Supplementary Information

Article title: Demographic composition, not demographic diversity, predicts biomass and turnover across temperate and tropical forests

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Table S1. Information on ForestGEO plots

Site	Census Years	Region	Latitude	Longitude	Area (ha)	No. Species	Koppen Climate Zone	MAT (℃)	MAP (mm yr^{-1})	Disturbance type
Amacayacu	2007- 2013	Neotropic	-3.80910	-70.26780	25.0	1133	Af	25.8	3215	Fl
BCI	2010-2015	Neotropic	9.15430	-79.84610	50.0	299	Am	27.1	2551	D; W
Changbaishan	2009-2014	Palearctic	42.38330	128.08300	25.0	52	Dwb	2.9	700	
Fushan	2008-2013	Indo-Malay	24.76140	121.55500	25.0	110	Cfa	18.2	4271	H
HKK	2004-2008	Indo-Malay	15.63240	99.21700	50.0	251	Aw	23.5	1476	Fi; D
Ituri	2001-2007	Afrotropic	1.43680	28.58260	40.0	445	Af	24.3	1682	W; A
Khao Chong	2005-2010	Indo-Malay	7.54347	99.79800	24.0	593	Am	27.1	2611	W; L
Korup	1997-2008	Afrotropic	5.07389	8.85472	55.0	494	Am	26.6	5272	W
Lambir	2002-2007	Indo-Malay	4.18650	114.01700	52.0	1182	Af	26.6	2664	L; D
La Planada	1997-2002	Neotropic	1.15580	-77.99350	25.0	240	Cfb	19.0	4087	W
Luquillo	2006-2011	Neotropic	18.32620	-65.81600	16.0	138	Am	22.8	3548	H; L
Mudumalai	1988-1992	Indo-Malay	11.59890	76.53380	50.0	72	Aw	22.7	1255	Fi; A; D
Palanan	2004-2010	Indo-Malay	17.04020	122.38800	25.6	335	Af	26.1	3380	H
Pasoh	2004-2010	Indo-Malay	2.98200	102.31300	16.0	814	Af	27.9	1788	W
SCBI	2008-2013	Palearctic	38.89350	-78.14540	25.6	64	Cfa	12.9	1001	W, Ic
SERC	2008-2014	Palearctic	38.88910	-76.55940	16.0	79	Cfa	13.2	1068	H; W
Wind River	2010-2016	Palearctic	45.81970	-121.95580	27.2	26	Csb	9.2	2495	Fi; W; In
Wytham	2008-2016	Palearctic	51.77430	-1.33790	18.0	23	Cfb	10.0	717	
XSBN	2006-2012	Indo-Malay	21.61170	101.57400	20.0	468	Cwa	21.8	1493	W; D
Yasuni	1995-2002	Neotropic	-0.68590	-76.39700	25.0	1114	Af	28.3	3081	

Adapted from Anderson-Teixeira et al. 2015 Table 2.

Koppen Climate Zone: Af: Tropical with significant precipitation year-round; Am: Tropical monsoon; Aw: Tropical wet and dry; Csb-Dry-summer subtropical/mid-latitude climate with dry sum- mers (a.k.a.: Warm-summer Mediterranean); Cfa: Humid subtropical/mid-latitude climate with significant precipitation year-round; Cwa: Humid subtropical/midlatitude cli- mate with dry winters; Cfb: Oceanic with significant precipitation year-round; Cwb: Oceanic with dry winters; Dfb: Humid Continental with significant precipitation year- round; Dwb: Humid continental with dry winters; Dfc: Subarctic.

Climate data are the best available for each site (based on judgment of site PIs; years vary). For sites where local data are not available or not reported, values (italicized) are mean 1950–2000 climate from WorldClim at 30 arcsecond resolution (Table S4; Hijmans et al., 2005).

Disturbance type: A, animal activity (destructive); D, Drought; E, Erosion; Fi, Fire; Fl, flood; H, hurricane/typhoon; Ic, Ice storms; Insect outbreaks; L, landslides; PT, permafrost thaw; W, wind storms (local); '–', no major natural disturbances.

When censuses spanned multiple years, the first year is listed.

SI Figures

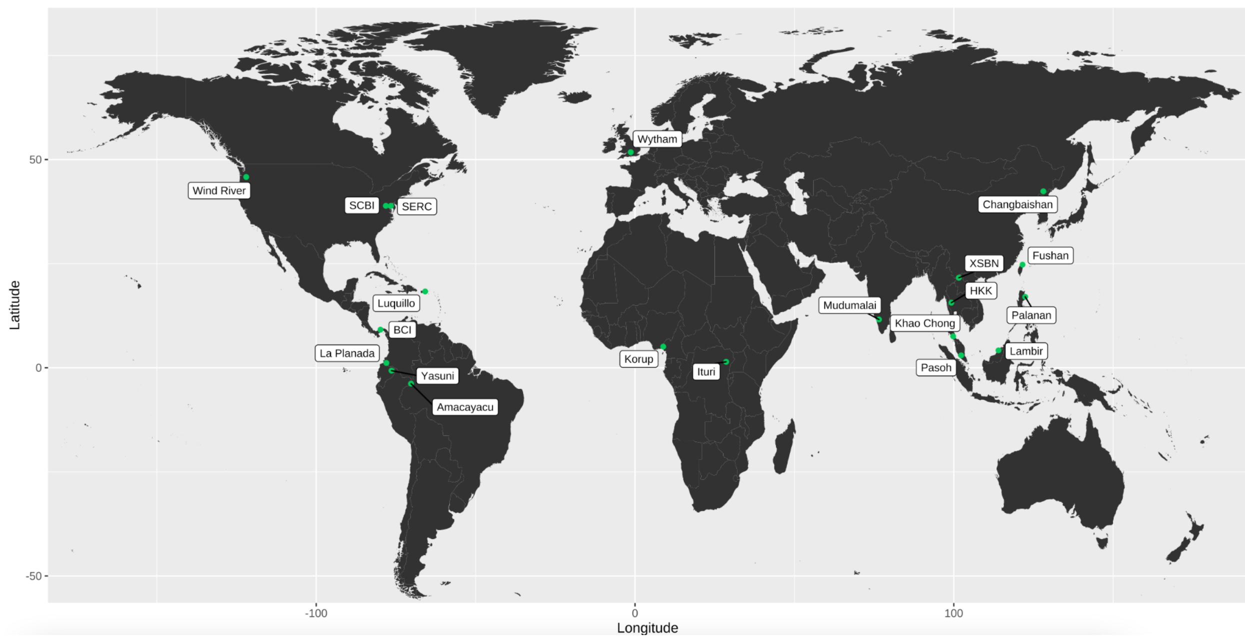

Fig. S1 Map of ForestGEO plots in this study.

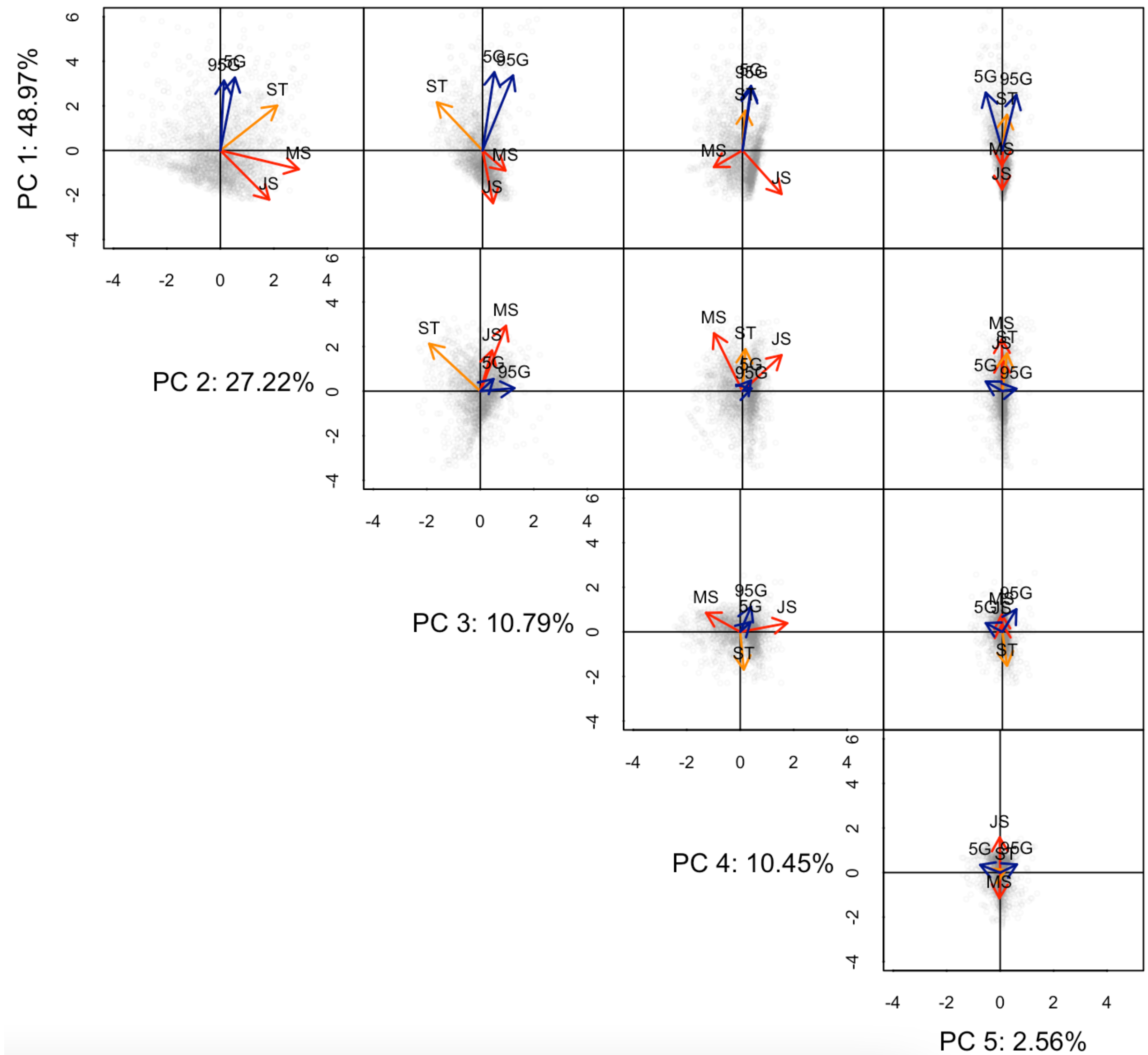

Fig. S2 All PCA axes. Variable loadings on each PC axis and the percent of variance explained by each axis. Variable names are explained in the full text.

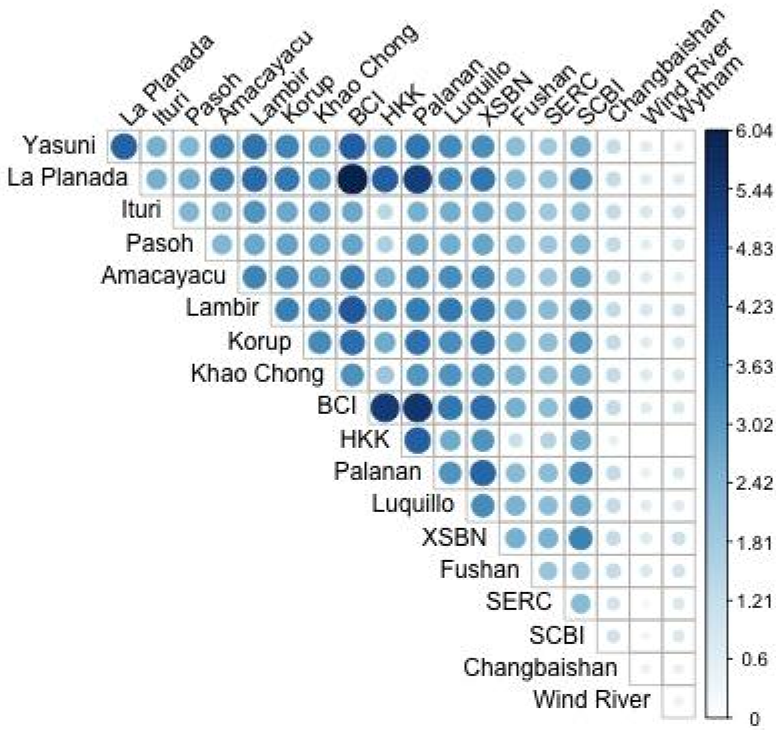

Fig. S3 Pairwise convex hull overlaps of sites. Convex hull volumes in PCA space were calculated for each site using the position of species from that site along the first two dimensions. Darker colours and larger circles indicate a higher degree of convex hull overlap, i.e. greater demographic similarity between sites. Mudumalai was excluded from this analysis because we did not have spatial information on stems and could not correct for plot size.

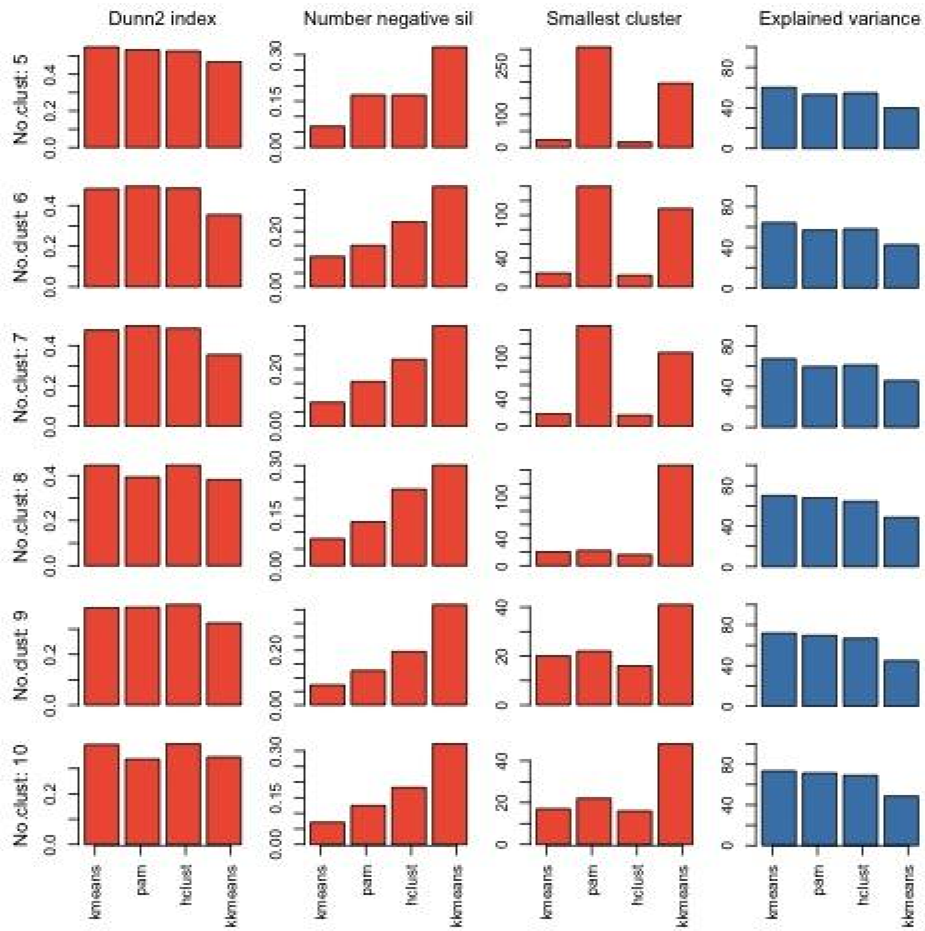

Fig. S4 Analysis of cluster number. Optimal clustering should have a high Dunn index, a low number of negative silhouettes, no cluster with too few species, and a high percentage of explained variance.

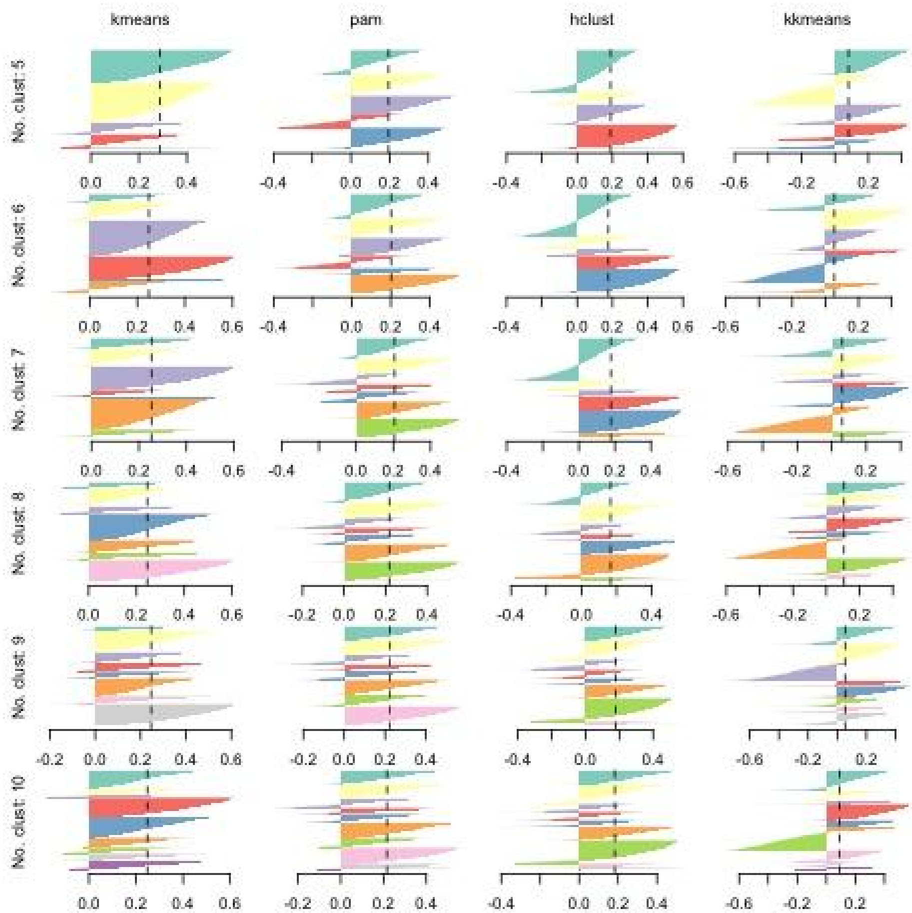

Fig. S5 Analysis of clustering algorithms. Optimal clustering should have a low number of negative silhouettes.

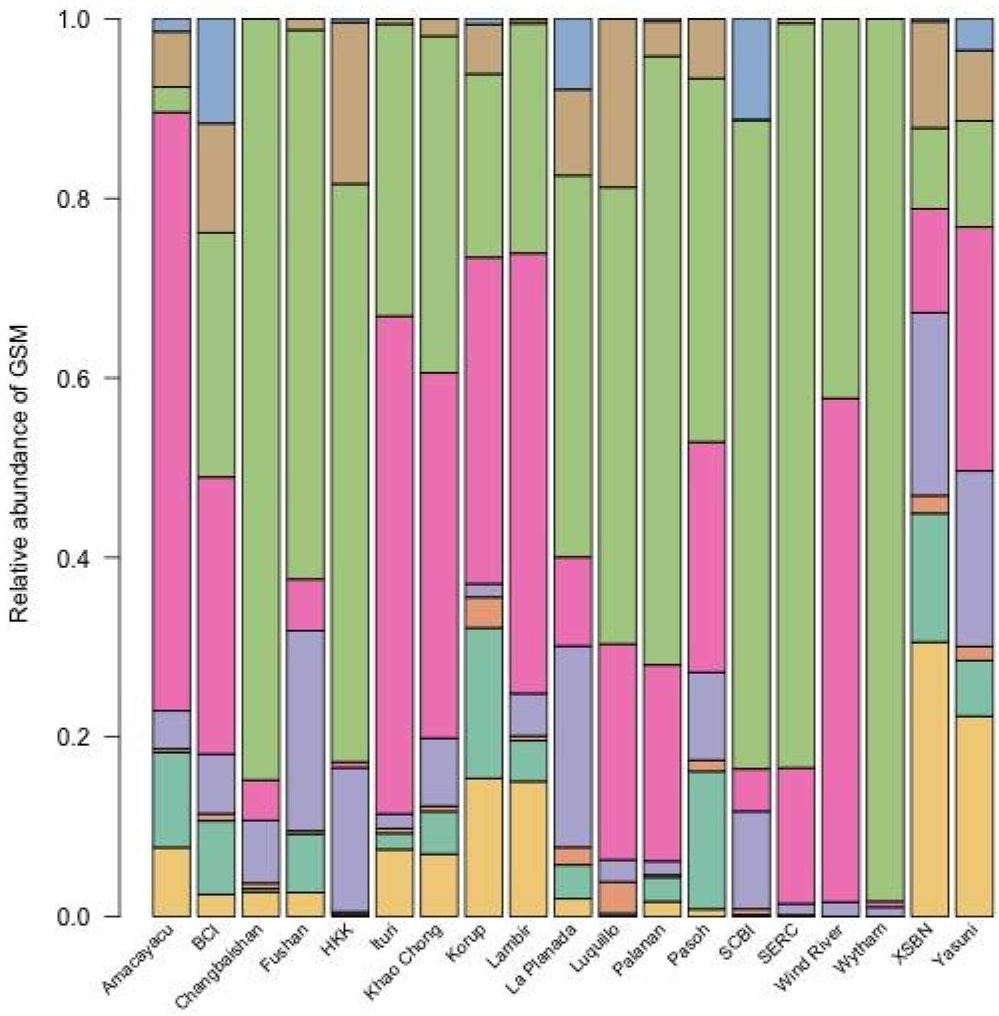

Fig. S6 Relative proportion of each GSSM across sites, by AGB. Colours match those in Fig. 1.

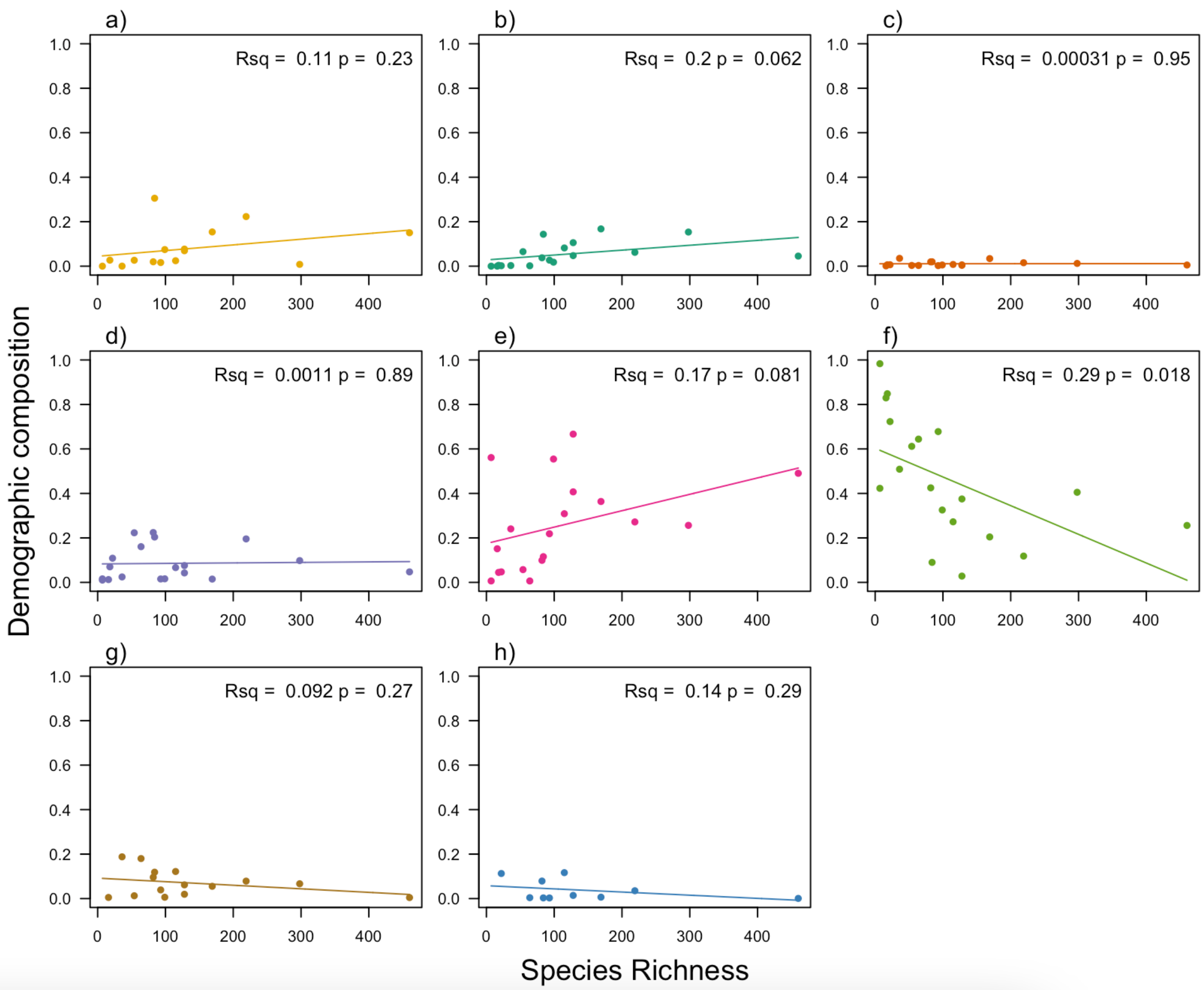

Fig. S7 Relationship between species richness and demographic composition. Species richness here is the mean number of species with over 200 individuals found in 500 bootleg samples of 16 ha from each plot. Demographic composition is the relative abundance of AGB of each GSM. GSMs 5 and 6 are both large statured demographic types and account for the majority of biomass across sites. There is weak evidence for an effect of species richness on GSSM 5 and moderate evidence for an effect of species richness on GSSM 6.

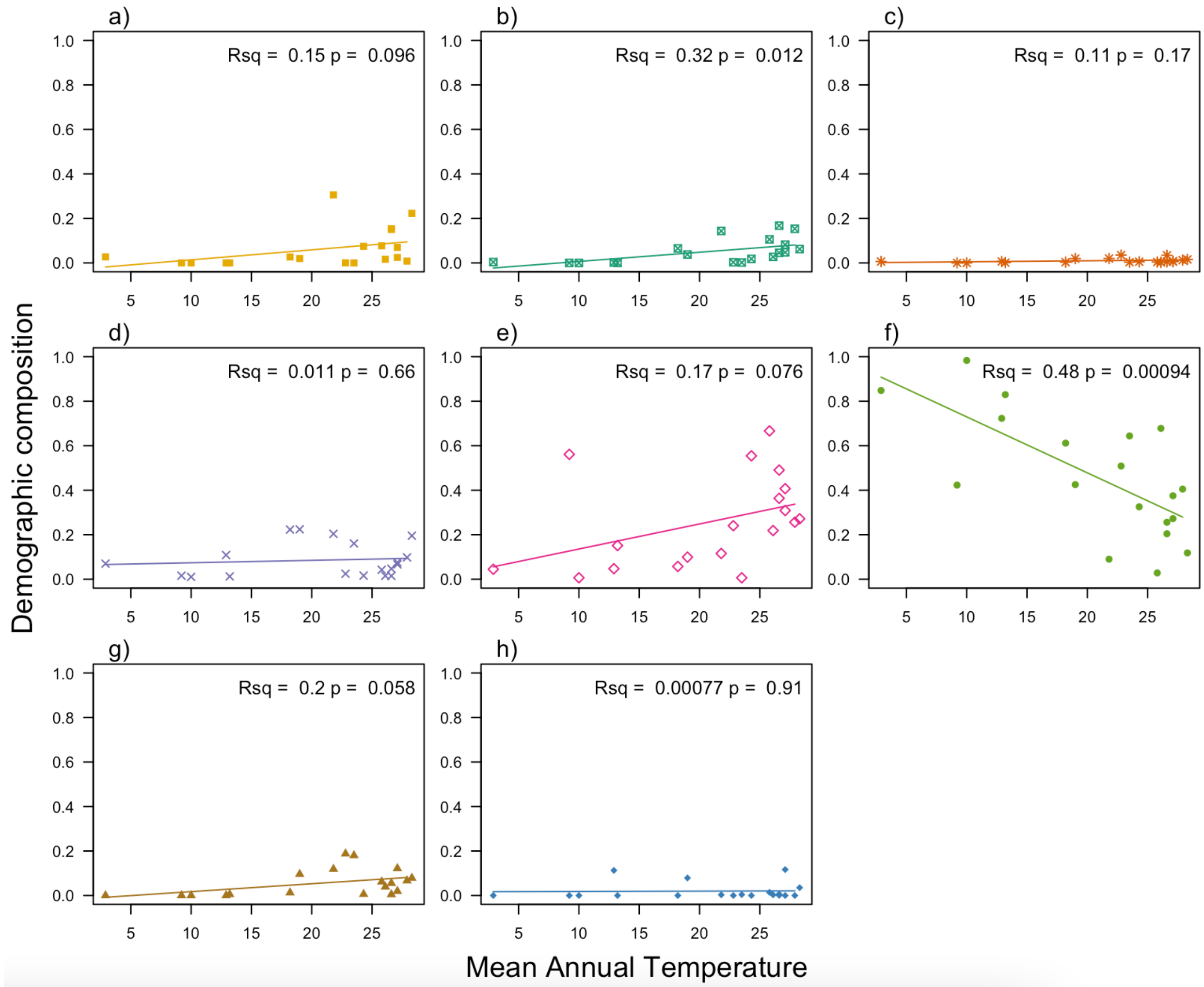

Fig. S8 Relationship between GSSMs and mean annual temperature. Mean annual temperature in degrees Celsius and the relative abundance of each demographic type at each site. There is strong evidence for an effect of MAT on the relative abundance of GSSM 6.

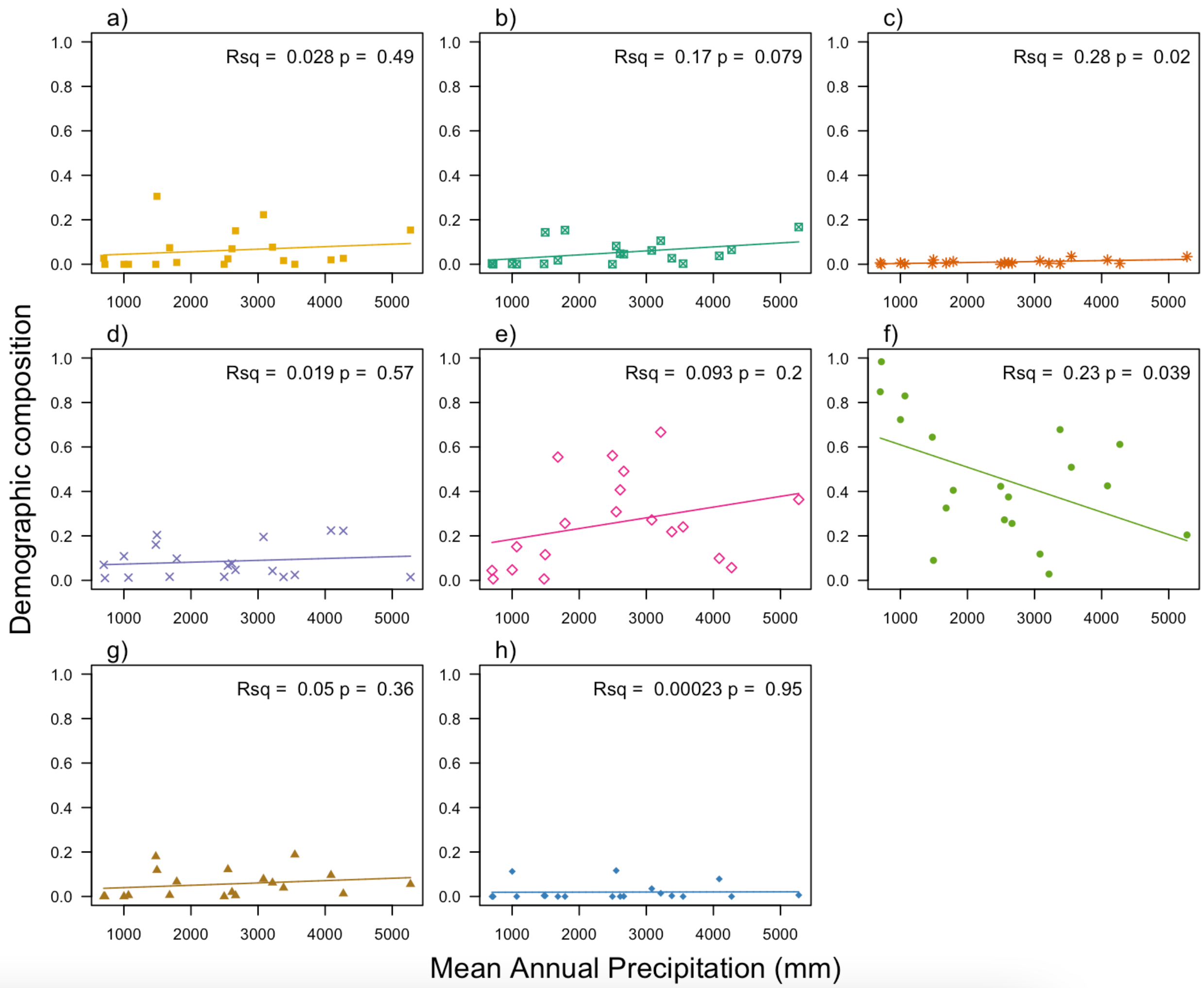

Fig. S9 Demographic composition and mean annual precipitation. Mean annual precipitation in mm and the relative abundance of each demographic type at each site. There is weak evidence for an effect of MAP on GSSM 2, and moderate evidence for an effect of MAP on GSSMs 3 and 6.

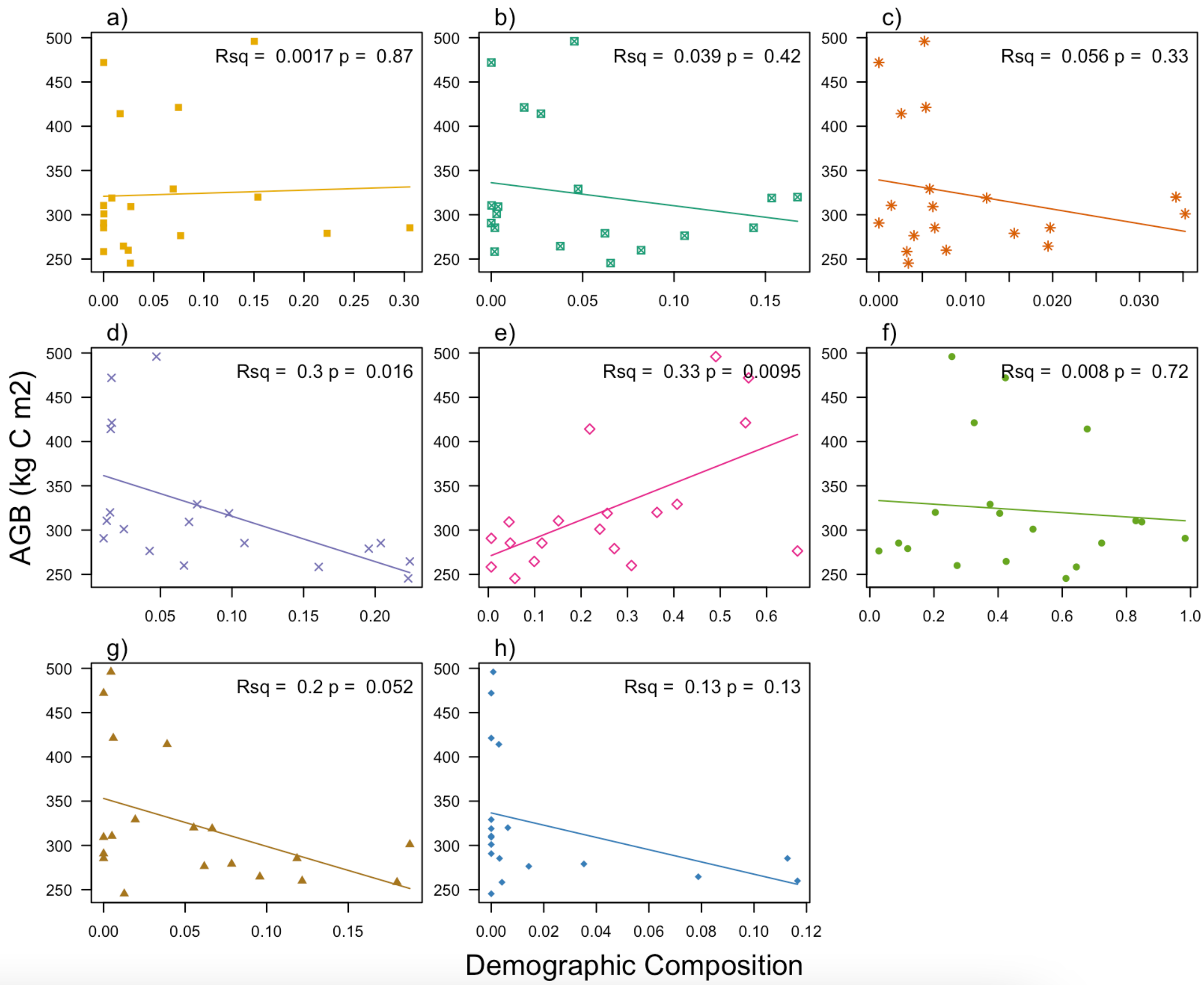

Fig. S10 Demographic composition and aboveground biomass (AGB). AGB and the relative abundance of each demographic type at each site. There is moderate evidence for an effect of GSSM 4 on AGB and strong evidence for an effect of GSSM 5 on AGB.

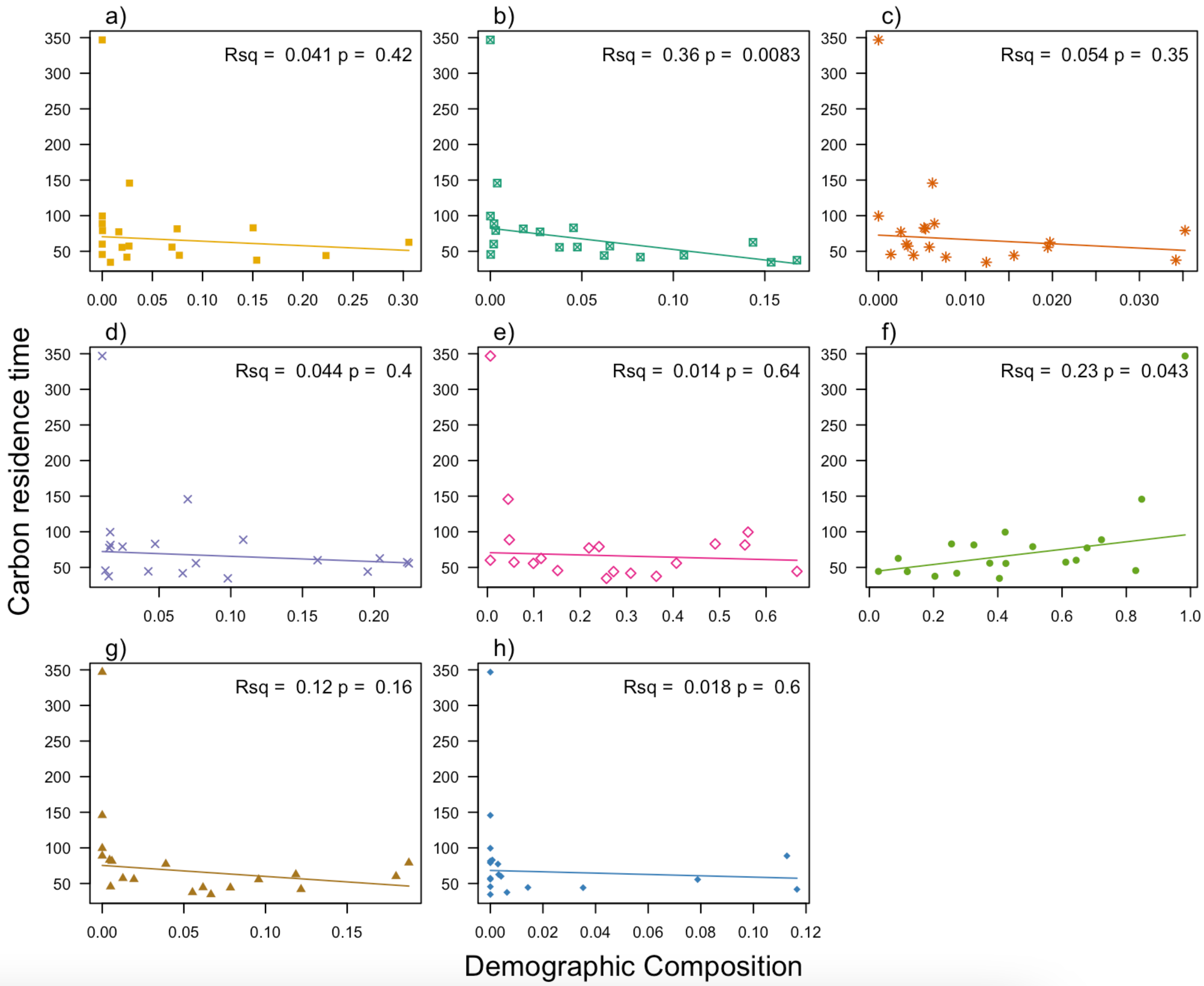

Fig. S11 Demographic composition and carbon residence time. Carbon residence time and the relative abundance of each demographic type at each site. There is strong evidence for an effect of GSSM 2 on carbon residence time, and moderate evidence for an effect of GSSM 6 on carbon residence time.

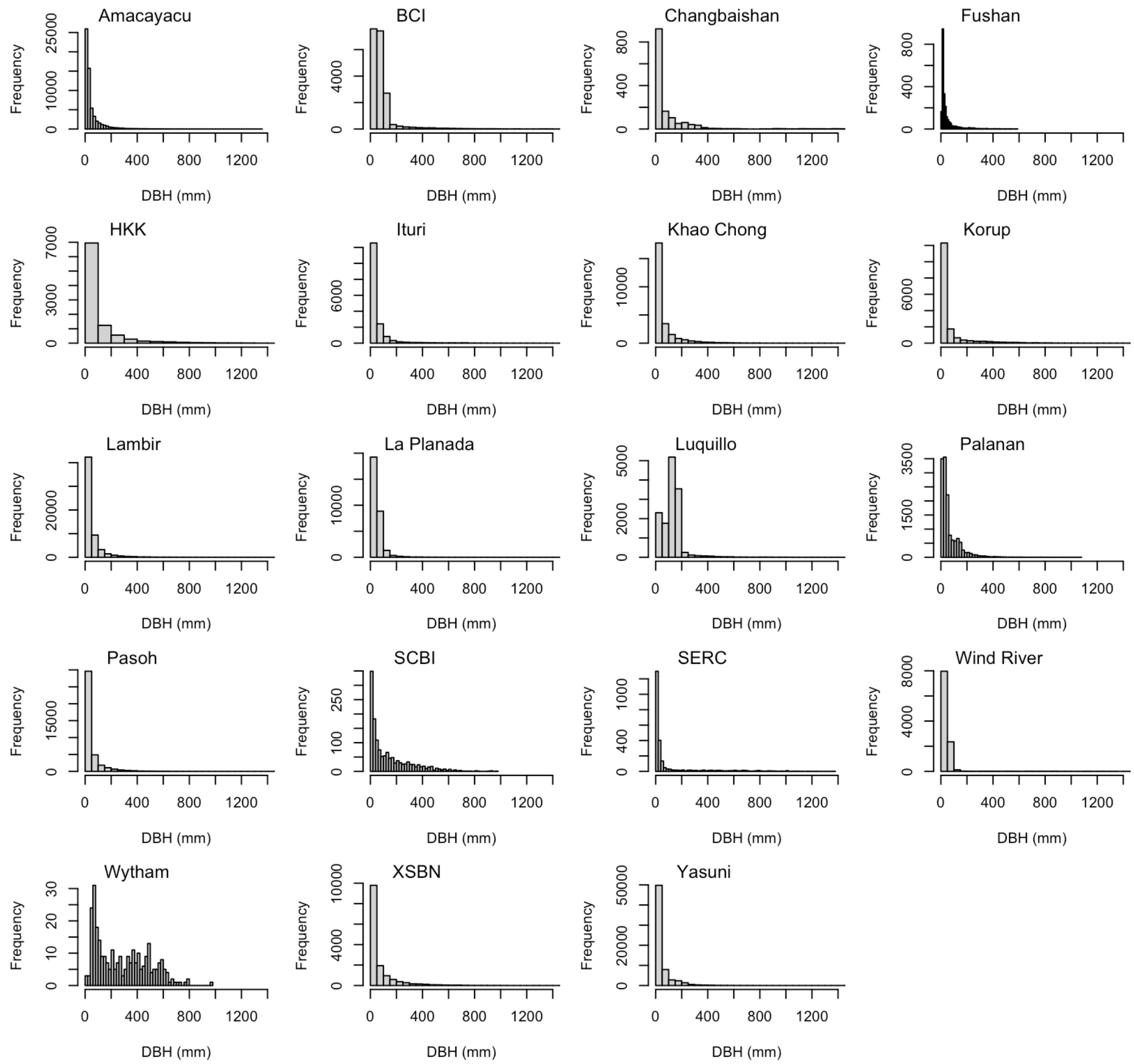

Fig. S12 Size distribution of excluded stems in each plot. Species with <200 individuals were not included in our analysis of DD, DC, or species richness. These rare species had size distributions similar to the size distributions of more more common species; highly skewed towards small stems. Note that all individuals were included in our calculation of AGB and carbon residence at each site.

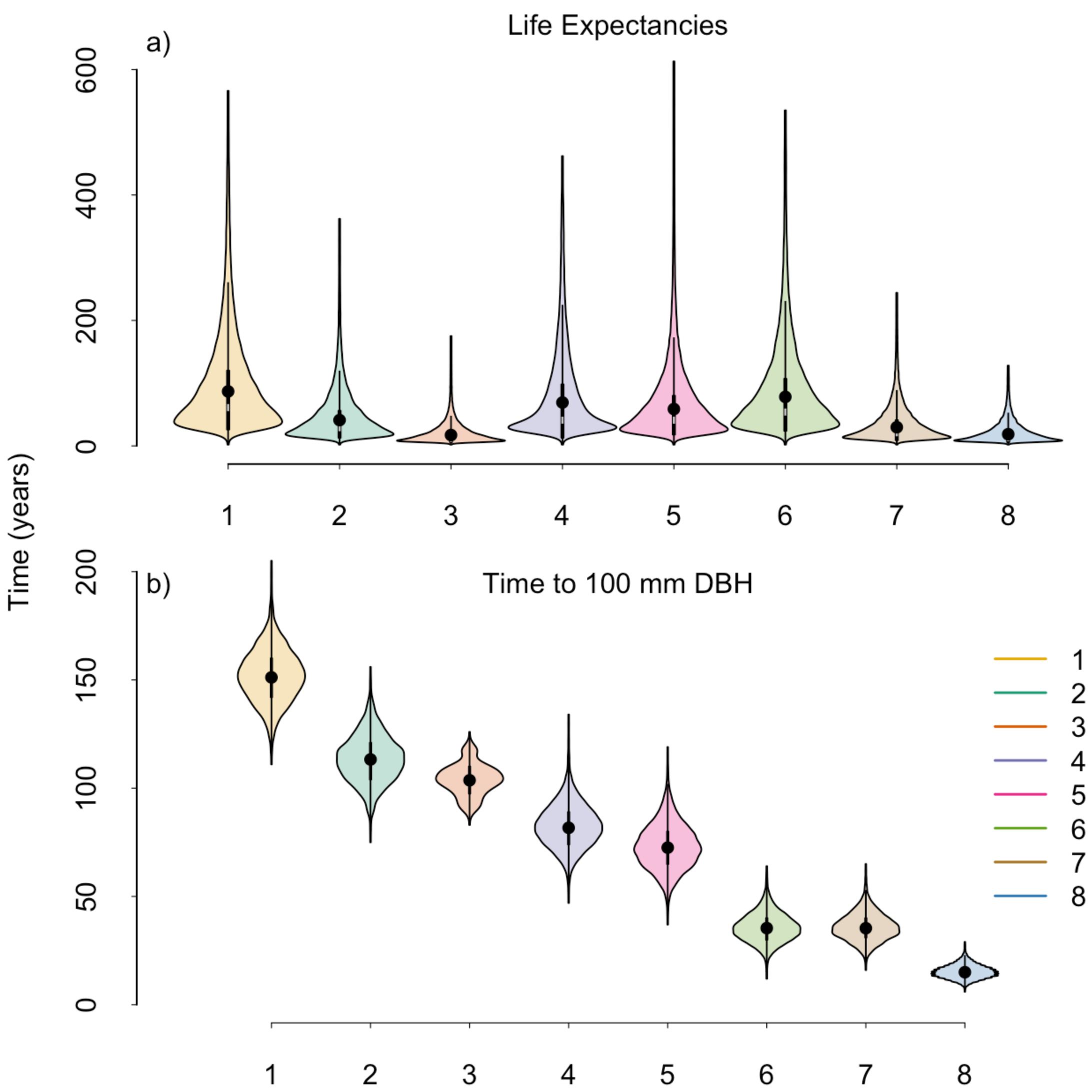

Fig. S13 Life expectancies and passage times of each GSSM. For each GSSM we found the mean growth and survival parameters from all species in that GSSM. We simulated 25000 individuals over 1500 years or until all individuals had died. Five percent of individuals grew according to the fast growth distribution, and 95% according to the slow growth distribution. Survival was a draw from a binomial distribution each year with probabilities given by the size-dependent function described in the methods. We calculated life expectancies as the mean time to death for a 10 mm DBH stem, and passage times as the times taken to grow from 10 mm DBH to 100 mm DBH (a size that all GSSMs can reach), conditional on survival.

Supplementary text

Unobserved growth of stems that died:

- Use plot level per capita mortality to estimate how many trees died in each year of the census interval:

  $Ma = 1 - (Nst/N0)^{(1/T)}$

  Where T is the length of the census interval, N0 is the number of individuals in the initial census, and Nst is the number that survived the census interval.
- Estimate the mean number of years a tree survived in the census interval before death, Ymean.
- Calculate plot level median growth rates for size classes; D < 200 mm, 200 mm <= D < 400 mm, D >= 400 mm, where D is dbh at the start of the census interval.
- Estimate dbh at death for trees that died as Ddeath = Dstart x growth rate x Ymean. Where Dstart is dbh at the start of the census interval and Ddeath is dbh at death.

- Convert Ddeath and Dstart to AGB using allometric equations described in the main test.
- Unobserved growth is the sum of AGBdeath - AGBstart.

Unobserved recruits:

- Calculate per capita annual mortality as

  $Ma = 1 - (Nst/N0)^{(1/T)}$

  Where T is the length of the census interval, N0 is the number of individuals in the initial census, and Nst is the number that survived the census interval.
- Calculate per-area annual recruitment (Ra) as:

  $Ra = Ma * (Nt-Nst)/(N0 - Nst)$

  Where Nt is the number of individuals in the final census (including trees that survived and new recruits).
- Estimate the probability of a new recruit surviving each year as

  $Psurv = (1-Ma)^T$
- Sum the number of unobserved recruits each year:

  $N\_unobs\_r = Ra - (1-Ma)^T*Ra$, for each T of the census interval.
- Estimate mean life span of a recruit in a given year
- Estimate the mean number of years a recruit would have survived (ymean_r) as the weighted mean of lifespan of recruits in each year, weighted by number of recruits in that year.
- Ddeath_r = 10 + (growth x Ymean_r).

Site Acknowledgements

Amacayacu

The Amacayacu forest dynamics plot is a collaborative project among Parques Nacionales Naturales de Colombia, InstitutoAmazónico de Investigaciones Científicas Sinchi, and Universidad Nacional de Colombia. We gratefully acknowledge to Eliana Martínez and staff members of the Amacayacu Natural National Park, as well as to the coworkers in Comunidad Indígena Palmeras and the students of forest engineering from the Universidad Nacional de Colombia for collecting the tree census data. See Duque *et al.* (2017); Zuleta *et al.* (2017, 2020) for more details.

Barro Colorado Island

The BCI forest dynamics research project was founded by S.P. Hubbell and R.B. Foster and is now managed by R. Condit, S. Lao and R. Perez under the Center for Tropical Forest Science and the Smithsonian Tropical Research in Panama. Numerous organizations have provided funding, principally the US National Science Foundation, and hundreds of field workers have contributed. See Hubbell *et al.* (1999) for more details.

Changbaishan

Zuoqiang Yuan & Zhanqing Hao were supported by National Natural Science Foundation of China (41671050 & 31730015). See Yuan *et al.* (2016) for more details.

Fushan

The Fushan Forest Dynamics Plot is a collaborative project among Taiwan Forestry Bureau, Taiwan Forestry Research Institute, and the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute. We gratefully acknowledge to Sheng-Hsin Su for species identification, and to the staff at Fushan Research Center for providing logistic sup- port.

We thank many field assistants and student volunteers for collecting the tree census data. See Su *et al.* (2010) for more details.

Huai Kha Khaeng

The Huai Kha Khaeng 50-hectare plot project has been financially and administratively supported by many institutions and agencies. Direct financial support for the plot has been provided by the Royal Thai Forest Department and the Department of National Parks Wildlife and Plant Conservation, the Arnold Arboretum of Harvard University (under NSF award DEB-0075334, and grants from USAID and the Rockefeller Foundation), the Smithsonian Tropical Research Institute, and the National Institute for Environmental Studies, Japan. The Huai Kha Khaeng Forest Dynamics Plot is part of the Center for Tropical Forest Science, a global network of large-scale demographic tree plots. We acknowledge the Department of National Parks Wildlife and Plant Conservation, Thailand for supporting and maintaining the project in Huai Kha Khaeng Wildlife Sanctuary, Thailand. See Bunyavejchewin *et al.* (1998, 2001, 2009) for more details.

Ituri

The Ituri 40-ha plot program is a collaborative project between the Centre de Formation et de Recherche en Conservation Forestière, the Wildlife Conservation Society DRC through their conservation project in the Okapi forest Reserve, in partnership with the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute. The Ituri plots are financially supported by the Wildlife Conservation Society, the Frank Levinson Family Foundation, and the Smithsonian Forest Global Earth Observatory. The Institut Congolais pour la Conservation de la Nature graciously provided the research permit. See Makana *et al.* (2004) for more details.

Khao Chong

The 24-hectare Khao Chong Forest Dynamics Plot is a collaborative project of the Royal Thai Forest Department, the Department of National Parks Wildlife and Plant Conservation, Thailand, the Arnold Arboretum of Harvard University, the Smithsonian Tropical Research Institute. The Khao Chong Forest Dynamics Plot is part of the Center for Tropical Forest Science, a global network of large-scale demographic tree plots. We acknowledge the Department of National Parks Wildlife and Plant Conservation, Thailand for supporting and maintaining the project in Khao Ban Tad Wildlife Sanctuary, Thailand.

Korup

The 50-ha Korup Forest Dynamics Plot is affiliated with the Smithsonian's Center for Tropical Forest Science - Forest Global Earth Observatory. The 3 principal investigators gratefully acknowledge funding and other support received from CTFS for our first and second censuses. Funding from the Botanical Research Foundation of Idaho is also gratefully acknowledged. Permission to conduct the field program in Cameroon is provided by the Ministry of Environment and Forests and the Ministry of Scientific Research and Innovation. We also acknowledge the dedicated support of our field team, especially field leadership by Sainge Nsanyi Moses and botanical work by Ekole Mambo Peter. See Chuyong *et al.* (2004); Thomas *et al.* (2003); Kenfack *et al.* (2007) for more details.

La Planada

The 25-ha plot La Planada Dynamics Plot is a collaborative project between the Insituto de Investigación de Recursos Biológicos Alexander von Humboldt in Colombia (Alexander von Humboldt Institute) and the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute. Funding for the first census was provided by the Alexander von Humboldt Institute and funding for the second census was funded by the Smithsonian Tropical Research Institute though the Andrew W. Mellon Foundation. See Vallejo *et al.* (2004) for more details.

Lambir

The 52-ha Long-Term Ecological Research Project is a collaborative project of the Forest Department of Sarawak, Malaysia, the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute, the Arnold Arboretum of Harvard University, USA (under NSF awards DEB-9107247 and DEB-9629601), and Osaka City, Ehime & Kyoto Universities, Japan (under MEXT/JSPS grant 09NP0901 and JST/JICA-SATREPS). The Lambir Forest Dynamics Plot is part of the Center for Tropical Forest Science, a global network of large-scale demographic tree plots. We acknowledge the Sarawak Forest Department for supporting and maintaining the project in Lambir Hills National Park. See Lee *et al.* (2005, 2002) for more details.

Luquillo

This research was supported by grants BSR-8811902, DEB 9411973, DEB 0080538, DEB 0218039, DEB 0620910, DEB 0963447 AND DEB-129764 from NSF to the Department of Environmental Science, University of Puerto Rico, and to the International Institute of Tropical Forestry, USDA Forest Service, as part of the Luquillo Long-Term Ecological Research Program. The U.S. Forest Service (Dept. of Agriculture) and the University of Puerto Rico gave additional support. The LFDP is part of the Smithsonian Institution Forest Global Earth Observatory, a worldwide network of large, long-term forest dynamics plots. See Zimmerman *et al.* (2010) for more details.

Mudumalai

The 50 hectare Mudumalai Forest Dynamics plot was set up by the Centre for Ecological Sciences, Indian Institute of Science, Bangalore. Most of the long-term funding for running the plot has come from the Ministry of Environment, Forest and Climate Change (Government of India). In recent years this has been supplemented with funding from the Department of Biotechnology (Government of India), the JC Bose National Fellowship (Department of Science and Technology) to Raman Sukumar, and the Divecha Centre for Climate Change, Indian Institute of Science. We also acknowledge the support of Tamil Nadu Forest Department for this long-term monitoring. See Sukumar *et al.* (2004) for more details.

Palanan

Palanan: Funding since 2010 had been provided by the Biodiversity Research Laboratory, Institute of Biology, University of the Philippines Diliman (BRL UP Biology), University of the Philippines Office of the Vice President for Academic Affairs under the Emerging Interdisciplinary Developing Research Program (EIDR), the University of the Philippines Diliman Office of the Vice Chancellor for Research and Development (UPD OVCRD), the Commission on Higher Education (CHED), the Department of Science and Technology-Grants in Aid (DOST-GIA) and Philippine Council for Agriculture, Aquatic Resources Research and Development (DOST-PCAARRD), the Energy Development Corporation (EDC), the Forest Foundation Philippines, the Diliman Science Research Foundation and the Smithsonian Tropical Research Institute (STRI). Research permits to work in the Northern Sierra Madre Natural Park were issued by its Protected Area Management Board (PAMB). The plot was established by the Isabela State University (Philippines), Conservation International, PLAN, Arnold Arboretum of Harvard University (USA). See Co *et al.* (2004) for more details.

Pasoh

Data from the Pasoh Forest Reserve was provided by the Forest Research Institute Malaysia - Smithsonian Tropical Research Institute/Centre for Tropical Forest Science - Forest Global Earth Observatory collaborative research supported by Negeri Sembilan Forestry Department. See Manokaran & LaFrankie (1990); Kochummen *et al.* (1990); Manokaran *et al.* (1992) for more details.

Smithsonian Conservation Biology Institute

Funding for the Smithsonian Conservation Biology Institute (SCBI) Large Forest Dynamics Plot (LFDP) was provided by the Smithsonian Institution, the National Zoological Park, and the HSBC Climate Partnership. The SCBI LFDP is part of the Smithsonian Institution Forest Global Earth Observatory, a worldwide network of large, long-term forest dynamics plots. See Bourg *et al.* (2013); Gonzalez-Akre *et al.* (2016b,a) for more details.

Smithsonian Environmental Research Center

Smithsonian Environmental Research Center (SERC) plot census data were provided by Geoffrey Parker on 8th December 2016. These data were gathered as part of forest ecology studies at SERC. SERC is a participant in the Smithsonian Institution Forest Global Earth Observatory (ForestGEO) network. This project was initiated with support from the HSBC-Carbon Project (HCP). We thank the project partners Hong Kong Shanghai Banking Corporation, the Earthwatch Institute, the Smithsonian Center for Tropical Forest Science (CTFS) and the Smithsonian Environmental Research Center (SERC). See McMahon & Parker (2014) for more details.

Wind River

Wind River: The Wind River Forest Dynamics Plot is a collaborative project of Utah State University and the USDA Forest Service Pacific Northwest Research Station. Funding was provided by the Smithsonian ForestGEO program, Utah State University, and the Utah Agricultural Experiment Station. We acknowledge the Gifford Pinchot National Forest and the Wind River Field Station for providing logistical support, and the students, volunteers and staff individually listed at http://wfdp.org for data collection. The Wind River Forest Dynamics Plot was made possible by a grant from Jennifer Walston Johnson to the Smithsonian ForestGEO. See Lutz *et al.* (2013) and Lutz *et al.* (2014) for more details.

Wytham Woods

The 18-ha Long-Term Forest Monitoring Plot in Wytham Woods, UK, is a collaborative project between the University of Oxford, the UK Centre for Ecology & Hydrology, and the Smithsonian Institution CTFS Forest-GEO (HSBC Climate Partnership). See Butt *et al.* (2009) for more details.

Xishuangbanna

See Cao *et al.* (2008) for more details.

Yasuní

The Yasuní Forest Dynamics plot was established by Pontifical Catholic University of Ecuador (PUCE) in 1995 in collaboration with Smithsonian Institution-CTFS and the University of Aarhus. Funding has been provided by several agencies, including NSF and the government of Ecuador (Donaciones del impuesto a la renta). PUCE has provided research funds for census work and related studies (grants L 13251 and N 13373 to R. Valencia). We also thank the Mellon Family Foundation and Smithsonian Tropical Research Institute for funding previous forest censuses. Dozens of fieldworkers have helped with census work and we are grateful to all of them, in particular M. Zambrano, P. Alvia, W. Loor, A. Loor, J. Suárez, G. Grefa, A. Loor, J. Zambrano and J. Suárez. We thank C. Hernández for data management and Á. Pérez for species identification. SeeValencia*etal.*(2004) for more details.

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