass") from Table 1. The mean was calculated in this way to allow better use of estimates available in the literature. Standard deviation was calculated from the values for the components (Table 1).
(d) The number of plots is approximated and could be greater because there are studies cited in Table 1 and 2 (see also Table S1 in Supplementary Material) for which it is not clear what the total number of plots sampled was.
(e) The calculations of the standard deviation of the biomass and of the total carbon (above-ground + below-ground) only considered means from estimates that reported both above-ground and below-ground biomass.

Table 4. Total gross loss of dry biomass and carbon stocks through 2013 in Brazil's "Legal Amazonia" and "Amazonia biome" regions and in the portion of Legal Amazonia not included in the Amazonia biome.

Stock reduction by region	Dry biomass [and carbon stocks] lost*			
	in Pg (= 10^9 tons or billions of tons)		(in Mg ha^{-1} ± standard deviation)	
Legal Amazonia	27.1 ± 6.6	[13.1 ± 3.2]	280.1 ± 68.2	[135.6 ± 32.9]
Amazonia biome	23.1 ± 5.4	[11.2 ± 2.6]	343.8 ± 80.8	[166.7 ± 39.2]
Area in Legal Amazonia not included in the Amazonia biome	5.6 ± 1.5	[2.7 ± 0.7]	108.5 ± 29.3	[51.8 ± 13.7]

* Note that these uncertainty values underestimate the true variation because some vegetation types do not have measurements of uncertainties associated with the biomass and carbon estimates (see Tables 1, 2 and 3).

Table 5. Dry biomass and carbon stocks in the "pre-modern" vegetation (prior to the great increases in disturbance beginning in the 1970s), in the remaining vegetation after cumulative clearing through 2013 and the corresponding gross loss of biomass for the states in Brazil's Legal Amazonia region.

States in Legal Amazonia	Cleared area in forest and non-forest types (km^2)*	Biomass stock in the 'pre-modern' vegetation	Remaining biomass stock in 2013	Biomass loss through 2013		Carbon stock in the 'pre-modern' vegetation	Remaining carbon stock in 2013	Carbon loss through 2013	
		in Pg (± uncertainty values)**			%	in Pg (± uncertainty values)			%
Acre [1]	20,850.62	4.79 ± 0.92	4.08 ± 0.77	0.71 ± 0.14	14.8	2.32 ± 0.44	1.98 ± 0.37	0.34 ± 0.07	14.8
Amazonas [1]	33,924.86	54.70 ± 10.97	53.49 ± 10.71	1.22 ± 0.26	2.2	26.44 ± 5.29	25.85 ± 5.16	0.59 ± 0.12	2.2
Amapá	2,951.14	4.43 ± 1.00	4.33 ± 0.98	0.10 ± 0.02	2.2	2.14 ± 0.48	2.09 ± 0.47	0.05 ± 0.01	2.2
Maranhão [2,3]	128,418.92	6.36 ± 1.51	2.42 ± 0.56	3.94 ± 0.94	61.9	3.08 ± 0.73	1.17 ± 0.27	1.91 ± 0.46	62.0
Mato Grosso [3]	338,530.22	19.05 ± 5.35	11.77 ± 3.28	7.28 ± 2.07	38.2	9.21 ± 2.57	5.69 ± 1.57	3.52 ± 0.99	38.2
Pará	254,017.13	41.81 ± 9.34	32.57 ± 7.30	9.25 ± 2.04	22.1	20.27 ± 4.53	15.79 ± 3.54	4.48 ± 0.99	22.1
Rondônia [3]	86,464.51	7.47 ± 1.71	4.56 ± 1.02	2.91 ± 0.69	39.0	3.62 ± 0.83	2.21 ± 0.49	1.41 ± 0.33	39.0
Roraima	9,844.23	6.66 ± 1.58	6.31 ± 1.49	0.34 ± 0.09	5.2	3.21 ± 0.76	3.04 ± 0.71	0.16 ± 0.04	5.2
Tocantins [3]	92,001.69	3.03 ± 0.77	1.66 ± 0.42	1.36 ± 0.35	45.0	1.44 ± 0.36	0.79 ± 0.19	0.65 ± 0.16	45.4
Total	967,003.32	148.32 ± 33.16	121.20 ± 26.55	27.11 ± 6.60	-	71.75 ± 15.99	58.62 ± 12.81	13.13 ± 3.18	-

* The value for total cleared area obtained by summing the values for all states is slightly lower that total area cleared in Legal Amazonia because there are small differences between the boundaries of Amazonia Legal and the state boundaries (*e.g.*, for the state of Tocantins).

** Uncertainty is expressed as the sum of the products of the area occupied by each vegetation type (ha) and the limits of the standard deviation of the biomass mean for the corresponding vegetation type. Some values for uncertainties can be larger than the values shown because some vegetation types do not have measurements of uncertainties associated with the biomass and carbon estimates (see Tables 1, 2 and 3).

[1] The estimates for these states were made considering the new state boundaries established by the "Cunha Gomes line."

[2] Refers only to the area of the state falling within the limits of Legal Amazonia.

[3] The total area cleared in these states includes areas deforested that are monitored by INPE/PRODES (Brazil, INPE, 2014) and the areas cleared in the *cerrado* monitored by IBAMA/PMDBBS (Brazil, IBAMA, 2013). In the case of Rondônia, only an area of ~14 km^2 of *cerrado* clearing monitored by IBAMA/PMDBBS was included.

Table 6. Total biomass and carbon stocks (dry weight in Pg) by vegetation physiognomy in Brazil's Legal Amazonia.

Status of vegetation	Vegetation types	Area (km^2)	Dry biomass estimates					
			Above-ground	Uncertainty values.*	Below-ground	Uncertainty values *	Above and below-ground	Uncertainty values*
'Pre-modern' vegetation (prior to the great increases in disturbance beginning in the 1970s)	Forest	3,634,717.94	109.164	24.149	22.162	4.903	131.317	29.052
	Campinarana	183,563.31	3.450	1.009	1.909	0.192	5.358	1.195
	Savanna	832,623.32	2.110	1.235	3.857	0.710	5.967	1.409
	Contact zones**	167,975.64	4.352	1.241	0.871	0.247	5.222	1.488
	Pioneer formations	86,931.29	0.353	0.017	0.165	0.007	0.518	0.025
	Refugium areas	3,999.93	0.0014	0.0006	0.0037	0.0018	0.0051	0.0022
	Total	4,909,811.42	119.43	27.65	28.97	6.06	148.39	33.17
Remaining vegetation in 2013 (after cumulative clearing through 2013).	Forest	3,011,029.80	90.753	19.812	18.438	4.027	109.181	23.838
	Campinarana	182,580.39	3.438	1.005	1.902	0.190	5.340	1.190
	Savanna	598,796.12	1.490	0.851	2.779	0.509	4.268	0.965
	Contact zones**	63,198.12	1.659	0.452	0.335	0.090	1.993	0.542
	Pioneer formations	81,863.06	0.324	0.016	0.151	0.007	0.475	0.023
	Refugium areas	3,812.82	0.0013	0.0006	0.0035	0.0017	0.0048	0.0021
	Total	3,941280.31	97.67	22.14	23.61	4.82	121.26	26.56

* Uncertainty values associated with large-scale estimates do not include uncertainties for those forest types reported in Table 3 without values for standard deviation associated with the mean biomass estimates.

** Includes contact zones between rainforest and seasonal forest, *campinarana* and rainforest, savanna and rainforest, savanna and seasonal forest, savanna and pioneer formations, and seasonal savanna and steppe-like savanna.

FIGURE CAPTIONS

Figure 1. Limits of Legal Amazonia, the Amazonia biome and the Brazilian states in these regions.

Figure 2. Distributions of total biomass (above- and below-ground; dry weight in Mg ha^{-1}) in the original vegetation (before extensive clearing) in two regions of Brazilian Amazonia: in the regions denominated as “Legal Amazonia” (whole map) and as the “Amazonia biome” (black line). See Table 3 for summary of biomass mean and standard deviation by vegetation type.

Figure 3. Framework showing the different stages used in this study for estimates of biomass loss in Legal Amazonia and the Amazonia biome.

SUPPLEMENTARY MATERIAL:

Carbon stock loss from deforestation through 2013 in Brazilian Amazonia

Euler Melo Nogueira[1*], Aurora M Yanai[1], Frederico O Fonseca[1], Philip Martin Fearnside[1*]

[1*] Department of Environmental Dynamics, National Institute for Research in Amazonia (INPA), Av. André Araújo n° 2936, CEP 69 067-375, Manaus, Amazonas, Brazil

Correspondence: Philip Martin Fearnside; Tel.: + 55 92 3643 1822, Fax: + 55 92 3642 3028;

e-mail: pmfearn@inpa.gov.br, philip.fearnside@gmail.com

Table S1. Details on collection sites, sampling methods, number and size of plots for each source dataset used in Tables 1 and 2.

Vegetation type (Legend from Brazil, Source	N° of Plots	Size of plots (m^2)	Sampling method: Direct	Collection site

IBGE, 1992)				**(D) or Indirect (I)**	
Forested shade-loving *campinarana* (Ld)	Lima *et al.* (2012, Table 2)	23	2500	(D) and (I)	State of Amazonas, Brazil.
	Bongers *et al.* (1985, Tables 3, 9 and 10) "Tall *Bana*"	2	5	(D)	San Carlos, Venezuela.
	Klinge & Herrera (1983, Tables 5 and 16)	13	100	(D)	San Carlos, Venezuela.
Treed shade-loving *campinarana* (La)	Barbosa & Ferreira (2004, Tables 4 and 6)	20	500	(D) and (I)	State of Roraima, Brazil.
	Barbosa & Fearnside (1999, Table 3)	-	-	-	State of Roraima, Brazil.
	Bongers *et al.* (1985, Tables 3, 9 and 10) "Low *Bana*"	5	5	(D)	San Carlos, Venezuela.
Grassy-woody shade-loving *campinarana* (Lg)	Bongers *et al.* (1985, Tables 3, 9 and 10) "Open *Bana*"	2	5	(D)	San Carlos, Venezuela.
Seasonal forested savanna (Sd)	Brazil, MCT (2006, Table 3) "*Cerradão*"	-	-	-	Distrito Federal, Brazil.
	Ottmar *et al.* (2001) "*Cerrado Denso*"	4	675*	(D) and (I)	Distrito Federal, Brazil.
Seasonal treed savanna (Sa)	Paiva *et al.* (2011, Table 3)	18	1000	(D) and (I)	Distrito Federal, Brazil.
	Ribeiro *et al.* (2011)	10	500	(D) and (I)	State of Minas Gerais, Brazil.

Brazil, MCT (2006, Table 2) "*Cerrado sensu stricto*"	-	-	-	Distrito Federal, Brazil.
Barbosa & Fearnside (2005, Tables 3 and 5) "Sa"	14	80	(D) and (I)	State of Roraima, Brazil.
Rezende (2002, p. 216)	10	1000	(D) and (I)	Distrito Federal, Brazil.
Santos *et al.* (2002, Table 1) "Savanna woodland"	7	500	(D)	State of Mato Grosso, Brazil.
de Araújo *et al.* (2001)	8	500	(D) and (I)	State of Mato Grosso, Brasil.
Lilienfein *et al.* (2001, Tables 2 and 4)	5	625	(D) and (I)	State of Minas Gerais, Brazil.
Ottmar *et al.* (2001) "*Sensu stricto*"	5	675*	(D) and (I)	Distrito Federal, States of Minas Gerais & Mato Grosso, Brazil.
Abdala *et al.* (1998)	2	1000	(D) and (I)	Distrito Federal, Brazil.
Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, aberto*"	16 a 32	45	(D) and (I)	Distrito Federal, Brazil.
Castro & Kauffman (1998, Table 1) "*Cerrado stricto sensu, denso*"	16 a 32	45	(D) and (I)	Distrito Federal, Brazil.
Kauffman *et al.* (1994,	10	5	(D) and (I)	Distrito Federal,

	Table 1) "*Cerrado sensu stricto*"				Brazil.
	Santos (1988, pp. 143-144)	38	100	(D)	Distrito Federal, Brazil.
Seasonal parkland savanna (Sp)	Delitti *et al.* (2006, Tables 4 and 8) "*Campo cerrado*"	60	-	(D) and (I)	State of São Paulo, Brazil.
	Barbosa & Fearnside (2005, Tables 3 and 5) "Sp"	40	80	(D) and (I)	State of Roraima, Brazil.
	Santos *et al.* (2002, Table 1) "Shrub and/or treed savanna"	18	500	(D)	States of Mato Grosso & Roraima, Brazil.
	Ottmar *et al.* (2001) "*Cerrado ralo*"	9	675*	(D) and (I)	Distrito Federal & States of Minas Gerais & Goiás, Brazil.
	Kauffman *et al.* (1994, Table 1) "*Campo cerrado*"	10	5	(D) and (I)	Distrito Federal, Brazil.
Seasonal grassy-woody savanna (Sg)	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Arg"	4	2500	(D) and (I)	State of Roraima, Brazil.
	Barbosa *et al.* (2012, Tables 1, 2 and 4) "DG-Lts"	8	2500	(D) and (I)	State of Roraima, Brazil.
	Barbosa *et al.* (2012, Tables 1, 2 and 4) "GP-Lts"	5	2500	(D) and (I)	State of Roraima, Brazil.

Barbosa *et al.* (2012, Tables 1, 2 and 4) "WG-Hyd"	10	2500	(D) and (I)	State of Roraima, Brazil.
Santos *et al.* (2002, Table 1) "Grassland savanna"	14	500	(D)	State of Roraima, Brazil.
Brasil, MCT (2006, Table 1) "*Campo sujo*"	-	-	-	Distrito Federal, Brazil.
Barbosa & Fearnside (2005, Tables 3 and 5) "Sg Clean field" (*Campo limpo*)	121	80	(D) and (I)	State of Roraima, Brazil.
Barbosa & Fearnside (2005; Tables 3 and 5) "Sg Dirty field" (*Campo sujo*)	77	80	(D) and (I)	State of Roraima, Brazil.
Ottmar *et al.* (2001) "*Campo limpo*"	7	675*	(D) and (I)	Distrito Federal & State of Goiás, Brazil.
Ottmar *et al.* (2001) "*Campo sujo*"	7	675*	(D) and (I)	Distrito Federal & States of Minas Gerais & Goiás, Brazil.
Castro & Kauffman (1998, Table 1) "*Campo limpo*"	16 a 32	45	(D) and (I)	Distrito Federal, Brazil.
Castro & Kauffman (1998, Table 1) "Campo sujo"	16 a 32	45	(D) and (I)	Distrito Federal, Brazil.
Cardoso *et al.* (2000, Figure 2)	220	1	(D)	State of Mato Grosso do Sul, Brazil.

	Kauffman *et al.* (1994, Table 1) "*Campo limpo*"	5	5	(D)	Distrito Federal, Brazil.
	Kauffman *et al.* (1994, Table 1) "*Campo sujo*"	5	5	(D)	Distrito Federal, Brasil.
Steppe-like seasonal treed savanna (Ta)	Barbosa & Fearnside (2005, Tables 4 and 6) "Ta"	34	80	(D) and (I)	State of Roraima, Brazil.
Steppe-like seasonal parkland savanna (Tp)	Barbosa & Fearnside (2005, Tables 4 and 6) "Tp"	38	80	(D) and (I)	State of Roraima, Brazil.
Steppe-like seasonal grassy-woody savanna (Tg)	Barbosa & Fearnside (2005, Tables 4 and 6) "Tg Clean field" (*Campo limpo*)	42	80	(D) and (I)	State of Roraima, Brazil.
	Barbosa & Fearnside (2005, Table 4 and 6) "Tg Dirty field" (*Campo sujo*)	12	80	(D) and (I)	State of Roraima, Brazil.
Pioneer vegetation in areas with riverine influence (Pa)	Schöngart *et al.* (2010, Table 18.10)	1	500	(I)	State of Amazonas, Brazil.
	Junk & Piedade (1993)	20	1	(D)	State of Amazonas, Brazil.
Pioneer vegetation in areas with marine influence (Pm)	Assis *et al.* (2011, p. 108)	30	0.29	(D)	State of São Paulo, Brazil.
	Alves *et al.* (2010, Table 3 "*Restinga* forest")	1	10000	(I)	State of São Paulo, Brazil.

	Dias *et al.* (2006, Table 2 "*Restinga* open woodland")	6	10000	(D) and (I)	State of Rio de Janeiro, Brazil.
	Pires *et al.* (2006; p.177)	10	0.25	(D)	State of Paraná, Brazil.
	de Moraes *et al.* (1999, Table 2)	30	0.25	(D)	State of São Paulo, Brazil.
Pioneer vegetation in areas with riverine and marine influence (Pf)	Medeiros & Sampaio (2008, Table 5)	-	-	(D) and (I)	State of Pernambuco, Brazil.
	de Menezes *et al.* (2008, Table 4)	-	-	(D) and (I)	State of Pará, Brazil.
	Fernandes *et al.* (2007)	21	1	(D)	State of Pará, Brazil.
	Proisy *et al.* (2007, Table 1)	26	200 - 10000	(D) and (I)	French Guiana
	Ribas (2007, p. 30)	21	0.49	(D)	State of Rio de Janeiro, Brazil.
	Gonçalves *et al.* (2006)	21	1	(D)	State of Pará, Brazil.
	Nordhaus *et al.* (2006)	8	1	(D)	State of Pará, Brazil.
	Fromard *et al.* (1998, Table 4)	23	150 - 400	(D) and (I)	French Guiana
	Silva *et al.* (1998)	11	0.30	(D)	State of Rio de Janeiro, Brazil.
	Silva *et al.* (1991, Table 1)	10	100	(D) and (I)	State of Rio de Janeiro, Brazil.

* In Ottmar *et al.* (2001) the sizes of the plots were calculated summing the area used for sampling woody vegetation (12 circular plots each 0.002 ha in area) with the area used for sampling the herbaceous-bushy stratum (15 plots each 0.25 m^2 in area).

Table S2. Notes for Tables 1 and 2.

Notes	Descriptions
[1]	Above-ground biomass of 'palm trees' and 'lianas' were included in the column 'Trees and shrubs'. According to Lima *et al.* (2012, p. 164), the below-ground biomass includes most of the coarse roots (>~2 mm).
[2]	Bongers *et al.* (1985) considered as "trees" all woody individuals with DBH ≥ 1 cm. The non-woody plants and the climbers (Bongers *et al.*, 1985, Table 3) were included in this study, respectively, in the "Herbaceous" and "Trees and shrubs" columns. For the maximum depth (m) the maximum values reported in Table 6 were considered.
[3]	Carbon stock in total above-ground biomass was estimated using the carbon percentage reported by Barbosa & Fearnside (2005, Table 5) for several savanna ecosystems. In areas classified as "seasonal forested savanna" (Sd), "treed shade-loving *campinarana*" (La), and "forested shade-loving *campinarana*" (Ld), carbon was estimated considering the same percentage (44.8%) reported by Barbosa & Fearnside (2005, Table 5) for "typical *cerrado*." In areas of "grassy-woody *campinarana*" (Lg) we used the carbon percentage (38.7%) reported by Barbosa & Fearnside (2005) for "grassy-woody savanna".
[4]	Klinge & Herrera (1983, Table 5) considered as 'trees' all woody individuals with DBH ≥ 1 cm. In the present study all 'trees' < 1 cm DBH, climbers < 1 cm DBH, epiphytes, moss and ground flora were included in the "Herbaceous" column. Climbers with DBH ≥ 1 cm were included in the "Trees and shrubs" column.
[5]	Among the components of the grassy-woody stratum cited in Table 4 of Barbosa & Ferreira (2004), we included the following in the "Herbaceous" column: Bromeliaceae, sedges and other weeds (Poaceae, Cyperaceae, Eriocaulaceae, Cladonia spp.), and young seedlings of trees and bushes with circumference at the base < 5 cm or diameter < 1.6 cm). The below-ground biomass was obtained by indirect methods, weighted by the results of Barbosa & Fearnside (2002).

[6] These estimates were obtained in the southern part of the state of Roraima in an area of "*campina/campinarana*" by Cavalcanti & Higuchi (personal communication originally cited in Barbosa & Fearnside (1999, Table 3).

[7] Mean biomass and standard deviation values reported in each column were obtained considering the values reported for sites sampled in each physiognomic formation. The "Herbaceous" column includes individuals with diameter < 2 cm and the "Necromass" column includes downed woody material < 2.6 cm in diameter and standing stems ≤ 2.0 cm in diameter measured 30 cm above the soil surface.

[8] The estimated above-ground carbon does not include components with diameter < 5 cm; therefore, it does not include the biomass of the herbaceous components. The biomass of woody individuals was separated into live (the "Trees and shrubs" column) and standing dead, which were included in the "Necromass" column together with the values reported for litter. The dry biomass was obtained by multiplying the estimated carbon by 2, since the equation used by Paiva *et al.* (2011, p. 529) estimates carbon considering that it constitutes 50% of the dry biomass, after Rezende *et al.* (2006). The biomasses of roots were sampled by Paiva *et al.* (2011, p. 530) to 0.30 m depth, with the biomass of roots between 0.30 m and 2 m being estimated based on the percentages reported by Castro (1996), which apparently are the same data as those published by Castro & Kauffman (1998).

[9] Details on sampling have not been supplied for these data because they are not included in the original source (unpublished estimates by H.S. Miranda cited by Brazil, MCT, 2006).

[10] Herbaceous biomass includes all live components (diameter < 2 cm, measured approximately 1 cm above the ground) defined by Barbosa & Fearnside (2005) as "Fine-fuels" pre-burn (Poaceae, Herbs, Cyperaceae, tree seedlings). Dead "fine-fuels" and dead "trees and shrubs" were considered to be "Necromass" in the present study.

[11] Rezende (2002, p. 216) estimated the carbon stock based on the percentages originally obtained in another study carried out in the same area (Castro, 1996). We considered the dry biomass to be double the carbon estimate.

[12] Some of these data come from de Araújo *et al.* (2001).

[13] In the present study we assumed that all of the above-ground components were weighed, although it was not stated explicitly in the methodology of de Araújo *et al.* (2001) that the necromass had also been included.

[14] "Necromass" values here include 2% of the biomass of “all trees” (>0.5 m) and 4% of the biomass of “shrubs and brown grass" because these percentages refer to dead wood (Lilienfein *et al.*, 2001, p. 491). Thus, the values in the "herbaceous" and "trees and shrubs" columns differ from those found in the Table 2 of Lilienfein *et al.* (2001).

[15] The five plots defined in Ottmar *et al.* (2001) as "*cerrado stricto sensu*" were considered to be Sa savanna (open woodland) in the present study.

[16] The palm biomass values were included in the column for biomass of "Trees and Shrubs".

[17] In the sum of subtotal biomass values one of the plots in Ottmar *et al.* (2001) differs from the total biomass reported here for the plot. We considered the sum of the reported sub-total biomass values as correct values, on the assumption that the sum of these reported by Ottmar *et al.* (2001) must be in error.

[18] The estimate of the mass of litter does not include branches and trunks with circumferences ≥ 6 cm.

[19] "Herbaceous" biomass includes green graminoids + dicots, palms and bromeliads. When present, the category "Trees and shrubs" includes the total biomass of shrubs and trees; "Necromass" includes litter, dry graminoids and total woody debris.

[20] Above-ground biomass of "shrub leaves" is not considered as part of the herbaceous component in the present study (see Kauffman *et al.* 1994, Table 1).

[21] Mean biomass was calculated assuming that all of the above-ground components were included in the sampling by Santos (1988) and that the reported values for woody biomass were expressed as dry weight.

[22] These values for above-ground biomass (live and dead) were considered to be the same as those used by Barbosa & Fearnside (1999, Table 3), derived by Barbosa (1998).

[23] Herbaceous biomass was defined as "grasses" (Poaceae, Cyperaceae, seedlings, small dicots and litter) and woody individuals with diameter at the base (Db) < 2 cm, measured at 2 cm above the ground (Barbosa *et al.*, 2012).

[24] The value for biomass refers to the mean of 11 monthly values obtained from digitizing Figure 2 “without burning” from Cardoso *et al.* (2000, p. 2313). Deviations can occur from the values obtained by digitalizing the figure and the original values.

[25] Estimates refer to a 500-m^2 circular plot that was established in young pioneer vegetation (7 years age) on a recently formed sand bar in the Japurá River. The above-ground live forest biomass values were based on three models (one from Cannell, 1984 and two models from Chave *et al.*, 2005). A mean value and a standard deviation of these three estimates were calculated.

[26] The carbon content of the above-ground biomass was considered to be 44.8%, the same percentage adopted by Schöngart *et al.* (2010, p. 368) for fast-growing tree species in the initial stages of succession. This same percentage is reported by da Silva (2007, Table 6.13c) for secondary forest.

[27] The biomass mean was obtained from two mixed herbaceous plant communities, both measured in the upper Amazon floodplain about 80 km upstream of the confluence of the Amazon River and the Rio Negro. A mixed population was composed of various terrestrial Cyperaceae, *Oryza perennis*, and *Paspalum repens*, with the sum of the biomass reached 12.7 Mg ha^{-1}. Other mixed population including *Hymenachne amplexicaulis*, various gramineans, cyperaceans, *Aeschynomene sensitiva*, besides the free floating species

Salvivia sp., *Pistia* sp., *Ceratopteris* sp., and *Eichhornia* sp., with the sum of the biomass reaching 30 Mg ha^{-1}.

[28] The estimates for litter refer to the annual production per hectare, not to estimates of stock per hectare.

[29] The biomass included in the "Trees and shrubs" component refers to trees, palms and tree ferns that have stems with DBH ≥ 4.8 cm.

[30] Estimates of above-ground biomass stock were obtained from three sites with 42, 29 and 20% vegetation cover.

[31] The estimates refer to the total amount of litter accumulated per hectare during the year.

[32] The litter biomass corresponds to the mean obtained from the eight estimates cited by de Menezes *et al.* (2008, Table 4).

[33] For the estimates at the Kaw site, adjusted above-ground biomass values were used (Proisy *et al*. 2007, Table 1).

[34] Biomass based on the mean of stands IV, V, VI and VII. The biomass values reported are clearly underestimated because some species were not evaluated (Fromard *et al.*, 1998, p. 45).

[35] The concentration of carbon was considered to be 48.27% of the dry weight of the wood, obtained from the mean of three species (Ribas, 2007, p. 30).

[36] Carbon was considered to constitute 50% of the dry below-ground biomass.

[37] The below-ground biomass was considered to be 2.12 times greater than the above-ground biomass. This value was obtained from the ratio between the below-ground and above-

Table S3. Total biomass and carbon stocks (dry weight in Pg) by vegetation physiognomy in the Amazonia biome.

Status of vegetation	Vegetation types	Area (km^2)	Dry biomass estimate (± uncertainties values)*						Carbon estimate (± uncertainties values)*					
			Above-ground	Uncertainty value	Below-ground	Uncertainty value	Above and below-ground	Uncertainty value	Above-ground	Uncertainty value	Below-ground	Uncertainty value	Above and below-ground	Uncertainty value
'Pre-modern' vegetation (prior to the great increases in disturbance beginning in the 1970s)	Forest	3,525,085.30	106.329	23.327	21.597	4.740	127.917	28.066	51.566	11.314	10.475	2.299	62.040	13.612
	Campinarana	183,511.85	3.448	1.008	1.908	0.192	5.356	1.195	1.544	0.451	0.954	0.096	2.498	0.545
	Savanna	187,217.29	0.512	0.259	1.020	0.138	1.532	0.233	0.227	0.113	0.500	0.066	0.726	0.107
	Contact zones**	110,275.57	2.888	0.798	0.580	0.159	3.467	0.957	1.400	0.387	0.281	0.077	1.681	0.464
	Pioneer formations	85,275.80	0.341	0.017	0.159	0.007	0.500	0.024	0.160	0.008	0.075	0.003	0.234	0.011
	Refugium areas	3,989.95	0.0014	0.0006	0.0037	0.0018	0.0050	0.0022	0.0006	0.0003	0.0018	0.0009	0.0024	0.0011
	Total	4,095,355.76	113.52	25.41	25.27	5.24	138.78	30.48	54.90	12.27	12.29	2.54	67.18	14.74
Remaining vegetation in 2013 (after cumulative clearing through 2013)	Forest	2,948,509.98	89.157	19.361	18.120	3.937	107.268	23.298	43.238	9.390	8.788	1.910	52.025	11.299
	Campinarana	182,529.21	3.437	1.005	1.901	0.190	5.338	1.190	1.539	0.450	0.950	0.095	2.489	0.542
	Savanna	168,222.06	0.440	0.223	0.878	0.129	1.319	0.214	0.195	0.098	0.429	0.062	0.624	0.099
	Contact zones**	38,603.14	1.033	0.262	0.210	0.052	1.243	0.314	0.501	0.127	0.102	0.025	0.603	0.152
	Pioneer formations	80,493.73	0.313	0.016	0.145	0.007	0.458	0.023	0.146	0.007	0.068	0.003	0.215	0.010
	Refugium areas	3,802.84	0.0013	0.0006	0.0035	0.0017	0.0048	0.0021	0.0006	0.0002	0.0018	0.0009	0.0023	0.0010
	Total	3,422,160.97	94.38	20.87	21.26	4.32	115.63	25.04	45.62	10.07	10.34	2.10	55.96	12.10

* Uncertainties values associated with large-scale estimates do not include uncertainties for those forest types reported in Table 3 without values for the standard deviation associated with the mean biomass estimates.

**Includes contact zones between rainforest and seasonal forest, *campinarana* and rainforest, savanna and rainforest, savanna and seasonal forest, savanna and pioneer formations, and seasonal savanna and steppe-like savanna.

ground biomass reported by Castro & Kauffman (1998, Table 1) in dense *cerrado stricto sensu*.

[38] Below-ground biomass was estimated considering it to be 1.88 times greater than above-ground biomass. This factor was obtained from the ratio between below- and above-ground biomass reported by Castro & Kauffman (1998, Table 1) in open *cerrado stricto sensu*.

[39] The carbon stock in roots was estimated using the mean carbon percentage (29.36%) calculated from the four values for percent total carbon reported by Barbosa *et al.* (2012) in Table 3. The carbon percentages reported by Barbosa *et al.* (2012) were obtained from roots collected to 1 m depth, while the roots collected by Castro & Kauffman (1998) were collected to 2 m depth.

[40] The below-ground biomass was calculated considering the biomass of roots as 3.06 times greater than the total above-ground biomass. This value was obtained from the ratio between the biomass of roots and the total above-ground biomass reported by Barbosa *et al.* (2012, Tables 1 and 2) for four types of grassy-woody savannas in Roraima.

[41] Below-ground biomass was considered to be 42% of the above-ground biomass. This percentage is equivalent to the root/shoot ratio used by Fearnside & Guimarães (1996, Tables 3 and 4) for secondary forest four years after abandonment.

[42] Below-ground biomass was obtained from the ratio between above-ground biomass and below-ground biomass (2.0) estimated by Komiyama *et al.* (2008, Fig. 3) from 12 mangrove stands.

References

Abdala GC, Caldas LS, Haridasan M, Eiten G (1998) Above and belowground organic matter and root:shoot ratio in a cerrado in central Brazil. Brazilian Journal of Ecology, **2**, 11–23.

Alves LF, Vieira SA, Scaranello MA, Camargo PB, Santos FAM, Joly CA, Martinelli LA (2010) Forest structure and live aboveground biomass variation along an elevational gradient of tropical Atlantic moist forest (Brazil). Forest Ecology and Management, **260**, 679–691.

Assis MA, Prata EMB, Pedroni F *et al.* (2011) Florestas de restinga e de terras baixas na planície costeira do sudoeste do Brasil: vegetação e heterogeneidade ambiental. Biota Neotropica, **11**, 103–121.

Barbosa RI (1998) Incêndios de Roraima (1997/98): Área queimada, biomassa, mortalidade e formação de carvão nas principais fitofisionomias. Instituto Nacional de Pesquisas da Amazônia / Núcleo de Pesquisas de Roraima (INPA/NPRR), 04.12.98. Boa Vista, RR, Brazil. 20 pp. (manuscript).

Barbosa RI, dos Santos JRS, da Cunha MS, Pimentel TP, Fearnside PM (2012) Root biomass, root: shoot ratio and belowground carbon stocks in the open savannahs of Roraima, Brazilian Amazonia. Australian Journal of Botany, **60**, 405–416.

Barbosa RI, Fearnside PM (1999) Incêndios na Amazônia brasileira: Estimativa da emissão de gases do efeito estufa pela queima de diferentes ecossistemas de Roraima na passagem do evento “El Niño” (1997/98). Acta Amazonica, **29**, 513–534.

Barbosa RI, Fearnside PM (2002) Área e biomassa dos ecossistemas terrestres da Amazônia Legal Brasileira: estimativas para avaliações da emissão de gases do efeito estufa. Relatório de Pesquisa, Núcleo de Pesquisas de Roraima, Instituto Nacional de

Pesquisas da Amazônia (INPA), Biblioteca do INPA, Manaus, Amazonas, Brazil. 30 pp.

Barbosa RI, Fearnside PM (2005) Above-ground biomass and the fate of carbon after burning in the savannas of Roraima, Brazilian Amazonia. Forest Ecology and Management, **216**, 295–316.

Barbosa RI, Ferreira CAC (2004) Biomassa acima do solo de um ecossistema de "campina" em Roraima, norte da Amazônia Brasileira. Acta Amazonica, **34**, 577–586.

Bongers F, Engelen D, Klinge H (1985) Phytomass structure of natural plant communities on spodosols in southern Venezuela: the Bana woodland. Vegetatio, **63**, 13–34.

Brazil, MCT (2006) Emissões de gases de efeito estufa da queima de biomassa no cerrado não-antrópico utilizando dados orbitais. Primeiro Inventário Brasileiro de Emissões Antrópicas de Gases de Efeito Estufa. Relatório de Referência. Ministério da Ciência e Tecnologia (MCT), Brasília, DF, Brazil, 51 pp.

Cannell MGR (1984) Woody biomass of forest stands. Forest Ecology and Management, **8**, 299–312.

Cardoso EL, Crispim SMA, Rodrigues CAG, Barioni Júnior W (2000) Composição e dinâmica da biomassa aérea após a queima em savana gramíneo-lenhosa no Pantanal. Pesquisa Agropecuária Brasileira, **35**, 2309–2316.

Castro EA (1996) Biomass, nutrient pools and response to fire in the Brazilian cerrado. Masters Thesis. Oregon State University, Corvalis, OR, USA.

Castro EA, Kauffman JB (1998) Ecosystem structure in the Brazilian Cerrado: A vegetation gradient of aboveground biomass, root mass and consumption by fire. Journal of Tropical Ecology, **14**, 263–283.

Chave J, Andalo C, Brown S *et al.* (2005) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia, **145**, 87–99.

da Silva RP (2007) Alometria, estoque e dinâmica da biomassa de florestas primárias e secundárias na região de Manaus (AM). PhD Thesis. Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil.

de Araújo LS, dos Santos JR, Keil M, Pardi Lacruz MS, Kramer JCM (2001) Razão entre bandas do SIR-C/ X SAR para estimativa de biomassa em áreas de contato floresta e cerrado. In: *Anais X Simpósio Brasileiro de Sensoriamento Remoto (SBSR)*, pp. 1513–1520, Foz do Iguaçu, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP. Brazil.

de Menezes MPM, Berger U, Mehlig U (2008) Mangrove vegetation in Amazonia: A review of studies from the coast of Pará and Maranhão States, north Brazil. Acta Amazonica, **38**, 403–420.

de Moraes RM, Delitti WBC, Struffaldi-de-Vuono Y (1999) Litterfall and litter nutrient content in two Brazilian Tropical Forests. Brazilian Journal of Botany, **22**, 9–16.

Delitti WBC, Meguro M, Pausas JG (2006) Biomass and mineralmass estimates in a "cerrado" ecosystem. Revista Brasileira de Botânica, **29**, 531–540.

Dias ATC, de Mattos EA, Vieira SA, Azeredo JV, Scarano FR (2006) Aboveground biomass stock of native woodland on a Brazilian sandy coastal plain: Estimates based on the dominant tree species. Forest Ecology and Management, **226**, 364–367.

Fearnside PM, Guimarães WM (1996) Carbon uptake by secondary forests in Brazilian Amazonia. Forest Ecology and Management, **80**, 35–46.

Fernandes MEB, do Nascimento AAM, Carvalho ML (2007) Estimativa da produção anual de serapilheira dos bosques de mangue no furo grande, Bragança-Pará. Revista Árvore, **31**, 949–958.

Fromard F, Puig H, Mougin E, Marty G, Betoulle JL, Cadamuro L (1998) Structure, above-ground biomass and dynamics of mangrove ecosystems: new data from French Guiana. Oecologia, **115**, 39–53.

Gonçalves ASC, Fernandes MEB, Carvalho ML (2006) Variação anual da produção de serapilheira em bosques de mangue no Furo Grande, Bragança, Pará. Boletim Museu Paraense Emílio Goeldi, Ciências Naturais, **1**, 35–42.

Junk WJ, Piedade MTF (1993) Biomass and primary-production of herbaceous plant communities in the Amazon floodplain. Hydrobiologia, **263**, 155–162.

Kauffman JB, Cummings DL, Ward DE (1994) Relationships of fire, biomass and nutrient dynamics along a vegetation gradient in the Brazilian cerrado. Journal of Ecology, **82**, 519–531.

Klinge H, Herrera R (1983) Phytomass structure of natural plant communities on spodosols in southern Venezuela: The tall Amazon Caatinga forest. Vegetatio, **53**, 65–84.

Komiyama A, Ong JE, Poungparn S (2008) Allometry, biomass, and productivity of mangrove forests: A review. Aquatic Botany, **89**, 128–137.

Lilienfein J, Wilcke W, Zimmermann R, Gerstberger P, Araújo GM, Zech W (2001) Nutrient storage in soil and biomass of native Brazilian Cerrado. Journal of Plant Nutrition and Soil Science, **164**, 487–495.

Lima AJN, Suwa R, Ribeiro GHPM *et al.* (2012) Allometric models for estimating above- and below-ground biomass in Amazonian forests at São Gabriel da Cachoeira in the upper Rio Negro, Brazil. Forest Ecology and Management, **277**, 163–172.

Medeiros TCC, Sampaio EVSB (2008) Allometry of aboveground biomasses in mangrove species in Itamaracá, Pernambuco, Brazil. Wetlands Ecology and Management, **16**, 323–330.

Nordhaus I, Wolff M, Diele K (2006) Litter processing and population food intake of the mangrove crab *Ucides cordatus* in a high intertidal forest in northern Brazil. Estuarine, Coastal and Shelf Science, **67**, 239–250.

Ottmar RD, Vihnanek RE, Miranda HS, Sato MN, Andrade SMA (2001) Stereo photo series for quantifying Cerrado fuels in central Brazil – Volume I. Gen. Tech. Rep. PNW-GTR-519. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA. 87 pp.

Paiva AO, Rezende AV, Pereira RS (2011) Estoque de carbono em cerrado *sensu stricto* do Distrito Federal. Revista Árvore, **35**, 527–538.

Pires LA, Britez RM, Martel G, Pagano SN (2006) Produção, acúmulo e decomposição da serapilheira em uma restinga da Ilha do Mel, Paranaguá, PR, Brasil. Acta Botanica Brasilica, **20**, 173–184.Proisy C, Couteron P, Fromard F (2007) Predicting and mapping mangrove biomass from canopy grain analysis using Fourier-based textural ordination of IKONOS images. Remote Sensing of Environment, **109**, 379–392.

Rezende AV (2002) Diversidade, estrutura, dinâmica e prognose do crescimento de um cerrado *sensu stricto* submetido a diferentes distúrbios por desmatamento. PhD Thesis. Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil.

Rezende AV, do Vale AT, Sanquetta CR, Filho AF, Felfili JM (2006) Comparação de modelos matemáticos para estimativa do volume, biomassa e estoque de carbono da vegetação lenhosa de um cerrado *sensu stricto* em Brasília, DF. Scientia Forestalis, **71**, 65–76.

Ribas LM (2007) Concentração e aporte de elementos da serapilheira do manguezal do estuário do Rio Paraíba do Sul, estado do Rio de Janeiro, Brasil. Masters Thesis. Universidade Federal do Norte Fluminense (UENF), Niteroi, RJ, Brazil.

Ribeiro SC, Fehrmann L, Soares CPB, Jacovine LAG, Klein C, Gaspar RO (2011) Above- and belowground biomass in a Brazilian Cerrado. Forest Ecology and Management, **262**, 491–499.

Santos JR (1988) Biomassa aérea da vegetação de cerrado: estimativa e correlação com dados do sensor Thematic Mapper do Satélite Landsat. PhD Thesis. Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil.

Santos JR, Pardi LaCruz MS, Araujo LS, Keil M (2002) Savanna and tropical rainforest biomass estimation and spatialization using JERS-1 data. International Journal of Remote Sensing, **23**, 1217–1229.

Schöngart J, Wittmann F, Worbes M (2010) Biomass and net primary production of central Amazonian floodplain forests. In: *Amazonian Floodplain Forests: Ecophysiology, Biodiversity and Sustainable Management* (eds Junk WJ, Piedade MTF, Wittmann F, Schöngart J, Parolin P), pp. 347–388, Ecological Studies 210. Springer Verlag, Berlin, Germany.

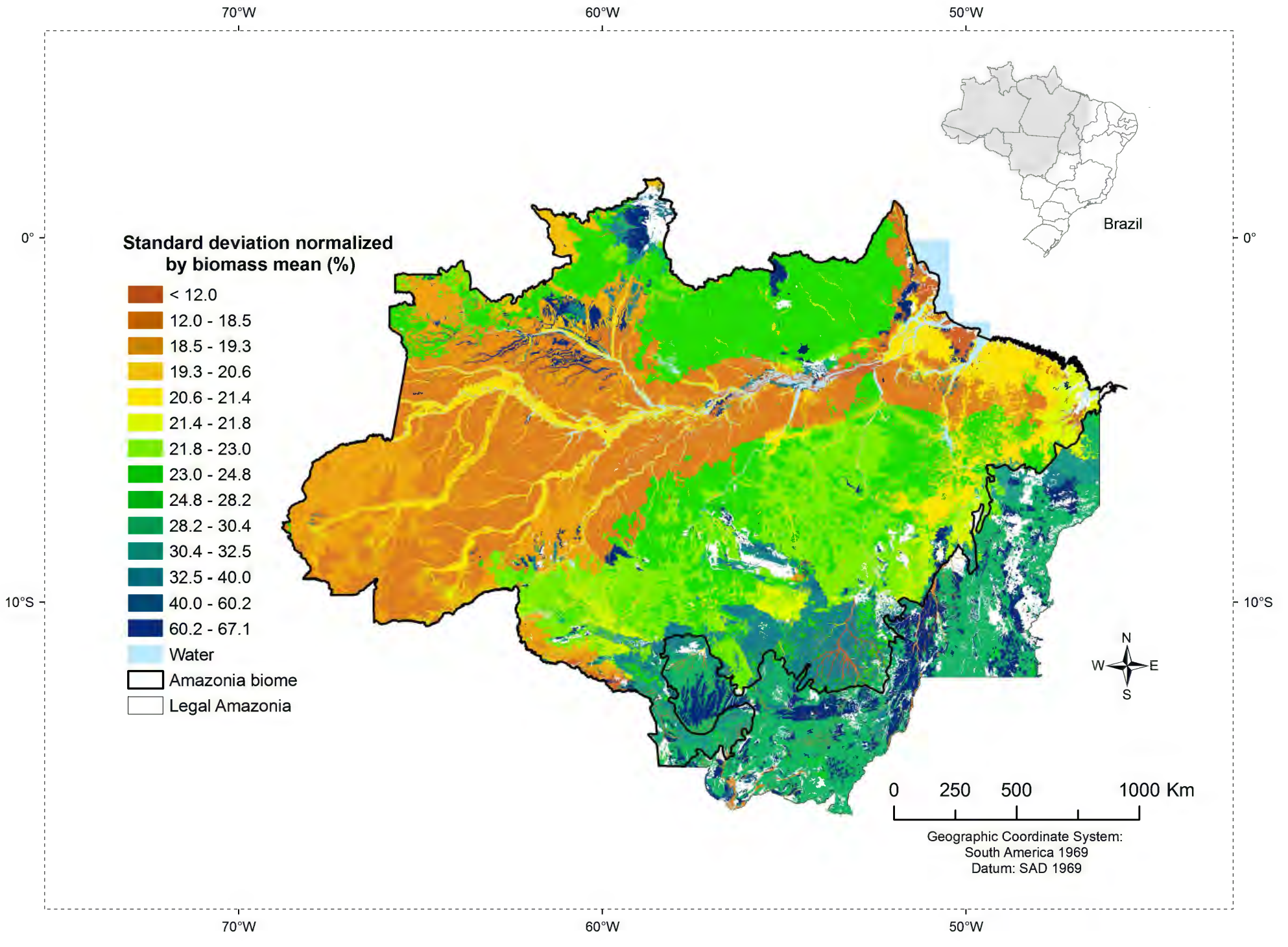
Silva CAR, Lacerda LD, Ovalle AR, Rezende CE (1998) The dynamics of heavy metals through litterfall and decomposition in a red mangrove forest. Mangroves and Salt Marshes, **2**, 149–157.

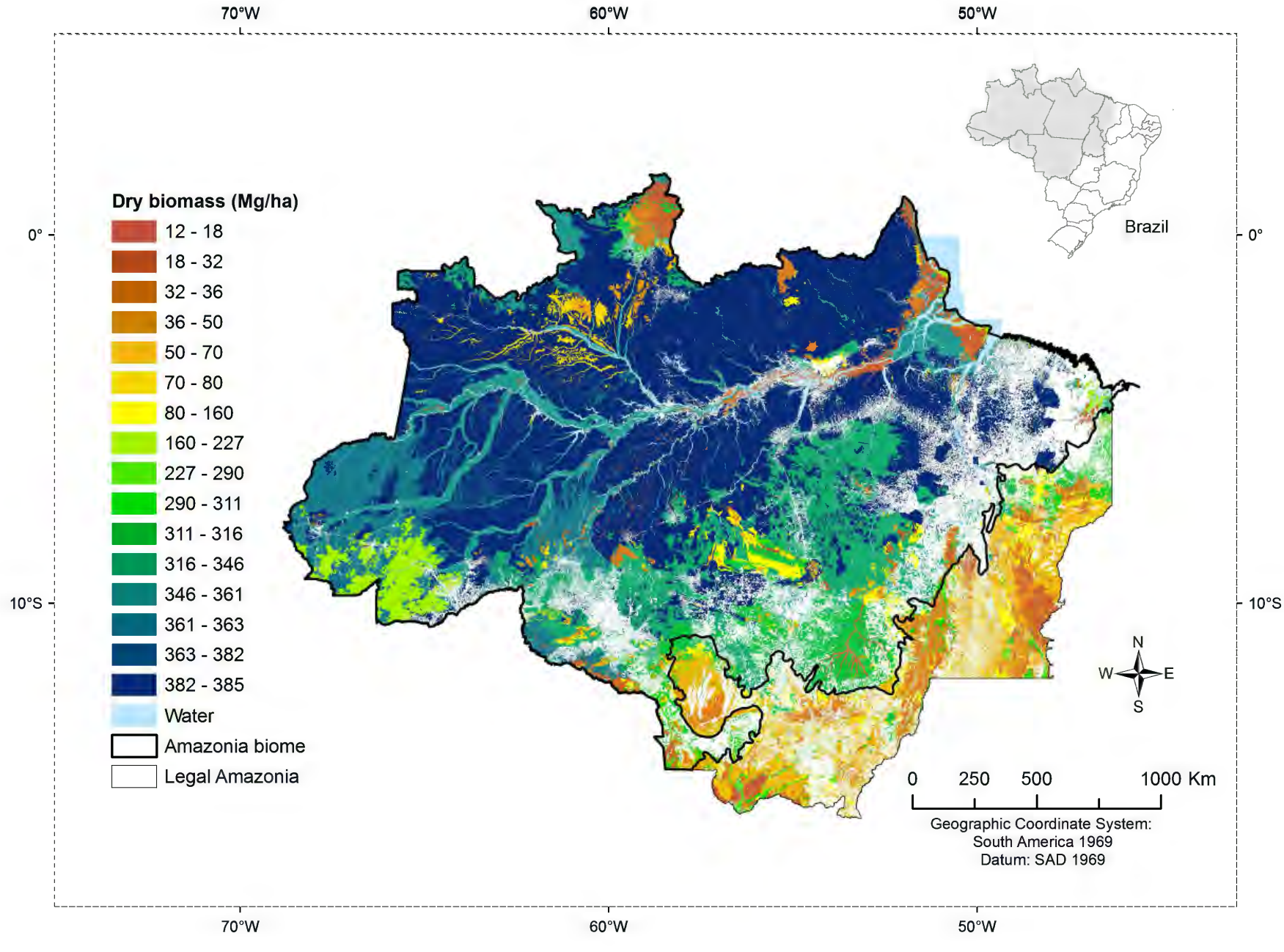
Silva CAR, Lacerda LD, Silva LFF, Rezende CE (1991) Forest structure and biomass distribution in a red mangrove stand in Sepetiba Bay, Rio de Janeiro. Revista Brasileira de Botânica, **14**, 21–25.

SUPPLEMENTARY MATERIAL - FIGURE CAPTIONS

Figure S1. Variability of total biomass shown in Figure 2; standard deviation values normalized by biomass mean across Legal Amazonia (whole map) and in the Amazonia biome (delimited by the black line). White areas on the map refer to vegetation types for which uncertainty estimates for the biomass values are not available (~213,485 km^2). Large variability that is shown for biomass estimates in areas covered by non-forest types could be caused by diverse methodologies employed in the studies cited in Tables 1 and 2.

Figure S2. Distribution of original total biomass (above- and below-ground; dry weight in Mg ha^{-1}) in areas cleared through 2013 in two regions of the Brazilian Amazon: "Legal Amazonia" (whole map) and the "Amazonia biome" (delimited by the black line). White areas on the map refer to total vegetation cleared through 2013 (~968,000 km^2). See Tables 6 and S3 for estimates of total biomass remaining in 2013.


70°W
60°W
50°W
0°
10°S
Brazil
Standard deviation normalized by biomass mean (%)
< 12.0
12.0 - 18.5
18.5 - 19.3
19.3 - 20.6
20.6 - 21.4
21.4 - 21.8
21.8 - 23.0
23.0 - 24.8
24.8 - 28.2
28.2 - 30.4
30.4 - 32.5
32.5 - 40.0
40.0 - 60.2
60.2 - 67.1
Water
Amazonia biome
Legal Amazonia
N
W
E
S
0 250 500 1000 Km
Geographic Coordinate System:
South America 1969
Datum: SAD 1969


70°W
60°W
50°W
0°
10°S
Dry biomass (Mg/ha)
12 - 18
18 - 32
32 - 36
36 - 50
50 - 70
70 - 80
80 - 160
160 - 227
227 - 290
290 - 311
311 - 316
316 - 346
346 - 361
361 - 363
363 - 382
382 - 385
Water
Amazonia biome
Legal Amazonia
Brazil
N
W
E
S
0 250 500 1000 Km
Geographic Coordinate System:
South America 1969
Datum: SAD 1969