Oecologia (2013) 173:1491–1498
DOI 10.1007/s00442-013-2709-5

COMMUNITY ECOLOGY - ORIGINAL RESEARCH

A taxonomic comparison of local habitat niches of tropical trees

Claire A. Baldeck · Steven W. Kembel · Kyle E. Harms · Joseph B. Yavitt · Robert John · Benjamin L. Turner · George B. Chuyong · David Kenfack · Duncan W. Thomas · Sumedha Madawala · Nimal Gunatilleke · Savitri Gunatilleke · Sarayudh Bunyavejchewin · Somboon Kiratiprayoon · Adzmi Yaacob · Mohd. N. Nur Supardi · Renato Valencia · Hugo Navarrete · Stuart J. Davies · Stephen P. Hubbell · James W. Dalling

Received: 2 March 2012 / Accepted: 6 June 2013 / Published online: 13 July 2013

Abstract The integration of ecology and evolutionary biology requires an understanding of the evolutionary lability in species' ecological niches. For tropical trees, specialization for particular soil resource and topographic conditions is an important part of the habitat niche, influencing the distributions of individual species and overall tree community structure at the local scale. However, little is known about how these habitat niches are related to the evolutionary history of species. We assessed the relationship between taxonomic rank and tree species' soil resource and topographic niches in eight large (24–50 ha) tropical forest dynamics plots. Niche overlap values, indicating the similarity of two species' distributions along soil or topographic axes, were calculated for all pairwise combinations of co-occurring tree species at each study site. Congeneric species pairs often showed greater niche overlap (i.e., more similar niches) than non-congeneric pairs along both soil and topographic axes, though significant effects were found for only five sites based on Mantel tests. No evidence for taxonomic effects was found at the family level. Our results indicate that local habitat niches of trees exhibit varying degrees of phylogenetic signal at different sites, which may have important ramifications for the phylogenetic structure of these communities.

Communicated by Walt Carson.

Electronic supplementary material The online version of this article (doi:10.1007/s00442-013-2709-5) contains supplementary material, which is available to authorized users.

C. A. Baldeck
Program in Ecology, Evolution, and Conservation Biology, University of Illinois, 505 S. Goodwin Ave., Urbana, IL 61801, USA

C. A. Baldeck (✉) · J. W. Dalling
Department of Plant Biology, University of Illinois, 265 Morrill Hall, 505 S. Goodwin Ave., Urbana, IL 61801, USA
e-mail: baldeck2@life.illinois.edu

S. W. Kembel
Département des sciences biologiques, Université du Québec à Montréal, C.P. 8888, Succ. Centre-ville, Montréal, QC H3C3P8, Canada

K. E. Harms · B. L. Turner · S. J. Davies · J. W. Dalling
Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Ancón, Republic of Panama

K. E. Harms
Department of Biological Sciences, Louisiana State University, 202 Life Sciences Building, Baton Rouge, LA 70803, USA

J. B. Yavitt
Department of Natural Resources, Cornell University, 16 Fernow Hall, Ithaca, NY 14853, USA

R. John
Indian Institute of Science Education and Research, P.O. BCKV Campus Main Office, Mohanpur, Nadia, West Bengal 741252, India

G. B. Chuyong
Department of Plant and Animal Sciences, University of Buea, P.O. Box 63, Buea, Republic of Cameroon

D. Kenfack · S. J. Davies
Center for Tropical Forest Science, Arnold Arboretum Asia Program, Harvard University, Cambridge, MA, USA

D. W. Thomas
Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902, USA

Keywords Community assembly · Phylogenetic community structure · Phylogenetic signal · Niche overlap · Tropical forest

Introduction

An understanding of the rate at which species' ecological niches evolve—and consequently the degree to which closely related species occupy similar niches—is a topic that is relevant to many aspects of ecological and evolutionary biology (Wiens and Graham 2005; Wiens et al. 2010). The tendency for closely related taxa to share similar traits and occupy similar niches is often termed 'phylogenetic signal' sensu Losos (2008). This idea is also the basis for Darwin's hypothesis that competition is greater among close relatives (Darwin 1859), which has become known as phylogenetic limiting similarity. Many empirical studies have documented similarity of observed ecological niches among closely related species for a variety of taxa and ecological traits (e.g., Peterson et al. 1999; Prinzing 2001; Chazdon et al. 2003; Burns and Strauss 2011; Violle et al. 2011). Phylogenetic signal is widely accepted in the biological community, and sometimes takes on the role of an untested assumption. This assumption often underlies the interpretation of community assembly processes in phylogenetic community ecology (Webb 2000; Webb et al. 2002), and is often implicit in species distribution modeling and historical biogeography (Wiens and Donoghue 2004).

However, in a review of studies examining phylogenetic signal of ecological traits, Losos (2008) called attention to several instances where no relationship between evolutionary relatedness and ecological similarity was found, or where the relationship was negative (indicating rapid niche evolution). For example, Silvertown et al. (2006b) found no phylogenetic signal in the hydrological niches of co-occurring meadow plants, Cavender-Bares et al. (2004) found phylogenetic signal in some traits but not others in Floridian oak communities, and Losos et al. (2003) found no phylogenetic signal in the habitat and feeding niches of *Anolis* lizards in Cuba. Additionally, Blomberg et al. (2003) tested for phylogenetic signal in a variety of continuous traits and phylogenies taken from the literature, and found that most traits exhibited less phylogenetic signal than expected based on Brownian motion evolution. The results of these studies and others reviewed by Losos (2008) caution against the use of a priori assumptions of phylogenetic signal for all ecological systems and traits.

Adaptation to specific soil and topographic conditions is known to be an important part of the niche of tropical tree species. Small-scale variation in soil type, soil resource availability, and topography influences tropical tree species distributions at the local scale (<1 km) (Harms et al. 2001; Davies et al. 2005; Gunatilleke et al. 2006; John et al. 2007; Chuyong et al. 2011). Furthermore, species responses to both soil and topographic gradients have been shown to influence tropical forest community structure within many tropical forest dynamics plots (Valencia et al. 2004; Legendre et al. 2009; Baldeck et al. 2013). However, despite the importance of species' habitat niches in structuring tropical forest communities, it is unknown whether tree species sort independently along environmental gradients or whether evolutionary history influences the sorting of species along these gradients.

The question of how species' habitat niches are influenced by their evolutionary history is particularly relevant to the field of phylogenetic community ecology. The analysis of phylogenetic community structure attempts to reveal the relative importance of community assembly processes, with a primary focus on competitive exclusion and habitat filtering (Webb 2000; Webb et al. 2002; reviewed in Cavender-Bares et al. 2009; Vamosi et al. 2009). In the most common framework, the phylogenetic relationships among species occurring in a sample are analyzed and the sample may be described as phylogenetically even (species in the sample tend to be more distantly related than expected by chance, also called overdispersion), clustered (species in the sample tend to be more closely related than expected by chance), or neither (Webb 2000). It is usually assumed at the outset that the phylogenetic relatedness between two species is an indicator of their ecological similarity—that closely related species generally share more similar habitat

---

S. Madawala · N. Gunatilleke · S. Gunatilleke
Department of Botany, Faculty of Science, University of Peradeniya, Peradeniya 20400, Sri Lanka

S. Bunyavejchewin
National Parks, Wildlife, and Plant Conservation Department, Chatuchak, Bangkok 10900, Thailand

S. Kiratiprayoon
Faculty of Science and Technology, Thammasat University (Rangsit), Klongluang, Patumtani 12121, Thailand

A. Yaacob
Faculty of Plantation and Agrotechnology, University Technology MARA, Shah Alam, Selangor 40450, Malaysia

M. N. Nur Supardi
Forest Environment Division, Forest Research Institute Malaysia, Kepong, Selangor Darul Ehsan 52109, Malaysia

R. Valencia · H. Navarrete
Laboratorio de Ecología de Plantas y Herbario QCA, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Apartado 17-01-2184, Quito, Ecuador

S. P. Hubbell
Department of Ecology and Evolutionary Biology, University of California, Los Angeles, CA 90095, USA

requirements but also compete more strongly with one another. The presence of phylogenetic clustering then indicates the predominance of habitat filtering in structuring the community, while the presence of phylogenetic evenness indicates the predominance of competitive exclusion. However, tests of the assumption of phylogenetic signal in the ecological niches of the organisms under investigation are rare (e.g., Swenson et al. 2007).

Here, we examine the relationship between the evolutionary relatedness of co-occurring tropical tree species and the similarity in their local-scale habitat niches. We use the taxonomic rank of the species to approximate their evolutionary relationships, which allows us to use data from eight long-term tropical forest dynamics plots from the Center for Tropical Forest Science (CTFS) network, including approximately 1.4 million individuals of 1,513 species. We thus compare soil and topographic niche similarity of species pairs belonging to the same genus or family to that of more distantly related species pairs.

We expected that any effects of evolutionary relatedness on local habitat niches would be stronger at the genus level than at the family level, simply because congeneric species pairs will have diverged more recently, on average, than confamilial species pairs. If congeneric or confamilial species pairs have more similar habitat niches than more distant relatives, this would indicate phylogenetic signal in local habitat niches. It would also suggest that habitat filtering via soil and topographic variation could contribute to phylogenetic clustering within tropical tree communities. Alternatively, if congeneric or confamilial species pairs have more dissimilar habitat niches than more distant relatives, this would indicate that local habitat niches are highly evolutionarily labile, or convergent. This outcome could contribute to the coexistence of closely related species within the same habitat (Silvertown et al. 2006a) and could result in phylogenetic evenness of tropical forest communities.

Materials and methods

Study sites

This study uses vegetation and soil data from eight long-term tropical forest plots from the CTFS network: Barro Colorado Island (BCI), Panama (Hubbell et al. 1999, 2005); Huai Kha Khaeng and Khao Chong Thailand; Korup, Cameroon; La Planada, Colombia; Pasoh, Peninsular Malaysia; Sinharaja, Sri Lanka; and Yasuni, Ecuador (see Table 1 for environmental and vegetation characteristics of each study site). The plots range from 24 to 50 ha in size. Within each plot, all trees >1 cm diameter at breast height were measured, mapped, and identified to species (protocol described in Condit 1998). Detailed descriptions of the study areas and forest dynamics plots are provided by Losos and Leigh (2004).

Soil and topographic data

Soil sampling and kriging methods followed those described in John et al. (2007). Briefly, soil samples were taken in a 40 or 50 m grid across the 24–50 ha study area, with additional samples taken near alternate grid points to estimate fine scale variation in soil variables. Soil nutrient extractions were conducted at each site using a standardized protocol. Non-nitrogen elements were extracted with Mehlich-III solution and analyzed on an atomic emission-inductively coupled plasma (AE-ICP; Perkin Elmer, MA, USA), with the exception of phosphorus at the Yasuni study site, which was extracted with Bray extract solution and analyzed calorimetrically on a Quickchem 8500 Flow Injection Analyzer (Hach, CO, USA). For the three neotropical study sites (BCI, La Planada, and Yasuni), an estimate of the in situ nitrogen mineralization rate was taken at each sample location by measuring nitrogen before and after a 28-day incubation period (see John et al. 2007 for a more detailed description). Nitrogen was measured as NH^{4+} and NO^{3-} extracted with 2 M KCl and analyzed with an auto-analyzer (OI FS 3000; OI Analytical, TX, USA). Sample values were kriged to obtain estimated concentrations of soil nutrients at the 20 × 20 m quadrat scale. The non-nitrogen soil variables included in this study were phosphorus, calcium, potassium, magnesium, manganese, aluminum, and pH, but the number of variables included in the analysis varied from site to site. At least five soil variables were included in the analysis for each of the study sites (Table S1).

Topographic variables consisted of elevation, slope, and convexity (the relative elevation of a quadrat with respect to its immediate neighbors). Throughout each plot, elevation was recorded at the intersections of a 20 × 20 m grid and used to calculate topographic variables at the 20 × 20 m quadrat scale. Mean elevation was calculated as the mean of the elevation measurements at the four corners of a quadrat. Slope was calculated as the average slope of the four planes formed by connecting three corners of a quadrat at a time. Convexity was the elevation of a quadrat minus the average elevation of all immediate neighbor quadrats.

Niche overlap test

To reduce the complexity of the soil resource data, which included up to eight highly intercorrelated variables, a principal components (PC) analysis was performed to extract the main axes of soil nutrient variation for each site. The first two PC axes were used in the subsequent analysis.

Table 1 Environmental and vegetation characteristics of the study sites

Study site	Country	Size (ha)	Forest type	Elev. (m)	Soil order	Species	Congen.	Confam.
BCI	Panama	50	Semideciduous lowland moist	120	Oxisol	143	70	409
Huai Kha Khaeng	Thailand	50	Seasonal dry evergreen	549	Ultisol	74	10	137
Khao Chong	Thailand	24	Mixed evergreen	120	Ultisol	202	185	857
Korup	Cameroon	50	Lowland evergreen	150	Oxisol/Ultisol	209	239	933
La Planada	Colombia	25	Pluvial premontane	1,796	Andisol	106	75	279
Pasoh	Malaysia	50	Lowland mixed dipterocarp	80	Ultisol/Entisol	417	1,017	3,725
Sinharaja	Sri Lanka	25	Mixed dipterocarp	424	Ultisol	126	126	365
Yasuni	Ecuador	50	Evergreen lowland wet	230	Ultisol	313	532	2,012

Forest type taken from Losos and Leigh (2004)

Elev. is the lowermost elevation in the forest dynamics plot. *Species* indicates the number of species included in the study from each site, using only species with at least 100 individuals, *Congen.* and *Confam.* are the number of congeneric and confamilial species pairs from each study site, respectively

Among the eight study sites, the first two PCs combined represented between 60 and 87 % of the total variation present in the raw soil data (summary information on PC axes is provided in Table S1). Topographic variables were not converted to PCs, as elevation, slope, and convexity were generally non-linearly related to one another.

To measure the degree of similarity between two species' niches along an environmental gradient, a measure of niche overlap was calculated. Our niche overlap metric is adopted from Potts et al. (2004) and is derived from a Kolmogorov–Smirnov (K–S) test. A K–S test was calculated between two species' distributions along a PC axis or topographic variable, yielding a D statistic. The D statistic is a value between 0 and 1 that describes the degree of dissimilarity between the two distributions, and accounts for differences in central tendency, spread, and skewness. The test is non-parametric and therefore no assumption of normality regarding the distributions of species along soil gradients was needed. To express similarity between two distributions, we used 1-D as our measure of niche overlap.

All species with at least 100 individuals present at a study site and that were identified to genus were included in the analysis. A minimum sample size of 100 individuals was set to reduce spurious results due to low sample sizes, though results were found to be robust to smaller minimum sample sizes. Study sites varied considerably in the number of species included in the study, ranging from 74 species at Huai Kha Khaeng to 417 species at Pasoh (Table 1). Information on the families and genera represented in each study site is presented in Table S2. For each study site, the niche overlap metric was calculated for all pairwise combinations of species, for the two soil PC axes and the three topographic variables. Mantel tests were used to test whether species pairs belonging to the same genus or the same family have higher or lower niche overlap than expected based on a randomization of the data. Tests at the two taxonomic levels were performed for each environmental gradient, resulting in ten non-independent Mantel tests for each study site. Statistical significance was assessed by a two-tailed test ($\alpha = 0.025$ for each tail). Our analysis makes the assumption that congeneric species pairs are more closely related on average than confamilial species pairs, which are more closely related on average than non-confamilial species pairs.

Previous work from some CTFS plots and other forests around the world has demonstrated that forest communities may be phylogenetically clustered at distances of up to 100 m and that community phylogenetic structure is spatially autocorrelated (e.g., Webb 2000; Kembel and Hubbell 2006; Swenson et al. 2007). It was therefore necessary to check whether the results of this study were the result of coincident spatial structure of soil resources and the phylogenetic structure of the tree community. We checked for spurious results by repeating the Mantel tests for each site after swapping its soil PC or topographic maps with maps from another study site of the same or larger size (in the method of John et al. 2007). This created a null model that preserved both the spatial structure of the environmental gradients and the phylogenetic structure and spatial aggregation patterns of the tree communities. Statistically significant results for the swapped soil PC or topographic maps at either the genus or family level would indicate that the results of the tests at that taxonomic level may arise only due to the spatial structure of the community and the environmental variables.

Results

Congeneric species pairs showed significantly higher niche overlap than expected for at least one soil resource PC axis in four out of the eight study sites (Fig. 1a; Table S3a). Additionally, congeneric species pairs showed significantly higher niche overlap than expected for at least one

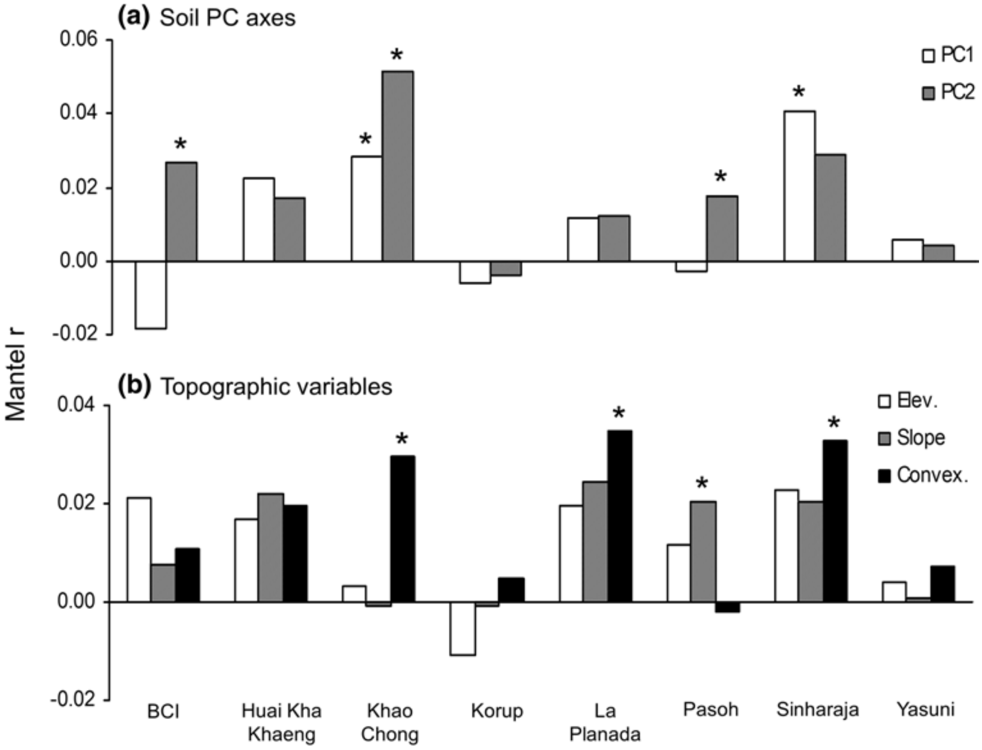

Fig. 1 Summary of Mantel tests comparing niche overlap among species from the same or different genera based on **a** soil PC axes and **b** topographic variables from eight sites. Positive values indicate that members of the same genus have higher niche overlap than members of different genera. *Asterisks* indicate significance ($\alpha = 0.025$ for each tail of a two-sided test)

topographic variable at four study sites (Fig. 1b; Table S3b). Of the topographic variables, convexity was the significant variable at three sites while slope was the significant variable at one site. Overall, congeneric species pairs generally had higher niche overlap than non-congeneric pairs (positive values of Mantel *r*), though a significant effect was only found for five sites total. When soil PC and topographic maps were swapped among sites, no spurious significant results were found at the genus level (data not shown).

In the genus-level Mantel tests, the PC axes for which congeneric species pairs showed significantly greater niche overlap than non-congeneric pairs tended to be highly correlated with aluminum (BCI PC2, Khao Chong PC2, Pasoh PC2, and Sinharaja PC1), with phosphorus (BCI PC2, Khao Chong PC2, and Pasoh PC2), base cations (Khao Chong PC1, Sinharaja PC1, and Yasuni PC2 as potassium), and manganese (Pasoh PC2, Yasuni PC2, Khao Chong PC1) having nearly equal overall importance to these axes (Table S1). Nitrogen mineralization rate was not found to be a large contributor to these axes, though it was only included for three sites.

The family level test results were more ambiguous. Significantly higher niche overlap along at least one soil PC axis was found for confamilial pairs at Khao Chong and Sinharaja, but the opposite result, significantly lower niche overlap, was found for La Planada (Table S4a). When soil PC maps were swapped among sites, a significantly higher niche overlap between members of the same family was found for Sinharaja (PC2), and significantly lower niche overlap was found for Yasuni (PC1; data not shown). Significantly higher niche overlap along at least one topographic axis was found for confamilial pairs at Khao Chong and Yasuni, and significantly lower overlap was found for La Planada (Table S4b). However, when topographic maps were swapped among sites, significantly higher niche overlap was found for Khao Chong (elevation and convexity; data not shown).

Discussion

Over all eight study sites, we found that very close relatives (i.e., congeners) often have more similar local habitat niches, indicating phylogenetic signal in the habitat niches of tropical trees. The genus-level results do not appear to be the consequence of coincident spatial structure of environmental variation and phylogenetic community structure, as no significant correlations were observed when habitat maps were swapped among sites. Although results were significant for five of the sites, and for only one or two environmental gradients per site, the majority of the effect sizes were positive, indicating a weak trend for congeneric species pairs to have higher niche overlaps than non-congeneric species pairs. However, there was considerable variability in the results from site to site, thus it may not be appropriate to assume phylogenetic signal in habitat niches of species across all sites. Additionally, the effects (Mantel *r* values) were small and it is unclear whether they are ecologically meaningful.

In contrast to the results at the genus level, there was no evidence for similar habitat niches at the family level. Although four sites showed significantly higher or lower niche overlap among members of the same family for at least one environmental gradient, three sites showed significant results at the family level when maps were swapped. The presence of spurious significant results at the family level indicates that the spatial structure of the environmental variables and the tree community may underlie observed niche overlap patterns at the family level. Additionally, our approach may be less able to detect patterns at the family level than at the genus level because of poorer representation of evolutionary divergence times at higher taxonomic ranks (i.e., confamilial species pairs will vary more in their evolutionary divergence times than congeneric species pairs).

We would expect that the use of taxonomic ranks would yield less power to detect evidence of phylogenetic signal than a well-resolved molecular phylogeny for the tree species in a community. However, this may not be the case when focusing on relationships among close relatives. For example, we found that congeneric species pairs had significantly higher niche overlap than expected for one soil PC axis at BCI. A previous study by Schreeg et al. (2010), using a barcode phylogeny for the tree community on BCI from Kress et al. (2009), found no phylogeny-wide signal in mean soil values and ranges using an analysis of traits approach. This discrepancy may have occurred because our analysis incorporates more information on species distributions across gradients and focuses on close relatives, where effects are most likely to be found. Thus, although taxonomic comparisons may be less effective at higher taxonomic ranks, they may yield decent power to detect effects at the genus level. As molecular phylogenies are increasingly available for many more tropical tree species, and are being created for some tropical forest communities (e.g., Kress et al. 2009), it may soon be possible to obtain estimates of the temporal extent of phylogenetic signal in species' ecological niches.

The variability in the genus level results do not display any global pattern that we can discern. The three sites that did not show any evidence for phylogenetic signal at the genus level were Huai Kha Kheng (Thailand), Korup (Cameroon), and Yasuni (Ecuador). These sites are located on three different continents, vary widely in their biogeographic history, climate, disturbance regimes, forest type, and species richness (Losos and Leigh 2004). There is no apparent commonality among these sites that differentiates them from the other sites, and thus we cannot infer any broad biogeographic trends in evolutionary lability of species' local habitat niches from this study.

However, our results may have important implications for the phylogenetic structure of these forest communities. It has been shown that, when patterns of phylogenetic signal in traits are incorporated into studies of phylogenetic ecology, they are tightly linked to observed patterns of phylogenetic community structure. Cavender-Bares et al. (2004) and Ackerly et al. (2006) showed that differences in the phylogenetic signal and the adaptive significance of traits explained observed phylogenetic community structure patterns in their study systems. For example, the convergent evolution of species' functional traits associated with habitat use in Floridian oaks explained the phylogenetic evenness of Floridian oak communities (Cavender-Bares et al. 2004). Additionally, Kraft et al. (2007) and Kembel (2009) used simulated communities with known assembly processes to show that differences in phylogenetic signal of traits strongly affect the outcome of phylogenetic community structure tests.

Further study is needed to understand how the patterns observed in the habitat niches of congeners is related to the phylogenetic structure of these communities. Phylogenetic signal in habitat-use niches may underlie some of the observed phylogenetic clustering of tree species at large scales in some CTFS and other tropical forest plots (e.g., Webb 2000; Swenson et al. 2007; Kraft and Ackerly 2010). However, if closely related species have more similar habitat niches at the plot scale, it does not necessarily follow that they will tend to be found within the same small-scale locations (i.e., a 5 × 5 or 10 × 10 m quadrat). Of the study sites included in this analysis, phylogenetic community structure has only been thoroughly examined at BCI (Kembel and Hubbell 2006; Swenson et al. 2007; but see Kress et al. 2009) and Yasuni (Kraft and Ackerly 2010). Future analyses connecting habitat variability with phylogenetic community structure could reveal the importance of phylogenetic signal in local-scale habitat niches in shaping phylogenetic structure in tropical forest communities.

Acknowledgments We thank the Center for Tropical Forest Science for their collection and organization of the tree census data used in this study. The BCI forest dynamics research project was made possible by National Science Foundation grants to Stephen P. Hubbell: DEB-0640386, DEB-0425651, DEB-0346488, DEB-0129874, DEB-00753102, DEB-9909347, DEB-9615226, DEB-9615226, DEB-9405933, DEB-9221033, DEB-9100058, DEB-8906869, DEB-8605042, DEB-8206992, DEB-7922197, support from the Center for Tropical Forest Science, the Smithsonian Tropical Research Institute, the John D. and Catherine T. MacArthur Foundation, the Mellon Foundation, the Small World Institute Fund. Funding for soils work was provided by the US National Science Foundation Grants DEB 0211004, DEB 0211115, DEB 0212284, DEB 0212818, and OISE 0314581, the soils initiative of the Smithsonian Tropical Research Institute, and a CTFS grant to cover collection and extraction of soils from Korup. The experiments comply with the current laws of the countries in which they were performed. We also thank editor Walter Carson and two anonymous reviewers for their valuable comments on the manuscript.

Author contributions GBC, DK, DWT, SM, NG, SG, SB, SK, AY, MNNS, RV, HN, SJD, and SPH coordinated collection of tree census and topographic data, JWD, KEH, JBY, and RJ designed the soil sampling protocol, BLT, HN, GBC, SM, SB, SK and AY collected soil data, RJ kriged the soil data, CAB designed and carried out the statistical analysis with JWD as advisor, CAB wrote the manuscript, and JWD and SWK contributed substantially to revisions.

References

Ackerly DD, Schwilk DW, Webb CO (2006) Niche evolution and adaptive radiation: testing the order of trait divergence. Ecology 87:50–61. doi:10.1890/0012-9658(2006)87[50:NEAART]2.0.CO;

Baldeck CA, Harms KE, Yavitt JB, John R, Turner BL, Valencia R, Navarette H, Davies SJ, Chuyong GB, Kenfack D, Thomas DW, Madawala S, Gunatilleke N, Gunatilleke S, Bunyavejchewin S, Kiratiprayoon S, Yaacob A, Supardi MNN, Dalling JW (2013) Soil resources and topography shape local tree community structure in tropical forests. Proc R Soc Lond B 280:20122532. doi:10.1098/rspb.2012.2532

Blomberg SP, Garland T, Ives AR (2003) Testing for phylogenetic signal in comparative data: behavioral traits are more labile. Evolution 57:717–745. doi:10.1111/j.0014-3820.2003.tb00285.x

Burns JH, Strauss SY (2011) More closely related species are more ecologically similar in an experimental test. Proc Natl Acad Sci USA 108:5302–5307. doi:10.1073/pnas.1013003108

Cavender-Bares J, Ackerly D, Baum D, Bazzaz F (2004) Phylogenetic overdispersion in Floridian oak communities. Am Nat 163:823–843

Cavender-Bares J, Kozak KH, Fine PVA, Kembel SW (2009) The merging of community ecology and phylogenetic biology. Ecol Lett 12:693–715. doi:10.1111/j.1461-0248.2009.01314.x

Chazdon RL, Careaga S, Webb C, Vargas O (2003) Community and phylogenetic structure of reproductive traits of woody species in wet tropical forests. Ecol Monogr 73:331–348. doi:10.1890/02-4037

Chuyong G, Kenfack D, Harms K, Thomas D, Condit R, Comita L (2011) Habitat specificity and diversity of tree species in an African wet tropical forest. Plant Ecol 212:1363–1374. doi:10.1007/s11258-011-9912-4

Condit R (1998) Tropical forest census plots. Springer-Verlag and R G Landes Company, Berlin, Germany, and Georgetown, Texas, USA

Darwin C (1859) On the origin of species. John Murray, London

Davies SJ, Tan S, LaFrankie JV, Potts MD (2005) Soil-related floristic variation in the hyperdiverse dipterocarp forest in Lambir hills Sarawak. In: Roubik DW, Sakai S, Hamid A (eds) Pollination ecology and rain forest diversity, Sarawak studies. Springer-Verlag, New York, pp 22–34

Gunatilleke CVS, Gunatilleke IAUN, Esufali S, Harms KE, Ashton PMS, Burslem DFRP, Ashton PS (2006) Species–habitat associations in a Sri Lankan dipterocarp forest. J Trop Ecol 22:371–384. doi:10.1017/S0266467406003282

Harms KE, Condit R, Hubbell SP, Foster RB (2001) Habitat associations of trees and shrubs in a 50-ha neotropical forest plot. J Ecol 89:947–959. doi:10.1111/j.1365-2745.2001.00615.x

Hubbell SP, Foster RB, O'Brien ST, Harms KE, Condit R, Wechsler B, Wright SJ, Loo de Lao S (1999) Light gap disturbances, recruitment limitation, and tree diversity in a neotropical forest. Science 283:554–557

Hubbell SP, Comdit R, Foster RB (2005) Barro Colorado forest census plot data. URL https://ctfs.arnarb.harvard.edu/webatlas/datasets/bci

John R, Dalling JW, Harms KE, Yavitt JB, Stallard RF, Mirabello M, Hubbell SP, Valencia R, Navarrete H, Vallejo M, Foster RB (2007) Soil nutrients influence spatial distributions of tropical tree species. Proc Natl Acad Sci USA 104:864–869. doi:10.1073/pnas.0604666104

Kembel SW (2009) Disentangling niche and neutral influences on community assembly: assessing the performance of community phylogenetic structure tests. Ecol Lett 12:949–960. doi:10.1111/j.1461-0248.2009.01354.x

Kembel SW, Hubbell SP (2006) The phylogenetic structure of a Neotropical forest tree community. Ecology 87:86–99. doi:10.1890/0012-9658(2006)87[86:TPSOAN]2.0.CO;2

Kraft NJB, Cornwell WK, Webb CO, Ackerly DD (2007) Trait evolution, community assembly, and the phylogenetic structure of ecological communities. Am Nat 170:271–283. doi:10.1086/519400

Kraft NJB, Ackerly DD (2010) Functional trait and phylogenetic tests of community assembly across spatial scales in an Amazonian forest. Ecol Monogr 80:401–422. doi:10.1890/09-1672.1

Kress WJ, Erickson DL, Jones FA, Swenson NG, Perez R, Sanjur O, Bermingham E (2009) Plant DNA barcodes and a community phylogeny of a tropical forest dynamics plot in Panama. Proc Natl Acad Sci USA 106:18621–18626. doi:10.1073/pnas.0909820106

Legendre P, Mi X, Ren H, Ma K, Yu M, Sun I, He F (2009) Partitioning beta diversity in a subtropical broad-leaved forest of China. Ecology 90:663–674. doi:10.1890/07-1880.1

Losos JB (2008) Phylogenetic niche conservatism, phylogenetic signal and the relationship between phylogenetic relatedness and ecological similarity among species. Ecol Lett 11:995–1003. doi:10.1111/j.1461-0248.2008.01229.x

Losos JB, Leal M, Glor RE, de Queiroz K, Hertz PE, Schettino LR, Lara AC, Jackman Todd R, Larson A (2003) Niche lability in the evolution of a Caribbean lizard community. Nature 424:542–545

Losos EC, Leigh EG Jr (2004) Tropical forest diversity and dynamism. University of Chicago Press, Chicago

Peterson AT, Soberón J, Sánchez-Cordero V (1999) Conservatism of ecological niches in evolutionary time. Science 285:1265–1267. doi:10.1126/science.285.5431.1265

Potts M, Davies S, Bossert W, Tan S, Nur Supardi MN (2004) Habitat heterogeneity and niche structure of trees in two tropical rain forests. Oecologia 139:446–453. doi:10.1007/s00442-004-1525-3

Prinzing A (2001) The niche of higher plants: evidence for phylogenetic conservatism. Proc R Soc Lond B 268:2383–2389. doi:10.1098/rspb.2001.1801

Schreeg LA, Kress WJ, Erickson DL, Swenson NG (2010) Phylogenetic analysis of local-scale tree soil associations in a lowland moist tropical forest. PLoS ONE 5:e13685

Silvertown J, Dodd M, Gowing D, Lawson C, McConway K (2006a) Phylogeny and the hierarchical organization of plant diversity. Ecology 87:39–49. doi:10.1890/0012-9658(2006)87[39:PATHO O]2.0.CO;2

Silvertown J, McConway K, Gowing D, Dodd M, Fay MF, Joseph JA, Dolphin K (2006b) Absence of phylogenetic signal in the niche structure of meadow plant communities. Proc R Soc Lond B 273:39–44. doi:10.1098/rspb.2005.3288

Swenson NG, Enquist BJ, Thompson J, Zimmerman JK (2007) The influence of spatial and size scale on phylogenetic relatedness in tropical forest communities. Ecology 88:1770–1780. doi:10.1890/06-1499.1

Valencia R, Foster RB, Villa G, Condit R, Svenning J, Hernández C, Romoleroux K, Losos E, Magård E, Balslev H (2004) Tree species distributions and local habitat variation in the Amazon: large forest plot in eastern Ecuador. J Ecol 92:214–229. doi:10.1111/j.0022-0477.2004.00876.x

Vamosi SM, Heard SB, Vamosi JC, Webb CO (2009) Emerging patterns in the comparative analysis of phylogenetic community structure. Mol Ecol 18:572–592. doi:10.1111/j.1365-294X.2008.04001.x

Violle C, Nemergut DR, Pu Z, Jiang L (2011) Phylogenetic limiting similarity and competitive exclusion. Ecol Lett 14:782–787. doi:10.1111/j.1461-0248.2011.01644.x

Webb CO, Ackerly DD, McPeek MA, Donoghue MJ (2002) Phylogenies and community ecology. Annu Rev Ecol Syst 33:475–505. doi:10.1146/annurev.ecolsys.33.010802.150448

Webb CO (2000) Exploring the phylogenetic structure of ecological communities: an example for rain forest trees. Am Nat 156:145–155

Wiens JJ, Donoghue MJ (2004) Historical biogeography, ecology and species richness. Trends Ecol Evol 19:639–644. doi:10.1016/j.tree.2004.09.011

Wiens JJ, Graham CH (2005) Niche conservatism: integrating evolution, ecology, and conservation biology. Annu Rev Ecol Evol Syst 36:519–539

Wiens JJ, Ackerly DD, Allen AP, Anacker BL, Buckley LB, Cornell HV, Damschen EI, Davies TJ, Grytnes J-A, Harrison SP, Hawkins BA, Holt RD, McCain CM, Stephens PR (2010) Niche conservatism as an emerging principle in ecology and conservation biology. Ecol Lett 13:1310–1324. doi:10.1111/j.1461-0248.2010.01515.x

Supplementary Information

Table S1. The loadings of each soil variable with each of the first two PC axes and the total variance explained by the two PC axes combined.

BCI	PC1	PC2
Al	0.26	-0.64
Ca	-0.46	-0.11
K	-0.45	-0.11
Mg	-0.43	-0.11
Mn	-0.31	-0.28
Nmin	-0.35	0.00
P	0.08	-0.69
pH	-0.32	0.05
Variance explained: 69%		

Huai Kha Khaeng	PC1	PC2
Al	-0.33	0.60
Ca	-0.47	0.15
K	-0.50	-0.12
Mg	-0.39	-0.18
Mn	-0.23	-0.43
P	-0.29	0.43
pH	-0.36	-0.45
Variance explained: 67%		

Khao Chong	PC1	PC2
Al	-0.09	0.77
Ca	-0.43	-0.08
K	-0.43	0.25
Mg	-0.41	0.28
Mn	-0.43	-0.11
P	-0.29	-0.46
pH	-0.43	-0.20
Variance explained: 81%		

Korup	PC1	PC2
Al	0.21	0.93
Ca	-0.46	0.00
K	-0.43	0.10
Mg	-0.46	0.08
Mn	-0.45	-0.04
P	-0.39	0.34
Variance explained: 87%		

La Planada	PC1	PC2
Al	0.10	-0.66
Ca	0.44	0.14
K	0.47	0.00
Mg	0.47	0.08
Mn	-0.09	0.61
Nmin	0.11	0.27
P	0.43	0.20
pH	-0.39	0.25
Variance explained: 68%		

Pasoh	PC1	PC2
Al	0.31	0.51
Ca	0.50	-0.15
K	0.45	0.22
Mg	0.53	-0.25
Mn	0.27	-0.66
P	0.30	0.41
Variance explained: 69%		

Sinharaja	PC1	PC2
Al	-0.51	0.22
Ca	-0.49	-0.49
K	-0.55	-0.32
P	-0.36	0.29
pH	0.27	-0.72
Variance explained: 67%		

Yasuni	PC1	PC2
Al	-0.39	0.04
Ca	0.51	0.23
K	0.26	-0.45
Mg	0.44	0.30
Mn	0.14	-0.59
Nmin	-0.22	0.50
P	0.05	0.21
pH	0.51	0.13
Variance explained: 58%		

Table S2. Families and genera included in the analysis for each study site

a) BCI

Family	Genus	No. species
Anacardiaceae	Spondias	1
Annonaceae	Anaxagorea	1
Annonaceae	Annona	2
Annonaceae	Desmopsis	1
Annonaceae	Guatteria	1
Annonaceae	Mosannona	1
Annonaceae	Unonopsis	1
Annonaceae	Xylopia	1
Apocynaceae	Aspidosperma	1
Apocynaceae	Lacmellea	1
Apocynaceae	Tabernaemontana	1
Arecaceae	Astrocaryum	1
Arecaceae	Oenocarpus	1
Arecaceae	Socratea	1
Bignoniaceae	Jacaranda	1
Bignoniaceae	Tabebuia	1
Bombacaceae	Quararibea	1
Boraginaceae	Cordia	3
Burseraceae	Protium	3
Burseraceae	Tetragastris	1
Capparaceae	Capparis	1
Cecropiaceae	Cecropia	2
Cecropiaceae	Pourouma	1
Chrysobalanaceae	Hirtella	1
Chrysobalanaceae	Licania	2
Clusiaceae	Calophyllum	1
Clusiaceae	Chrysochlamys	1
Clusiaceae	Garcinia	2
Clusiaceae	Symphonia	1
Elaeocarpaceae	Sloanea	1
Erythroxylaceae	Erythroxylum	2
Euphorbiaceae	Acalypha	1
Euphorbiaceae	Adelia	1
Euphorbiaceae	Alchornea	1
Euphorbiaceae	Croton	1
Euphorbiaceae	Drypetes	1
Euphorbiaceae	Hura	1
Fabaceae	Andira	1
Fabaceae	Inga	8
Fabaceae	Lonchocarpus	1
Fabaceae	Ormosia	2
Fabaceae	Platymiscium	1
Fabaceae	Platypodium	1
Fabaceae	Prioria	1
Fabaceae	Pterocarpus	1
Fabaceae	Senna	1
Fabaceae	Swartzia	2
Fabaceae	Tachigali	1
Flacourtiaceae	Casearia	3
Flacourtiaceae	Hasseltia	1
Flacourtiaceae	Lacistema	1
Flacourtiaceae	Laetia	1
Lauraceae	Beilschmiedia	1
Lauraceae	Nectandra	2
Lauraceae	Ocotea	4
Lecythidaceae	Gustavia	1
Malvaceae	Hampea	1
Melastomataceae	Miconia	3
Melastomataceae	Mouriri	1
Meliaceae	Guarea	2
Meliaceae	Trichilia	2
Monimiaceae	Siparuna	1
Moraceae	Brosimum	1
Moraceae	Maquira	1
Moraceae	Perebea	1
Moraceae	Poulsenia	1
Moraceae	Sorocea	1
Moraceae	Trophis	2
Myristicaceae	Virola	2
Myrsinaceae	Ardisia	1
Myrsinaceae	Stylogyne	1
Myrtaceae	Chamguava	1
Myrtaceae	Eugenia	4
Nyctaginaceae	Guapira	1
Ochnaceae	Ouratea	1
Olacaceae	Heisteria	2

Picramniaceae	Picramnia	1
Piperaceae	Piper	1
Polygonaceae	Coccoloba	2
Polygonaceae	Triplaris	1
Rhizophoraceae	Cassipourea	1
Rubiaceae	Alibertia	1
Rubiaceae	Alseis	1
Rubiaceae	Coussarea	1
Rubiaceae	Faramea	1
Rubiaceae	Guettarda	1
Rubiaceae	Palicourea	1
Rubiaceae	Pentagonia	1
Rubiaceae	Psychotria	2
Rubiaceae	Randia	1
Rutaceae	Zanthoxylum	2
Sapindaceae	Allophylus	1
Sapindaceae	Cupania	1
Sapindaceae	Talisia	2
Sapotaceae	Chrysophyllum	2
Sapotaceae	Pouteria	1
Simaroubaceae	Quassia	1
Simaroubaceae	Simarouba	1
Sterculiaceae	Herrania	1
Tiliaceae	Apeiba	1
Tiliaceae	Luehea	1
Ulmaceae	Celtis	1
Violaceae	Hybanthus	1
Violaceae	Rinorea	1

b) HKK

Family	Genus	No. species
Alangiaceae	Alangium	1
Anacardiaceae	Buchanania	1
Anacardiaceae	Semecarpus	1
Annonaceae	Alphonsea	1
Annonaceae	Cyathocalyx	1
Annonaceae	Mitrephora	1
Annonaceae	Orophea	1
Annonaceae	Polyalthia	2
Annonaceae	Saccopetalum (Miliusa)	1
Bignoniaceae	Markhamia	1
Bignoniaceae	Radermachera	1
Bignoniaceae	Stereospermum	1
Boraginaceae	Cordia	1
Burseraceae	Garuga	1
Clusiaceae	Garcinia	1
Datiscaceae	Tetrameles	1
Dipterocarpaceae	Anisoptera	1
Dipterocarpaceae	Dipterocarpus	1
Dipterocarpaceae	Hopea	1
Dipterocarpaceae	Vatica	1
Ebenaceae	Diospyros	3
Euphorbiaceae	Alchornea	1
Euphorbiaceae	Antidesma	1
Euphorbiaceae	Baccaurea	1
Euphorbiaceae	Cleidion	1
Euphorbiaceae	Croton	1
Euphorbiaceae	Macaranga	1
Euphorbiaceae	Mallotus	2
Euphorbiaceae	Phyllanthus	1
Euphorbiaceae	Trewia	1
Irvingiaceae	Irvingia	1
Lauraceae	Litsea	1
Lauraceae	Neolitsea	1
Lauraceae	Phoebe	1
Leguminosae	Albizia	1
Leguminosae	Cassia	2
Leguminosae	Dalbergia	1
Leguminosae	Dialium	1
Lythraceae	Lagerstroemia	2
Melastomataceae	Memecylon	2
Meliaceae	Aglaia	2
Meliaceae	Aphanamixis	1
Meliaceae	Chukrasia	1
Meliaceae	Dysoxylum	1
Meliaceae	Melia	1
Myrsinaceae	Ardisia	1
Myrtaceae	Syzygium	1

Opiliaceae	Urobotrya	1
Polygalaceae	Xanthophyllum	1
Rubiaceae	Hyptianthera	1
Rubiaceae	Prismatomeris	1
Rubiaceae	Tarenna	1
Rutaceae	Glycosmis	1
Rutaceae	Melicope	1
Rutaceae	Murraya	1
Sapindaceae	Acer	1
Sapindaceae	Arytera	1
Sapindaceae	Dimocarpus	1
Sapindaceae	Harpullia	2
Sapindaceae	Lepisanthes	1
Sapindaceae	Mischocarpus	1
Solanaceae	Solanum	1
Sterculiaceae	Helicteres	1
Sterculiaceae	Pterospermum	1
Verbenaceae	Vitex	1

c) Khao Chong

Family	Genus	No. species
Acanthaceae	Justicia	1
Achariaceae	Hydnocarpus	1
Achariaceae	Ryparosa	1
Actinidiaceae	Saurauia	1
Anacardiaceae	Bouea	1
Anacardiaceae	Dracontomelon	1
Anacardiaceae	Gluta	1
Anacardiaceae	Melanochyla	1
Anacardiaceae	Parishia	1
Annonaceae	Alphonsea	1
Annonaceae	Anaxagorea	1
Annonaceae	Cyathocalyx	1
Annonaceae	Dasymaschalon	1
Annonaceae	Enicosanthum	1
Annonaceae	Goniothalamus	3
Annonaceae	Meiogyne	1
Annonaceae	Mezzettia	1
Annonaceae	Miliusa	3
Annonaceae	Orophea	3
Annonaceae	Polyalthia	3
Annonaceae	Popowia	1
Annonaceae	Pseuduvaria	2
Annonaceae	Sageraea	1
Annonaceae	Trivalvaria	1
Apocynaceae	Alstonia	1
Apocynaceae	Hunteria	1
Apocynaceae	Wrightia	1
Araliaceae	Macropanax	1
Araliaceae	Trevesia	1
Arecaceae	Pinanga	1
Bignoniaceae	Pajanelia	1
Burseraceae	Canarium	1
Burseraceae	Dacryodes	1
Celastraceae	Euonymus	1
Celastraceae	Glyptopetalum	1
Chrysobalanaceae	Maranthes	1
Clusiaceae	Calophyllum	1
Clusiaceae	Garcinia	4
Clusiaceae	Mesua	1
Cornaceae	Alangium	1
Crypteroniaceae	Crypteronia	1
Dilleniaceae	Dillenia	1
Dipterocarpaceae	Dipterocarpus	2
Dipterocarpaceae	Parashorea	1
Dipterocarpaceae	Shorea	2
Ebenaceae	Diospyros	12
Euphorbiaceae	Agrostistachys	1
Euphorbiaceae	Balakata	1
Euphorbiaceae	Blumeodendron	1
Euphorbiaceae	Macaranga	3
Euphorbiaceae	Mallotus	2
Euphorbiaceae	Neoscortechinia	1
Euphorbiaceae	Ptychopyxis	1
Euphorbiaceae	Trigonostemon	1
Fabaceae	Crudia	1
Fabaceae	Cynometra	1
Fabaceae	Intsia	1
Fabaceae	Millettia	1

Fabaceae	Saraca	1
Hypericaceae	Cratoxylum	1
Lauraceae	Beilschmiedia	1
Lauraceae	Cinnamomum	1
Lauraceae	Dehaasia	1
Lauraceae	Litsea	3
Lauraceae	Nothaphoebe	1
Lauraceae	Persea	1
Lecythidaceae	Barringtonia	1
Lythraceae	Duabanga	1
Magnoliaceae	Michelia	1
Malvaceae	Durio	1
Malvaceae	Leptonychia	1
Malvaceae	Microcos	1
Malvaceae	Pentace	1
Malvaceae	Scaphium	1
Melastomataceae	Melastoma	1
Meliaceae	Aglaia	7
Meliaceae	Chisocheton	1
Meliaceae	Dysoxylum	3
Meliaceae	Lansium	1
Meliaceae	Toona	1
Meliaceae	Walsura	1
Memecylaceae	Memecylon	2
Moraceae	Ficus	6
Moraceae	Streblus	1
Myristicaceae	Horsfieldia	1
Myristicaceae	Knema	4
Myrsinaceae	Ardisia	3
Myrtaceae	Cleistocalyx	1
Myrtaceae	Syzygium	7
Olacaceae	Strombosia	2
Oleaceae	Chionanthus	1
Pandaceae	Galearia	1
Pandaceae	Microdesmis	1
Phyllanthaceae	Actephila	1
Phyllanthaceae	Antidesma	3
Phyllanthaceae	Aporosa	3
Phyllanthaceae	Baccaurea	3
Phyllanthaceae	Bridelia	2
Phyllanthaceae	Cleistanthus	1
Phyllanthaceae	Glochidion	1
Polygalaceae	Xanthophyllum	2
Putranjivaceae	Drypetes	2
Rosaceae	Prunus	1
Rubiaceae	Aidia	1
Rubiaceae	Canthium	2
Rubiaceae	Fagerlindia	1
Rubiaceae	Ixora	3
Rubiaceae	Mussaenda	1
Rubiaceae	Nauclea	1
Rubiaceae	Neolamarckia	1
Rubiaceae	Prismatomeris	1
Rubiaceae	Psydrax	1
Rubiaceae	Rothmannia	1
Rubiaceae	Saprosma	1
Rubiaceae	Urophyllum	1
Rutaceae	Glycosmis	2
Salicaceae	Osmelia	1
Salicaceae	Scolopia	1
Sapindaceae	Allophylus	1
Sapindaceae	Lepisanthes	2
Sapindaceae	Nephelium	1
Sapindaceae	Xerospermum	1
Sapotaceae	Palaquium	2
Sapotaceae	Payena	1
Staphyleaceae	Turpinia	1
Stemonuraceae	Stemonurus	1
Thymelaeaceae	Aquilaria	1
Urticaceae	Boehmeria	1
Violaceae	Rinorea	1
Vitaceae	Leea	2

d) Korup

Family	Genus	No. species
Achariaceae	Camptostylus	1
Achariaceae	Dasylepis	1
Achariaceae	Scottellia	1
Anacardiaceae	Sorindeia	1

Anacardiaceae	Trichoscypha	6
Anisophylleaceae	Anisophyllea	1
Annonaceae	Annickia	1
Annonaceae	Isolona	1
Annonaceae	Pachypodanthium	1
Annonaceae	Piptostigma	1
Annonaceae	Polyceratocarpus	1
Annonaceae	Uvariastrum	1
Annonaceae	Uvariodendron	1
Annonaceae	Uvariopsis	2
Annonaceae	Xylopia	2
Apocynaceae	Hunteria	1
Apocynaceae	Pleiocarpa	1
Apocynaceae	Rauvolfia	1
Apocynaceae	Tabernaemontana	2
Apocynaceae	Voacanga	1
Burseraceae	Dacryodes	1
Burseraceae	Santiria	1
Celastraceae	Salacia	3
Chrysobalanaceae	Dactyladenia	1
Chrysobalanaceae	MaGuiistipula	1
Clusiaceae	Endodesmia	1
Clusiaceae	Garcinia	4
Clusiaceae	Symphonia	1
Combretaceae	Strephonema	1
Connaraceae	Jollydora	2
Dichapetalaceae	Tapura	1
Ebenaceae	Diospyros	9
Euphorbiaceae	Croton	1
Euphorbiaceae	Crotonogyne	1
Euphorbiaceae	Crotonogynopsis	1
Euphorbiaceae	Dichostemma	1
Euphorbiaceae	Discoglypremna	1
Euphorbiaceae	Klaineanthus	1
Euphorbiaceae	Macaranga	1
Euphorbiaceae	Mareyopsis	1
Euphorbiaceae	Pycnocoma	1
Fabaceae	Angylocalyx	1
Fabaceae	Anthonotha	1
Fabaceae	Baphia	2
Fabaceae	Berlinia	2
Fabaceae	Calpocalyx	1
Fabaceae	Dialium	1
Fabaceae	Gilbertiodendron	1
Fabaceae	Hymenostegia	2
Fabaceae	Talbotiella	1
Icacinaceae	Lasianthera	1
Icacinaceae	Leptaulus	1
Irvingiaceae	Irvingia	1
Lamiaceae	Vitex	2
Lauraceae	Beilschmiedia	6
Lauraceae	Hypodaphnis	1
Lecythidaceae	Napoleonaea	1
Lecythidaceae	Oubanguia	1
Lecythidaceae	Rhaptopetalum	1
Lecythidaceae	Scytopetalum	1
Malvaceae	Cola	12
Malvaceae	Leptonychia	2
Malvaceae	Microcos	1
Malvaceae	Scaphopetalum	1
Medusandraceae	Soyauxia	1
Melastomataceae	Warneckea	3
Meliaceae	Carapa	1
Meliaceae	Guarea	1
Meliaceae	Trichilia	2
Meliaceae	Turraeanthus	1
Memecylaceae	Memecylon	4
Monimiaceae	Glossocalyx	1
Moraceae	Treculia	1
Myristicaceae	Staudtia	1
Myrtaceae	Eugenia	1
Ochnaceae	Campylospermum	3
Olacaceae	Diogoa	1
Olacaceae	Heisteria	1
Olacaceae	Octoknema	1
Olacaceae	Ptychopetalum	1
Olacaceae	Strombosia	3
Olacaceae	Strombosiopsis	1
Pandaceae	Microdesmis	1
Phyllanthaceae	Antidesma	1
Phyllanthaceae	Maesobotrya	3
Phyllanthaceae	Protomegabaria	1
Phyllanthaceae	Thecacoris	1
Phyllanthaceae	Uapaca	1
Polygalaceae	Carpolobia	1
Putrangivaceae	Drypetes	4

Putrangivaceae	Sibangea	1
Rhamnaceae	Lasiodiscus	1
Rubiaceae	Aulacocalyx	3
Rubiaceae	Belonophora	2
Rubiaceae	Bertiera	1
Rubiaceae	Calycosiphonia	1
Rubiaceae	Canthium	1
Rubiaceae	Craterispermum	1
Rubiaceae	Didymosalpinx	1
Rubiaceae	Euclinia	1
Rubiaceae	Gaertnera	1
Rubiaceae	Heinsia	1
Rubiaceae	Ixora	2
Rubiaceae	Massularia	1
Rubiaceae	Oxyanthus	1
Rubiaceae	Pauridiantha	1
Rubiaceae	Pausinystalia	1
Rubiaceae	Petitiocodon	1
Rubiaceae	Polysphaeria	1
Rubiaceae	Psychotria	2
Rubiaceae	Rothmannia	2
Rubiaceae	Schumanniophyton	1

Rubiaceae	Tricalysia	1
Ruscaceae	Dracaena	1
Rutaceae	Araliopsis	1
Rutaceae	Fagara	1
Rutaceae	Zanthoxylum	1
Salicaceae	Homalium	2
Salicaceae	Phyllobotryon	1
Sapindaceae	Allophylus	1
Sapindaceae	Aporrhiza	1
Sapindaceae	Chytranthus	1
Sapindaceae	Deinbollia	2
Sapindaceae	Laccodiscus	1
Sapindaceae	Placodiscus	1
Sapotaceae	Chrysophyllum	1
Sapotaceae	Englerophytum	1
Sapotaceae	Lecomtedoxa	1
Sapotaceae	Synsepallum	1
Urticaceae	Musanga	1
Violaceae	Allexis	1
Violaceae	Rinorea	11
Vochysiaceae	Erismadelphus	1

d) La Planada

Family	Genus	No. species
Actinidaceae	Saurauia	1
Annonaceae	Guatteria	1
Apocynaceae	Tabernaemontana	1
Araliaceae	Schefflera	2
Arecaceae	Aiphanes	1
Arecaceae	Chamaedorea	1
Arecaceae	Geonoma	1
Arecaceae	Prestoea	1
Asteraceae	Crytoniopsis	1
Bombacaceae	Matisia	1
Boraginaceae	Cordia	1
Caesalpinaceae	Macrolobium	1
Cecropiaceae	Cecropia	1
Cecropiaceae	Pourouma	1
Celastraceae	Gymnosporia	1
Chrysobalanaceae	Couepia	1

Family	Genus	No. species
Chrysobalanaceae	Licania	1
Clusiaceae	Chrysochlamys	1
Clusiaceae	Clusia	1
Clusiaceae	Vismia	1
Cyatheaceae	Alsophila	2
Cyatheaceae	Cyathea	3
Cyatheaceae	Dicksonia	1
Dichapetalaceae	Stephanopodium	1
Elaeocarpaceae	Sloanea	1
Euphorbiaceae	Alchornea	3
Euphorbiaceae	Hieronyma	1
Fabaceae	Dussia	1
Flacourtiaceae	Casearia	1
Gesneriaceae	Alloplectus	1
Gesneriaceae	Besleria	1
Hippocastanaceae	Billia	1

Hippocrateaceae	Salacia	1
Icacinaceae	Calatola	1
Lauraceae	Aniba	1
Lauraceae	Beilschmiedia	1
Lauraceae	Ocotea	4
Lauraceae	Rhodostemonodaphne	1
Lecythidaceae	Eschweilera	1
Melastomataceae	Blakea	1
Melastomataceae	Centronia	1
Melastomataceae	Conostegia	1
Melastomataceae	Meriania	2
Melastomataceae	Miconia	8
Melastomataceae	Ossaea	2
Meliaceae	Carapa	1
Meliaceae	Guarea	1
Meliaceae	Trichilia	1
Mimosaceae	Inga	4
Monimiaceae	Siparuna	1
Moraceae	Ficus	3
Moraceae	Morus	1
Moraceae	Naucleopsis	1
Myristicaceae	Otoba	1
Myrsinaceae	Cybianthus	1
Myrsinaceae	Geissanthus	1
Myrtaceae	Eugenia	2
Myrtaceae	Myrcia	3
Myrtaceae	Psydium	1
Piperaceae	Piper	3
Rosaceae	Prunus	1
Rubiaceae	Bathysa	1
Rubiaceae	Elaeagia	1
Rubiaceae	Faramea	5
Rubiaceae	Ladenbergia	1
Rubiaceae	Palicourea	3
Rubiaceae	Psychotria	2
Sapindaceae	Allophylus	1
Solanaceae	Cestrum	2
Solanaceae	Solanum	1

f) Pasoh

Family	Genus	No. species
Alangiaceae	Alangium	2
Anacardiaceae	Bouea	2
Anacardiaceae	Buchanania	1
Anacardiaceae	Drimycarpus	1
Anacardiaceae	Gluta	1
Anacardiaceae	Mangifera	4
Anacardiaceae	Melanochyla	5
Anacardiaceae	Parishia	1
Anacardiaceae	Pentaspadon	1
Anacardiaceae	Semecarpus	1
Annonaceae	Alphonsea	2
Annonaceae	Anaxagorea	1
Annonaceae	Dendrokingstonia	1
Annonaceae	Enicosanthum	1
Annonaceae	Goniothalamus	1
Annonaceae	Meiogyne	1
Annonaceae	Mezzettia	1
Annonaceae	Mitrephora	1
Annonaceae	Monocarpia	1
Annonaceae	Phaeanthus	1
Annonaceae	Polyalthia	9
Annonaceae	Popowia	2
Annonaceae	Pseuduvaria	1
Annonaceae	Xylopia	5
Apocynaceae	Dyera	1
Apocynaceae	Hunteria	1
Apocynaceae	Kibatalia	1
Apocynaceae	Tabernaemontana	1
Aquifoliaceae	Ilex	1
Arecaceae	Oncosperma	1
Bombacaceae	Coelostegia	1
Bombacaceae	Durio	1
Burseraceae	Canarium	6
Burseraceae	Dacryodes	6
Burseraceae	Santiria	5
Burseraceae	Triomma	1
Celastraceae	Bhesa	1
Celastraceae	Glyptopetalum	1

Celastraceae	Kokoona	1
Celastraceae	Lophopetalum	1
Convolvulaceae	Erycibe	1
Dilleniaceae	Dillenia	1
Dipterocarpaceae	Anisoptera	1
Dipterocarpaceae	Dipterocarpus	3
Dipterocarpaceae	Hopea	2
Dipterocarpaceae	Neobalanocarpus	1
Dipterocarpaceae	Parashorea	1
Dipterocarpaceae	Shorea	11
Dipterocarpaceae	Vatica	2
Dracaenaceae	Dracaena	3
Ebenaceae	Diospyros	16
Elaeocarpaceae	Elaeocarpus	1
Euphorbiaceae	Antidesma	3
Euphorbiaceae	Aporosa	11
Euphorbiaceae	Baccaurea	3
Euphorbiaceae	Blumeodendron	3
Euphorbiaceae	Cleistanthus	2
Euphorbiaceae	Croton	2
Euphorbiaceae	Drypetes	6
Euphorbiaceae	Elateriospermum	1
Euphorbiaceae	Epiprinus	1
Euphorbiaceae	Glochidion	1
Euphorbiaceae	Koiladepas	1
Euphorbiaceae	Macaranga	2
Euphorbiaceae	Mallotus	2
Euphorbiaceae	Microdesmis	1
Euphorbiaceae	Neoscortechinia	2
Euphorbiaceae	Neoscortechinii	1
Euphorbiaceae	Pimelodendron	1
Euphorbiaceae	Ptychopyxis	1
Euphorbiaceae	Suregada	1
Euphorbiaceae	Trigonostemon	2
Fagaceae	Castanopsis	1
Fagaceae	Lithocarpus	5
Fagaceae	Quercus	2
Flacourtiaceae	Flacourtia	1
Flacourtiaceae	Homalium	2
Flacourtiaceae	Ryparosa	1
Flacourtiaceae	Scaphocalyx	1
Flacourtiaceae	Scolopia	1
Gnetaceae	Gnetum	1
Guttiferae	Calophyllum	4
Guttiferae	Cratoxylum	1
Guttiferae	Garcinia	7
Guttiferae	Kayea	4
Guttiferae	Mesua	1
Icacinaceae	Gomphandra	1
Icacinaceae	Gonocaryum	1
Icacinaceae	Medusanthera	1
Irvingiaceae	Irvingia	1
Ixonanthaceae	Ixonanthes	1
Lauraceae	Actinodaphne	1
Lauraceae	Alseodaphne	2
Lauraceae	Beilschmiedia	3
Lauraceae	Cinnamomum	2
Lauraceae	Cryptocarya	5
Lauraceae	Dehaasia	1
Lauraceae	Litsea	3
Lauraceae	Nothaphoebe	1
Lecythidaceae	Barringtonia	2
Leguminosae	Adenanthera	1
Leguminosae	Archidendron	2
Leguminosae	Callerya	1
Leguminosae	Cynometra	1
Leguminosae	Dialium	2
Leguminosae	Intsia	1
Leguminosae	Koompassia	1
Leguminosae	Parkia	1
Leguminosae	Saraca	2
Leguminosae	Sindora	2
Linaceae	Ctenolophon	1
Melastomataceae	Memecylon	11
Melastomataceae	Pternandra	2
Meliaceae	Aglaia	11
Meliaceae	Aphanamixis	1
Meliaceae	Chisocheton	2
Meliaceae	Dysoxylum	1
Meliaceae	Lansium	1
Meliaceae	Pseudoclausena	1
Meliaceae	Reinwardtiodendron	1
Meliaceae	Sandoricum	1
Meliaceae	Walsura	1
Moraceae	Artocarpus	7
Myristicaceae	Gymnacranthera	1

Myristicaceae	Horsfieldia	5
Myristicaceae	Knema	7
Myristicaceae	Myristica	2
Myrsinaceae	Ardisia	5
Myrtaceae	Rhodamnia	1
Myrtaceae	Syzygium	26
Olacaceae	Anacolosa	1
Olacaceae	Ochanostachys	1
Opiliaceae	Champereia	1
Oxalidaceae	Sarcotheca	2
Pandaceae	Galearia	1
Passifloraceae	Paropsia	1
Polygalaceae	Xanthophyllum	7
Proteaceae	Heliciopsis	1
Rhizophoraceae	Anisophyllea	1
Rhizophoraceae	Carallia	1
Rhizophoraceae	Gynotroches	1
Rosaceae	Atuna	2
Rosaceae	Licania	1
Rosaceae	Prunus	2
Rubiaceae	Aidia	1
Rubiaceae	Chasalia	1
Rubiaceae	Diplospora	1
Rubiaceae	Gaertnera	1
Rubiaceae	Hypobathrium	2
Rubiaceae	Ixora	7
Rubiaceae	Nauclea	1
Rubiaceae	Pavetta	2
Rubiaceae	Porterandia	1
Rubiaceae	Prismatomeris	2
Rubiaceae	Psydrax	1
Rubiaceae	Rothmannia	1
Rubiaceae	Saprosma	1
Rubiaceae	Tarenna	1
Rubiaceae	Timonius	1
Rubiaceae	Urophyllum	2
Rutaceae	Glycosmis	1
Rutaceae	Maclurodendron	1
Rutaceae	Melicope	1
Santalaceae	Scleropyrum	1
Sapindaceae	Lepisanthes	3
Sapindaceae	Nephelium	4
Sapindaceae	Pometia	1
Sapindaceae	Xerospermum	1
Sapotaceae	Madhuca	2
Sapotaceae	Palaquium	1
Sapotaceae	Payena	1
Simarubiaceae	Eurycoma	1
Sterculiaceae	Heritiera	2
Sterculiaceae	Scaphium	1
Sterculiaceae	Sterculia	3
Symplocaceae	Symplocos	2
Thymeliaceae	Aquilaria	1
Thymeliaceae	Gonystylus	1
Tiliaceae	Microcos	4
Tiliaceae	Pentace	2
Tiliaceae	Schoutenia	1
Trigoniaceae	Trigoniastrum	1
Ulmaceae	Gironniera	3
Verbenaceae	Teijsmanniodendron	1
Violaceae	Rinorea	2

g) Sinharaja

Family	Genus	No. species
Anacardiaceae	Campnosperma	1
Anacardiaceae	Mangifera	1
Anacardiaceae	Nothopegia	1
Anacardiaceae	Semecarpus	5
Annonaceae	Goniothalamus	1
Annonaceae	Xylopia	1
Aristolochiaceae	Apama	1
Bombacaceae	Cullenia	2
Celastraceae	Bhesa	1
Clusiaceae	Calophyllum	2
Clusiaceae	Garcinia	3
Clusiaceae	Mesua	2
Cornaceae	Mastixia	1
Dilleniaceae	Dillenia	1

Dilleniaceae	Schumacheria	1
Dipterocarpaceae	Dipterocarpus	1
Dipterocarpaceae	Hopea	2
Dipterocarpaceae	Shorea	8
Ebenaceae	Diospyros	5
Elaeocarpaceae	Elaeocarpus	2
Erythroxylaceae	Erythroxylum	1
Euphorbiaceae	Agrostistachys	2
Euphorbiaceae	Antidesma	1
Euphorbiaceae	Chaetocarpus	2
Euphorbiaceae	Glochidion	2
Euphorbiaceae	Mallotus	2
Euphorbiaceae	Podadeniya	1
Euphorbiaceae	Putranjiva	1
Flacourtaceae	Hydnocarpus	1
Flacourtaceae	Scolopia	1
Icacinaceae	Gomphandra	1
Icacinaceae	Nothopodites	1
Icacinaceae	Urandra	1
Lauraceae	Actinodaphne	1
Lauraceae	Cinnamomum	3
Lauraceae	Cryptocarya	1
Lauraceae	Litsea	3
Lauraceae	Neolitsea	1
Leeaceae	Leea	1
Leguminosae	Humboldtia	1
Loganiaceae	Gaertnera	2
Lythraceae	Axinandra	1
Melastomataceae	Memecylon	5
Meliaceae	Aglaia	1
Meliaceae	Dysoxylum	2
Meliaceae	Pseudocarapa	1
Meliaceae	Walsura	1
Myrtaceae	Eugenia	1
Myrtaceae	Syzygium	9
Myrysticaceae	Myristica	1
Ochnaceae	Gomphia	1
Olacaceae	Strombosia	1
Rhizophoraceae	Anisophyllea	1
Rhizophoraceae	Carallia	1
Rubiaceae	Ixora	1
Rubiaceae	Lasianthus	1
Rubiaceae	Nargedia	1
Rubiaceae	Pavetta	1
Rubiaceae	Prismatomeris	1
Rubiaceae	Psychotria	4
Rubiaceae	Timonius	1
Rubiaceae	Uncaria	1
Rubiaceae	Urophyllum	1
Rutaceae	Glycosmis	1
Sapindaceae	Allophyllus	1
Sapindaceae	Euphoria	1
Sapindaceae	Glenniea	1
Sapindaceae	Pometia	1
Sapotaceae	Isonandra	1
Sapotaceae	Madhuca	1
Sapotaceae	Palaquium	3
Symplocaceae	Symplocos	3
Theaceae	Eurya	1
Thymeleaceae	Gyrinops	1
Verbenaceae	Vitex	1

h) Yasuni

Family	Genus	No. species
Anacardiaceae	Tapirira	1
Annonaceae	Duguetia	2
Annonaceae	Guatteria	5
Annonaceae	Trigynaea	1
Annonaceae	Unonopsis	2
Annonaceae	Xylopia	1
Apocynaceae	Himatanthus	1
Apocynaceae	Tabernaemontana	1
Araliaceae	Dendropanax	2
Arecaceae	Aiphanes	1
Arecaceae	Chamaedorea	1
Arecaceae	Geonoma	2
Arecaceae	Hyospathe	1
Arecaceae	Iriartea	1

Arecaceae	Oenocarpus	1
Arecaceae	Phytelephas	1
Arecaceae	Prestoea	1
Arecaceae	Wettinia	1
Bignoniaceae	Memora	1
Bombacaceae	Matisia	5
Bombacaceae	Pachira	2
Bombacaceae	Quararibea	2
Boraginaceae	Cordia	1
Burseraceae	Crepidospermum	1
Burseraceae	Dacryodes	1
Burseraceae	Protium	7
Burseraceae	Tetragastris	1
Capparidaceae	Capparis	2
Cecropiaceae	Cecropia	2
Cecropiaceae	Pourouma	5
Chrysobalanaceae	Couepia	1
Chrysobalanaceae	Licania	4
Clusiaceae	Marila	1
Dichapetalaceae	Tapura	2
Elaeocarpaceae	Sloanea	3
Erythroxylaceae	Erythroxylum	1
Euphorbiaceae	Acalypha	1
Euphorbiaceae	Acidoton	1
Euphorbiaceae	Alchornea	1
Euphorbiaceae	Aparisthmium	1
Euphorbiaceae	Caryodendron	1
Euphorbiaceae	Conceveiba	1
Euphorbiaceae	Drypetes	1
Euphorbiaceae	Mabea	2
Euphorbiaceae	Margaritaria	1
Euphorbiaceae	Pausandra	1
Euphorbiaceae	Richeria	1
Euphorbiaceae	Tetrorchidium	1
Fabaceae	Bauhinia	2
Fabaceae	Brownea	1
Fabaceae	Browneopsis	1
Fabaceae	Calliandra	1
Fabaceae	Hymenaea	1
Fabaceae	Inga	20
Fabaceae	Lonchocarpus	1
Fabaceae	Macrolobium	2
Fabaceae	Marmaroxylon	1
Fabaceae	Pseudopiptadenia	1
Fabaceae	Pterocarpus	1
Fabaceae	Swartzia	3
Fabaceae	Tachigali	1
Fabaceae	Zygia	2
Flacourtiaceae	Carpotroche	1
Flacourtiaceae	Casearia	5
Flacourtiaceae	Hasseltia	1
Flacourtiaceae	Lozania	1
Flacourtiaceae	Mayna	2
Flacourtiaceae	Ryania	1
Flacourtiaceae	Tetrathylacium	1
Hippocrateaceae	Salacia	1
Icacinaceae	Discophora	1
Lauraceae	Aniba	4
Lauraceae	Cryptocarya	1
Lauraceae	Endlicheria	2
Lauraceae	Licaria	1
Lauraceae	Nectandra	4
Lauraceae	Ocotea	5
Lauraceae	Pleurothyrium	1
Lecythidaceae	Eschweilera	4
Lecythidaceae	Grias	1
Lecythidaceae	Gustavia	2
Magnoliaceae	Talauma	1
Melastomataceae	Miconia	8
Meliaceae	Cabralea	1
Meliaceae	Cedrela	1
Meliaceae	Guarea	12
Meliaceae	Trichilia	7
Menispermaceae	Abuta	1
Monimiaceae	Mollinedia	1
Monimiaceae	Siparuna	5
Moraceae	Batocarpus	1
Moraceae	Brosimum	1
Moraceae	Castilla	1
Moraceae	Helicostylis	1
Moraceae	Maquira	1
Moraceae	Naucleopsis	4
Moraceae	Perebea	1
Moraceae	Pseudolmedia	3
Moraceae	Sorocea	3
Myristicaceae	Compsoneura	1

Myristicaceae	Iryanthera	2
Myristicaceae	Otoba	1
Myristicaceae	Virola	3
Myrsinaceae	Ardisia	1
Myrsinaceae	Stylogyne	1
Myrtaceae	Calyptranthes	3
Myrtaceae	Eugenia	2
Myrtaceae	Myrcia	1
Myrtaceae	Myrciaria	2
Nyctaginaceae	Guapira	1
Nyctaginaceae	Neea	8
Olacaceae	Dulacia	1
Olacaceae	Heisteria	1
Olacaceae	Minquartia	1
Passifloraceae	Dilkea	1
Picramniaceae	Picramnia	1
Piperaceae	Piper	6
Polygonaceae	Coccoloba	2
Pteridophyta	Cyathea	1
Quiinaceae	Lacunaria	1
Quiinaceae	Quiina	1
Rubiaceae	Alseis	1
Rubiaceae	Borojoa	1
Rubiaceae	Calycophyllum	1
Rubiaceae	Chomelia	1
Rubiaceae	Duroia	2
Rubiaceae	Faramea	2
Rubiaceae	Guettarda	1
Rubiaceae	Ixora	2
Rubiaceae	Palicourea	2
Rubiaceae	Pentagonia	2
Rubiaceae	Posoqueria	1
Rubiaceae	Psychotria	2
Rubiaceae	Warszewiczia	1
Rubiaceae	Wittmackanthus	1
Rutaceae	Esenbeckia	1
Rutaceae	Zanthoxylum	1
Sabiaceae	Ophiocaryon	1
Sapindaceae	Allophylus	1
Sapindaceae	Talisia	2
Sapotaceae	Chrysophyllum	2
Sapotaceae	Micropholis	1
Sapotaceae	Pouteria	6
Sapotaceae	Sarcaulus	2
Simaroubaceae	Simaba	2
Solanaceae	Solanum	1
Staphyleaceae	Turpinia	1
Sterculiaceae	Herrania	2
Sterculiaceae	Sterculia	3
Sterculiaceae	Theobroma	2
Tiliaceae	Apeiba	1
Ulmaceae	Ampelocera	1
Ulmaceae	Celtis	1
Verbenaceae	Petrea	1
Violaceae	Gloeospermum	2
Violaceae	Leonia	2
Violaceae	Rinorea	3
Vochysiaceae	Qualea	1

Table S3. Exact Mantel r values and significance for the genus level Mantel tests for (a) soil PC axes and (b) topographic variables. Positive values indicate that members of the same genus have higher niche overlap than members of different genera. Bold font indicates significance ($\alpha = 0.025$ for each tail of a two-sided test).

(a)

	PC1		PC2	
Study site	Mantel r	P value	Mantel r	P value
BCI	-0.0184	0.879	**0.0268**	**0.019**
Huai Kha Khaeng	0.0224	0.122	0.017	0.202
Khao Chong	**0.0283**	**0.013**	**0.0517**	**<0.001**
Kroup	-0.0057	0.684	-0.0038	0.623
La Planada	0.0119	0.291	0.0121	0.314
Pasoh	-0.0028	0.63	**0.0178**	**0.013**
Sinharaja	**0.0409**	**0.007**	0.0287	0.031
Yasuni	0.0059	0.174	0.0040	0.303

(b)

	Elevation		Slope		Convexity	
Study site	Mantel r	P value	Mantel r	P value	Mantel r	P value
BCI	0.0211	0.077	0.0077	0.338	0.0109	0.236
Huai Kha Khaeng	0.0167	0.202	0.0218	0.124	0.0198	0.154
Khao Chong	0.0033	0.404	-0.0008	0.541	**0.0296**	**0.008**
Korup	-0.0107	0.803	-0.0007	0.527	0.0048	0.366
La Planada	0.0194	0.172	0.0246	0.105	**0.0347**	**0.024**
Pasoh	0.0117	0.075	**0.0203**	**0.003**	-0.0021	0.607
Sinharaja	0.0228	0.084	0.0206	0.110	**0.0329**	**0.021**
Yasuni	0.0041	0.259	0.0009	0.450	0.0070	0.126

Table S4. Exact Mantel r values and significance for family level Mantel tests for (a) soil PC axes and (b) topographic variables. Positive values indicate that members of the same family have higher niche overlap than members of different families. Bold font indicates significance (α = 0.025 for each tail of a two-sided test).

(a)

	PC1		PC2	
Study site	Mantel r	P value	Mantel r	P value
BCI	-0.0178	0.792	0.037	0.033
Huai Kha Khaeng	-0.0102	0.648	-0.0417	0.937
Khao Chong	**0.0399**	**0.003**	**0.0537**	**<0.001**
Kroup	0.0129	0.163	-0.0051	0.63
La Planada	**-0.055**	**0.979**	-0.0517	0.957
Pasoh	-0.0098	0.868	0.0021	0.398
Sinharaja	0.0257	0.055	**0.03**	**0.022**
Yasuni	0.0128	0.032	0.0029	0.366

(b)

	Elevation		Slope		Convexity	
Study site	Mantel r	P value	Mantel r	P value	Mantel r	P value
BCI	0.0268	0.104	0.0205	0.173	0.0188	0.184
Huai Kha Khaeng	-0.0250	0.815	0.0081	0.385	-0.0422	0.935
Khao Chong	**0.0384**	**0.006**	**0.0311**	**0.022**	**0.0491**	**<0.001**
Korup	0.0135	0.158	0.0187	0.090	0.0207	0.082
La Planada	-0.0336	0.879	-0.0081	0.628	-0.0397	0.903
Pasoh	-0.0014	0.563	0.0055	0.253	**-0.0202**	**0.989**
Sinharaja	0.0253	0.054	0.0114	0.238	0.0166	0.136
Yasuni	0.0126	0.029	**0.0146**	**0.020**	**0.0131**	**0.022**