



UNIVERSITY OF LEEDS

This is a repository copy of *Patterns of tree species composition at watershed-scale in the Amazon 'arc of deforestation': implications for conservation*.

White Rose Research Online URL for this paper:  
<http://eprints.whiterose.ac.uk/102244/>

Version: Accepted Version

---

**Article:**

Morandi, PS, Marimon, BS, Eisenlohr, PV et al. (7 more authors) (2016) Patterns of tree species composition at watershed-scale in the Amazon 'arc of deforestation': implications for conservation. *Environmental Conservation*, 43 (4). pp. 317-326. ISSN 0376-8929

<https://doi.org/10.1017/S0376892916000278>

---

(c) 2016, Foundation for Environmental Conservation. This is an author produced version of a paper published in *Environmental Conservation*. Uploaded in accordance with the publisher's self-archiving policy.

**Reuse**

Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



[eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk)  
<https://eprints.whiterose.ac.uk/>

1 **Patterns of tree species composition at watershed-scale in the Amazon ‘Arc**  
2 **of Deforestation’: implications for conservation**

3

4 Paulo Sérgio Morandi<sup>a</sup>, Beatriz Schwantes Marimon<sup>a,f</sup>, Pedro V. Eisenlohr<sup>b</sup>, Ben  
5 Hur Marimon-Junior<sup>a</sup>, Claudinei Oliveira-Santos<sup>a</sup>, Ted R. Feldpausch<sup>c</sup>, Edmar  
6 Almeida de Oliveira<sup>a</sup>, Simone Matias Reis<sup>a</sup>, Jon Lloyd<sup>d</sup> and Oliver L. Phillips<sup>e</sup>

7

8 <sup>a</sup>Universidade do Estado de Mato Grosso, Campus de Nova Xavantina, BR 158,  
9 km 655, Caixa Postal 08, 78690-000, Nova Xavantina, MT, Brazil.

10 <sup>b</sup>Universidade do Estado de Mato Grosso, Campus de Alta Floresta, MT 208, km  
11 147, Caixa Postal 324, 78580-000, Alta Floresta, MT, Brazil.

12 <sup>c</sup>College of Life and Environmental Sciences, University of Exeter, Exeter, EX4  
13 4RJ, United Kingdom.

14 <sup>d</sup>Imperial College London, Faculty of Natural Sciences, Department of Life  
15 Sciences, SW7 2AZ, London, United Kingdom.

16 <sup>e</sup>University of Leeds, School of Geography, LS2 9JT, Leeds, United Kingdom.

17 <sup>f</sup>Corresponding author: [biamarimon@unemat.br](mailto:biamarimon@unemat.br), phone (+55-66-3438-1224)

18

19 E-mail addresses: [morandibio@gmail.com](mailto:morandibio@gmail.com) (P.S. Morandi),

20 [biamarimon@unemat.br](mailto:biamarimon@unemat.br) (B.S. Marimon), [pedrov.eisenlohr@gmail.com](mailto:pedrov.eisenlohr@gmail.com) (P.V.

21 Eisenlohr), [bhmjunior@gmail.com](mailto:bhmjunior@gmail.com) (B.H. Marimon-Junior),

22 [claudineisantosnx@gmail.com](mailto:claudineisantosnx@gmail.com) (C. Oliveira-Santos), [edmardinei@gmail.com](mailto:edmardinei@gmail.com) (E.A.

23 Oliveira), [T.R.Feldpausch@exeter.ac.uk](mailto:T.R.Feldpausch@exeter.ac.uk) (T.R. Feldpausch),

24 [simonematiasreis@gmail.com](mailto:simonematiasreis@gmail.com) (S.M. Reis), [jonathan.lloyd@imperial.ac.uk](mailto:jonathan.lloyd@imperial.ac.uk) (J.

25 Lloyd), [O.Phillips@leeds.ac.uk](mailto:O.Phillips@leeds.ac.uk) (O.L. Phillips).

26 **6984 words**

27

28 **SUMMARY**

29 The loss of biodiversity in transitional forests between the Cerrado and Amazonia,  
30 the two largest neotropical phytogeographic domains, is an issue of great concern.  
31 This extensive region is located within the zone of the 'arc of deforestation' where  
32 tropical forests are being lost at the fastest rate on the planet, but floristic diversity  
33 and variation among forests here is still poorly understood. We aimed to  
34 characterize the floristic composition of forests in this zone and explore the degree  
35 and drivers of differentiation within and across Araguaia and Xingu watersheds. In  
36 ten sites we identified all trees with diameter  $\geq 10$  cm; these totaled 4,944  
37 individuals in 257 species, 107 genera and 52 families. We evaluated the data for  
38 multivariate variation using TWINSpan and DCA to understand the species  
39 distribution among sites. There was a larger contribution from the Amazonian flora  
40 (169 species) than that of the Cerrado (109) to the transitional forests.  
41 Remarkably, 142 species (55%) were restricted to only one sampling site, while 29  
42 species (> 16%) are endemic to Brazil, suggesting a high risk for biological  
43 conservation, and the disappearance of species and forests with unique floristic  
44 composition with loss and fragmentation of large areas. Watersheds may be a  
45 critical factor driving species distribution among forests in the Amazonian-Cerrado  
46 transition zone, and quantifying their role can provide powerful insight into devising  
47 better conservation strategies of the remaining forests.

48 **Keywords:** endemic species; floristic connections; Araguaia; Xingu; watersheds;  
49 species distribution.

50

51

## 52 INTRODUCTION

53           Between the two major tropical domains of the South America, Amazonia  
54 and Cerrado, there are transitional zones (Ackerly et al. 1989) where a mosaic of  
55 various forest and savanna communities exists (Staver et al. 2011; Murphy and  
56 Bowman 2012). The transition forests have lower density, height, basal area,  
57 biomass and species richness than the forests located in the core region of  
58 Amazonia (Ivanauskas et al. 2004a; Balch et al. 2008) and represent the  
59 Amazonia advancing front on the Cerrado (Marimon et al. 2006).

60           Different environmental factors may determine transitions between  
61 phytogeographic domains, depending on the scale being considered. Tropical  
62 forests generally occur in regions with wetter climate (Schwartz and Namri 2002)  
63 and lower precipitation seasonality in comparison with savannas (Staver et al.  
64 2011). The climate variation acts at broad scales, determining the differentiation of  
65 vegetation patterns, as one can see in both Amazonia and Cerrado domains  
66 (Ab'Saber 2003; Staver et al. 2011; Lehmann et al. 2011).

67           The rainfall seasonality also shapes forest and savanna distribution  
68 patterns, but this factor is most evident in Africa than in Australia and South  
69 America (Lehmann et al. 2011). In regions with intermediate rainfall (1,000 to  
70 2,500 mm) and average seasonality (<7 months), forest and savanna coexist as  
71 alternative stable states, depending on fire frequency (Staver et al. 2011; Murphy  
72 and Bowman 2012). At smaller scales, edaphic factors play a greater role in  
73 determining the species composition of plant communities (Askew et al. 1970;  
74 Veenendaal et al. 2015). Additionally, fire, resource availability and species traits  
75 can influence the occurrence of certain vegetation types (Hoffmann et al. 2012).  
76 Topographic features, such as the groundwater level, also determine the  
77 occurrence of forest or savanna (Murphy and Bowman 2012; Silva 2015). Here,

78 we investigate floristic diversity and variations in a transition zone at a large scale,  
79 between phytogeographic domains.

80 In the large contact region between Cerrado and Amazonia there are  
81 different tree-dominated vegetation types, including semideciduous forests (Araujo  
82 et al. 2009; Mews et al. 2011), monodominant forests of *Brosimum rubescens*  
83 Taub. (Marimon et al. 2001a), evergreen seasonal forests (Ivanauskas et al.  
84 2008), deciduous forests (Pereira et al. 2011), cerrado sensu stricto and cerradão  
85 (Marimon et al. 2014). This transition zone hundreds of kilometres wide with a  
86 sinuous total length of more than 6,000 km following the complex inter digitation of  
87 Amazonia and the entire Cerrado domain around the southern Brazilian Amazon  
88 Basin (Ackerly et al. 1989; Marimon et al. 2014; Ratter et al. 1973), has high  
89 biodiversity, forming a vegetation mosaic (Ratter et al. 2003; Marimon et al. 2006;  
90 Torello-Raventos et al. 2013), which contributes to the fauna diversity (Sick 1955;  
91 Lacher and Alho 2001; Oliveira et al. 2010; Rocha et al. 2014).

92 The loss of biodiversity of the Amazonia-Cerrado transition forests is of  
93 great concern, mainly because it is located within the region known as the 'arc of  
94 deforestation'. Here land-use change is progressively removing most of the natural  
95 forest vegetation (Fearnside 2005), and deforestation for agriculture is the main  
96 threat (Araujo et al. 2009; Ivanauskas et al. 2004a, 2004b). Furthermore,  
97 anthropogenic fires (Fearnside 2005) and the severe drought events of the last  
98 decade in this region (e.g., Lewis et al. 2011; Marengo et al. 2011) have also been  
99 linked to floristic and structural changes (Marimon et al. 2014; Phillips et al. 2009),  
100 and to the rate of deforestation itself (Davidson et al. 2012). Stronger seasonal  
101 droughts may also be linked to anthropogenic climate change and most global  
102 climate model simulations for the 21<sup>st</sup> century show a markedly increase drought  
103 risk for southern Amazonia (e.g., Fu et al. 2013). Wherever species are restricted

104 to only one area or region they are vulnerable to extinction as a result of human  
105 disturbance (Peterson and Watson 1998; Werneck et al. 2011) and large-scale  
106 environmental changes such as [drought and fire](#).

107 The [vegetation](#) of the Amazonia-Cerrado transition region is gradually being  
108 revealed, but not enough is known yet to evaluate the threat to biodiversity posed  
109 by the elimination of the transition forests. For example, [in](#) an evergreen seasonal  
110 forest of the Xingu River Basin, [there are many](#) species (94%) with Amazonian  
111 distribution ([Ivanauskas et al. 2004b](#); Lista de Espécies da Flora do Brasil 2012).  
112 One explanation for the high contribution of Amazonian flora to these transitional  
113 forests could be the high number of streams distributed across a general flat relief,  
114 which reduces water stress compared to that encountered in other seasonal  
115 forests of the Central Highlands of Brazil in similar climate ([Ivanauskas et al. 2008](#);  
116 [Oliveira-Filho and Ratter 1995](#)).

117 Phytogeographic studies should consider the varied causes and  
118 mechanisms potentially involved in species turnover across space. One 'null'  
119 explanation for species turnover is simply that it is influenced by geographic  
120 distance ([Hubbell 2001](#)). Space will be an important factor influencing the  
121 separation of communities if all individuals of the same trophic guild are equivalent  
122 competitors and have limited dispersal ability - this scenario results in a decreased  
123 similarity between communities with increasing geographic distance ([Hubbell](#)  
124 [2001](#)). However, other mechanisms, such as physical barriers (e.g., watersheds),  
125 also act to control species distribution ([Francis and Currie 1998](#)) and may  
126 determine the variation in floristic composition between communities ([Bell 2001](#);  
127 [Condit et al. 2002](#)). Thus, species migration may be favored by corridors shaped  
128 by the forests accompanying streams and rivers, constituted into networks of  
129 dendritic connections between waterways in a basin ([Oliveira-Filho and Ratter](#)

130 1995). Based on this hypothesis, watersheds should form links between major  
131 forested biomes (here, Atlantic and Amazonian forests), acting as routes of  
132 species dispersal and hence genetic linkages connecting floras (Oliveira-Filho and  
133 Ratter 1995) and faunas (Costa 2003; Ribas et al. 2011).

134 In addition to the above mentioned factors that can influence the distribution  
135 of taxa, environmental condition also affects the occurrence of the species. Thus,  
136 the presence of a particular species at a site is favored by adaptations of this  
137 species to a range of environmental conditions and resources available there, in  
138 which the species has a range of tolerances and requirements, that is, the  
139 ecological niche (Hutchinson 1957). Thus, we expected that areas under similar  
140 environmental conditions would share more species than areas under different  
141 environmental conditions (Gurevitch et al. 2009).

142 This work was intended to inform conservation decisions by quantifying the  
143 contributions made by species endemic to Brazil and, more specifically, endemic  
144 to Cerrado and Amazonia domains. We addressed two questions. 1) Does the  
145 Amazon and/or the Cerrado flora dominate the composition of the sampling site?  
146 We expected a greater contribution of Amazonian flora because, despite the  
147 region having a markedly seasonal climate, locally enhanced water availability  
148 favors the occurrence of Amazonian species (Ivanauskas et al. 2008). 2) How do  
149 the forests vary in distribution and floristic composition? We expected to find  
150 signatures of both 'neutral' and habitat-driven phytogeographic variation. Thus,  
151 closer sites, independent of the watershed in which they happen to be located  
152 (Xingu River or Araguaia River), should have higher floristic similarity than more  
153 distant areas because species turnover typically increases with geographic  
154 distance (Hubbell 2001) and among different habitat types (e.g., Condit et al.  
155 2002).

156

157 **METHODS**158 **Study sites**

159           In the transition zone between the Cerrado and Amazonian domains in  
160 Brazil we sampled 10 sites, five located in [the](#) Xingu River Basin and five in [the](#)  
161 Araguaia River Basin. These sampling sites were distributed over a distance of up  
162 to 606.4 km (Table S1, see supplementary material as  
163 [Journals.cambridge.org/ENC](https://journals.cambridge.org/ENC)) and all within the central part of the 'arc of  
164 deforestation' (Fig.1). The climate, according to the Köppen classification, is Aw  
165 (tropical with a dry winter) (Alvares et al. 2013), with highly seasonal annual  
166 average rainfall between 1,500 and 1,740 mm (Table 1). We selected primary  
167 forests with no obvious sign of [human actions](#). According to IBGE (2012), all  
168 studied forests [were](#) Evergreen Seasonal, the five located in the Araguaia River  
169 Basin [being](#) Evergreen Seasonal of the Lowlands (Floresta Estacional Sempre-  
170 Verde das Terras Baixas), and the five [of the](#) Xingu River Evergreen Seasonal  
171 Submontane (Floresta Estacional Sempre-Verde Submontana).

172

173 **Table 1**

174

175           The data [were](#) curated within the ForestPlots database (Lopez-Gonzalez et  
176 al. 2009, 2011), where each forest has a unique site code. In this study, we  
177 [applied](#) new codes to reflect the vegetation differences (viz, XIN= Xingu River  
178 Basin forest and ARA= Araguaia River Basin forest) (Table 1, Fig. 1).

179

180 **Figure 1**

181



## 182 **Data collection**

183 We sampled 1 ha in each sampling site, and identified all tree individuals  
184 with diameter at breast height (DBH at 1.30 m above the ground)  $\geq 10$  cm. We  
185 identified the species in the field by comparisons with herbarium (NX, UFMT, UnB  
186 and IAN) material of known specific identity, and with the help of specialists. After  
187 identification, the material was incorporated into the Herbarium NX, Mato Grosso,  
188 Nova Xavantina (Coleção Zoobotânica James Alexander Ratter). We determined  
189 the classification of families based on APG III (2009), and assigned species  
190 names using the 'Flora of Brazil' database (Lista de Espécies da Flora do Brasil  
191 2012). We used this same database to determine the occurrence of species in  
192 different Brazilian phytogeographic domains and Brazilian endemic species.

193

## 194 **Data analysis**

195 We evaluated species distribution among forests based on a 'compound'  
196 graph from the function `of` Landeiro et al. (2010) in R version 3.0.3 (R  
197 Development Core Team 2014), *where* species and their abundances are  
198 represented on the y axis, ordered according to the weighted average, with the  
199 ecological gradient represented on the x axis. We analyzed the 48 most abundant  
200 species ( $> 13$  individuals) to help ensure confidence that results are not affected  
201 by sampling issues of rarest taxa (see also Landeiro et al. 2010).

202 We also investigated the spatial patterns of species distribution by means of  
203 Mantel tests in PASSaGE 2.0 (Rosenberg and Anderson 2011), using the  
204 abundance species matrix. The distance coefficient used in this step was the  
205 Czekanowski index (McCune and Grace 2002). The decision on the presence of  
206 spatial autocorrelation was made after 999 permutations.

207 To classify the forests based on species composition and their respective  
208 abundances, we used TWINSpan (Two-Way Indicator Species Analysis), using  
209 the default option of the software PC-ORD 5.0 (McCune and Mefford 2006) to  
210 define the cut off level of the 'pseudo species' (see McCune and Grace 2002).

211 We ordinated the plots based on a DCA (Detrended Correspondence  
212 Analysis) in PC-ORD 5.0. We obtained the standardized length of the gradient,  
213 assuming that a value greater than four standard deviations (SD) would indicate  
214 complete replacement of species (Hill and Gauch 1980). Since the DCA is based  
215 on chi-square distance, which is sensitive to rare species (McCune and Grace  
216 2002), we removed these species, here understood as the singletons (species  
217 with only one individual). The DCA, however, still showed excessive residuals in  
218 the first axis, and therefore, we also eliminated species with only two individuals.  
219 We submitted the reduced matrix (with 146 species) to a new DCA; here the  
220 residuals were better distributed.

221

## 222 **RESULTS**

223 We sampled 4,944 trees, distributed in 257 species, 107 genera and 52  
224 families in the 10 sampling sites (Table S2). Species diversity was concentrated in  
225 a few families: 20% of the families contained 60% of the species, while on the  
226 other hand 35% (18 families) were represented only by a single species (Table S2,  
227 Table 2). In almost every sampling site, more than 50% of families were  
228 represented by a single species, with the marginal exceptions of XIN-02 and ARA-  
229 03 (48 and 45%) (Table 2). The richest families were Chrysobalanaceae (24  
230 species), Fabaceae (22), Annonaceae (21), Melastomataceae (17), Moraceae  
231 (14), Sapotaceae (13), Apocynaceae (11), Burseraceae and Myrtaceae (10 each)  
232 and Lauraceae (9) (Table S2). The richest genera were Licania (13 species),

233 Miconia (12), Aspidosperma, Hirtella and Xylopia (10 each), Pouteria (9), Inga (8),  
234 Ficus and Ocotea (7 each), Casearia, Cecropia, and Trichilia (5 each) (Table S2).  
235 The proportion of genera with only one local species was also high ranging from  
236 68 to 100% in each forest (Table 2).

237

238 **Table 2.**

239

#### 240 **Contribution of Amazonian and Cerrado floras to transitional forests**

241 The species recorded in this transitional region also occur in four Brazilian  
242 phytogeographic domains, with 169 species in the Amazonian domain, 109 in the  
243 Cerrado, 88 in the Atlantic Forest and 49 in the Caatinga domain. All ten of our  
244 sampling sites had more species from the Amazonian (from 71 to 100%) than the  
245 Cerrado domain (42 to 85%). Still, the two forests (ARA-01 and ARA-02) located  
246 further south, most distant from the Amazonian domain, showed the smallest  
247 difference between the occurrence of the Amazonia and Cerrado species, while  
248 the forests ARA-03 and ARA-04 located further north, closer to Amazonia, were  
249 dominated by typical Amazonian species (Table 2). Twenty-nine of the sampled  
250 species were endemic to Brazil, representing 16% of taxa identified to the species  
251 level. Of these, seven occur only in the Amazonian and in the Cerrado domains  
252 and seven in Amazonia (Table S2). Every sampling site plot included at least two  
253 species that are endemic to Brazil (Table 2).

254

#### 255 **Spatial distribution, watersheds, and floristic composition**

256 Considering the amplitude of species occurrence among sampling sites, 43  
257 (17%) occurred in five or more sites, while 143 (55%) were restricted to just one  
258 forest, especially ARA-02 (19 unique species), XIN-04 and ARA-04 (20 unique

259 species each) and ARA-05 (21 unique species) (Table S2, Table 2). The highest  
260 degree of species sharing was observed in the plots close to the Araguaia River  
261 Basin in Mato Grosso state (ARA-01 and ARA-02) (Table S2). However, the  
262 progressive substitution of species across space is evident throughout the study  
263 areas (Fig.2). Only 11 species were recorded with high abundance (> 70  
264 individuals) in the forests of both Xingu and Araguaia watersheds: *Tapirira*  
265 *guianensis* Aubl., *Pseudolmedia macrophylla* Trécul, *Trattinnickia glaziovii* Swart,  
266 *Jacaranda copaia* (Aubl.) D. Don, *Sacoglottis guianensis* Benth., *Sloanea eichleri*  
267 *K.Schum.*, *Protium pilossissimum* Engl., *Miconia pyrifolia* Naudin, *Amaioua*  
268 *guianensis* Aubl., *Chaetocarpus echinocarpus* (Baill.) Ducke and *Cheilochlinium*  
269 *cognatum* (Miers) A.C.Sm. (Fig.2). Overall, the most abundant species were  
270 preferentially found in particular watersheds (i.e., abundant in either Rio Xingu or  
271 Rio Araguaia watersheds, but rarely in both).

272

## 273 **Figure 2**

274

275 Two floristic groups emerge from TWINSPAN (Fig.3), the first composed of  
276 seasonal forests of the Xingu River Basin (XIN-01, XIN-02, XIN-03, XIN-04 and  
277 XIN-05), and the second of seasonal forests (ARA-01, ARA-02, ARA-03, ARA-04  
278 and ARA-05) of the Araguaia River Basin (Fig.3). The first division (eigenvalue=  
279 0.56) separated the Araguaia from the Xingu forests, while in the second division  
280 (eigenvalue= 0.42) two new groups were revealed: one with XIN-01 and XIN-03  
281 and the other by XIN-02, XIN-04 and XIN-05 (Fig.3). Only in the third division  
282 (eigenvalue= 0.61), were the southern Araguaia forests (ARA-01 and ARA-02)  
283 separated from the other Araguaia forests far to the north.

284

285 **Figure 3**

286

287 In the DCA (Eigenvalues: Axis 1= 0.59032; Axis 2= 0.33288) we captured  
288 similar trends as recorded in TWINSPAN. Here, ARA-01 and ARA-02 were  
289 floristically disconnected from ARA-03, ARA-04 and ARA-05 on the second axis  
290 (Fig.4), but these geographically distant plot groups still scored closer to one  
291 another than did either to the Xingu Basin forests which geographically lie between  
292 the southernmost and northernmost Araguaia forests. The DCA also confirmed the  
293 high species replacement indicated by the 'compound' graph, because both the  
294 length of the gradient ( $> 4$  SD) and the eigenvalues for the first two axes were  
295 high. Geographic distance had no effect on species replacement, since there was  
296 no significant correlation between floristic composition and geographical distances  
297 (Mantel test,  $r = -0.0633$ ;  $p = 0.5360$ ).

298

299 **Figure 4**

300

301 **DISCUSSION**

302 Our results reveal [the influence of both, the Amazonia and the Cerrado](#)  
303 domains on the composition of transitional forests, but confirmed our expectation  
304 that the contribution of the Amazonian flora is greater, [which probably is related to](#)  
305 [the fact that the environmental conditions are more favorable to Amazonian](#)  
306 [species](#). We also detected an apparent large-scale role that watersheds play in  
307 structuring regional forest composition. Thus, while there was a signature of  
308 potentially neutrally-driven phytogeographic variation, because closer forests  
309 tended to be more similar, very distant pairs of forests in the Araguaia watershed

310 were actually more similar to one another than were either to geographically-  
311 intermediate Xingu sites.

312

### 313 **Influence of phytogeographic domain on floristic composition**

314       The families Chrysobalanaceae, Fabaceae, Annonaceae and Sapotaceae,  
315 the species-richest in this study, are common in Amazonia (Oliveira-Filho and  
316 Ratter 1995). These are among the pan-Amazon dominant groups (ter Steege et  
317 al. 2006), being also among the most speciose in Amazonian upland 'Terra Firme'  
318 forests 1,000 km to the north of our sites and more than 2,000 km to the west  
319 (Lima-Filho et al. 2004; Oliveira and Amaral 2004; Oliveira et al. 2008; Phillips et  
320 al. 2003), as well as in seasonal forests (Ivanauskas et al. 2004a; Kunz et al.  
321 2008; Marimon et al. 2006), and savanna woodland (Marimon-Junior and  
322 Haridasan 2005; Marimon et al. 2006) at the southern edge of the Amazonian  
323 domain. Fabaceae, in particular, though, also have high richness in the Cerrado  
324 domain (Sano et al. 2008). Sapotaceae, Burseraceae and Moraceae are typical of  
325 the Amazonian domain, and Melastomataceae, Myrtaceae and Lauraceae, are  
326 more speciose in Atlantic moist forests, with Annonaceae featuring strongly in both  
327 domains (Pinto and Oliveira-Filho 1999). The occurrence of the humid tropical  
328 forest flora in seasonally-dry Central Brazil, as in this study, would be favored by a  
329 dendritic network of rivers that acting as bridges, allowing species from Amazonian  
330 and Atlantic domains to migrate deep into areas that would otherwise be  
331 climatically challenging for such taxa (Oliveira-Filho and Ratter 1995). These  
332 findings therefore reinforce the transitional aspect of the study sites, and confirm  
333 the ecological importance of these key families in the composition and  
334 characterization of the transitional zone flora.

335           The finding that families with most species also have the highest  
336 abundance of individuals is not unexpected (e.g., Campbell et al. 1986;  
337 Ivanauskas et al. 2004a). Families richer in species and/or more abundant than  
338 others are capable of better exploit the environment, because they have adaptive  
339 characteristics (Tello et al. 2008). The large number of families and genera  
340 represented by only one species in each community on the other hand highlights  
341 the great taxonomic diversity of the studied forests.

342           Licania, Miconia, Pouteria, Inga and Ocotea, among the richest genera in  
343 this study, are well represented in different vegetation types of the transition zone  
344 (Araujo et al. 2009; Kunz et al. 2008; Marimon et al. 2006) and also in the distant,  
345 terra firme forests of central Amazonia growing in much wetter climates (Oliveira et  
346 al. 2008). This overlapping of genera from different vegetation sources further  
347 confirms the transitional aspect of southern Amazonia (Oliveira-Filho and Ratter  
348 1995). The fact that most species belong to the Amazonian domain confirms our  
349 expectation that transitional forest tree floristics are more strongly influenced by  
350 the Amazon than by the Cerrado domain, especially for forests that occur in the  
351 northern portion of the studied area.

352           This information is not new to ecology, but it is new for the vegetation of the  
353 study sites and has an important consequence for conservation measures. An  
354 approach on genera is important because this taxa level helped reinforce which  
355 biome has greater contribution in species composition, and also confirmed the  
356 change in species diversity between areas, as in other studies (Condit et al. 2005;  
357 Qian 1999).

358

359

## 360 **Spatial separation and watersheds**

361       The third division of TWINSPAN and the second axis of DCA show that  
362 there may be a **spatial** effect in the dissimilarity between the communities,  
363 especially in the Araguaia Basin. However, **this effect was not a clear pattern; if it**  
364 **had been** we expected that ARA-01 and ARA-02 would be more similar to the  
365 forests of the Xingu Basin, because they are closer to each other, **but this was not**  
366 **the case**. Thus, we emphasize on the results of the first division of TWINSPAN  
367 and the first DCA axis.

368       The Mantel test **showed further that** geographic distance does not drive the  
369 spatial turnover of species and the floristic dissimilarity between these sites,  
370 **suggesting** that factors associated with habitat type appear to be involved (Condit  
371 et al. 2002; Gurevitch et al. 2009). Why though should the abundant species in the  
372 forests of Mato Grosso State also be shared with those of the forests of southern  
373 Pará, given the great geographic distance **among** the sites? These data suggest  
374 that other geographical processes have allowed these taxa to overcome dispersal  
375 limitation. Thus, and in support of Oliveira-Filho and Ratter (1995) in discussing  
376 the origin of the forests of Central Brazil, it appears that it is the north-south  
377 hydrological network associated with the Araguaia River Basin that provides the  
378 ultimate explanation for the greater floristic similarity between these distant forests  
379 than that which exists between any of them and much geographically-closer  
380 vegetation in the Xingu River Basin.

381

## 382 **Conservation**

383       Conservation of the transition zone vegetation is of paramount importance  
384 for three reasons. First, on-going land-use processes have already destroyed most  
385 natural vegetation here (Marimon et al. 2014). Second, both Amazonian and



386 Cerrado vegetation are highly diverse (Castro et al. 1999; Fiaschi and Pirani 2009;  
387 Gentry 1988). And third, this transitional region connects the floras of the Cerrado,  
388 the Atlantic Forest, and Amazon Rainforest (Méio et al. 2003; Oliveira-Filho and  
389 Ratter 1995; see also study on fauna: e.g. Costa 2003), and thus can potentially  
390 provide critical habitat space and corridors for the migration that could help to  
391 partly mitigate the great biological challenge that global climate change poses for  
392 communities of the neotropics (Loarie et al. 2009).

393       To emphasize the relevance of conserving the communities and  
394 ecosystems of the transition zone, it is important also to take into account the high  
395 faunal diversity of the region. On the banks of the tributaries of the Mortes River  
396 (Araguaia Basin) 81 species of birds living in forests and cerrado (Sick 1955), 238  
397 species of birds and 57 species of non-flying mammals were recorded in some  
398 forests of the Xingu Basin (Oliveira et al. 2010). Forests of the Araguaia basin  
399 have been considered as shelters and food source for several species of small  
400 mammals (Rocha et al. 2014), and the mosaic of habitats generated by the  
401 Amazonia-Cerrado contact may determine species diversity in this region (Lacher  
402 and Alho 2001; Oliveira et al. 2010; Rocha et al. 2014). Thus, conservation of the  
403 vegetation becomes more urgent and necessary as it will also benefit the rich  
404 fauna of this important transitional area (Sick 1955; Lacher and Alho 2001; Oliveira  
405 et al. 2010; Rocha et al. 2014).

406       Our eco-floristic results reinforce the need for serious conservation action  
407 here. We found that one in six of the species identified in these forests are  
408 endemic to Brazil, and that most of these endemic species are also endemic to the  
409 two phytogeographic domains (Cerrado and Amazonian). We also conclude that  
410 most of the species must be either very rare, have restricted distribution, or both,  
411 as almost three-fifths of the tree taxa were only found in one of the 10 studied

412 sites, suggesting the existence of a large and heterogeneous mosaic of plant  
413 communities in the Amazonia-Cerrado transition. The removal and fragmentation  
414 of large areas due to agricultural activities may therefore already be leading to the  
415 disappearance of species and unique assemblages, before they can even be  
416 adequately documented.

417 Furthermore, our finding that the taxonomic coherence within watersheds  
418 trumps effects of geographic proximity highlights the importance of considering  
419 whole watersheds in conservation efforts. As a simple but important example,  
420 establishing a single large reserve around the Xingu watershed may be less  
421 effective in conserving maximal tree diversity than would ensuring that the same  
422 size of area captures vegetation lying within both the Xingu and Araguaia  
423 watersheds.

424 Tree composition in this complex transition zone appears to be partly driven  
425 by subtle environmental patterns at the watershed scale, suggesting that the  
426 biogeography of the major neotropical domains has still to be well understood.  
427 Further investigations should focus on better understanding of how environmental  
428 factors determine the species composition and distribution across the transitional  
429 regions. This information will help improve the ability of conservation efforts to  
430 protect floristic and structural diversities in the communities of the vast Amazonia-  
431 Cerrado contact zone. This is especially important in light of the intense threat  
432 facing this region due to its close alignment with the ‘arc of deforestation’.

433

#### 434 **ACKNOWLEDGMENTS**

435 The authors thank CAPES for the scholarship granted to the first author;  
436 CNPq for the financial support (Project PELD – Amazonia-Cerrado transition:  
437 environmental and ecological basis for conservation – Proc. No. 558069/2009-6

438 and No. 403725/2012-7) and for the post doctoral scholarship awarded to B.S.  
439 Marimon (Proc. 201914/2012-3); to RAINFOR (Gordon and Betty Moore  
440 Foundation and NERC consortium AMAZONICA; [www.rainfor.org](http://www.rainfor.org)) for the use of  
441 the ForestPlots.net database; PROCAD-CAPES (UNB and UNEMAT); farm-  
442 owners (Fazenda Fartura-PA, Faz. Tanguro-MT, Faz. Floresta and Faz. Vera  
443 Cruz-MT) for their collaboration in implementing permanent plots; and to Dr Victor  
444 Landeiro for providing the R script to run the 'compound' graph of species  
445 distribution. We thank Eduardo Q. Marques for his assistance in preparation of  
446 Figure 1. O.P. is supported by an ERC Advanced Grant and is a Royal Society-  
447 Wolfson Research Merit Award holder.

448

449 **REFERENCES**

- 450 Ab'Sáber, A. (2003) Os Domínios de natureza no Brasil: potencialidades  
451 paisagísticas. São Paulo, SP, Brasil: Ateliê.
- 452 Ackerly, D.D., Thomas, W.W., Ferreira, C.A.C. & Pirani, J.R. (1989) The forest-  
453 cerrado transition zone in southern Amazonia: results of the 1985 Projeto Flora  
454 Amazonica Expedition to Mato Grosso. *Brittonia* **41**: 113-128.
- 455 Alvares, C.A., Stape, J.L., Sentelhas, P.C., Moraes, J.L.M. & Sparovek, G. (2013)  
456 Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* **22**:  
457 711-728.
- 458 APGIII - ANGIOSPERM PHYLOGENY GROUP. (2009) An update of the  
459 Angiosperm Phylogeny Group classification for the orders and families of  
460 flowering plants: APG III. *Botanical journal of the Linnean Society of London*  
461 **161**: 105-121.

- 462 Araujo, R.A., Costa, R.B., Felfili, J.M., Kuntz, I., Sousa, R.A.T.M. & Dorval, A.  
463 (2009) Florística e estrutura de fragmento florestal em área de transição na  
464 Amazônia Matogrossense no município de Sinop. *Acta Amazonica* **39**: 865-878.
- 465 Askew, G.P., Moffatt, D.J., Montgomery, R.F. & Searl, P.L. (1970) Soil landscapes  
466 in northeastern Mato Grosso. *The Geographical Journal* **136**: 211-227.
- 467 Balch, J.K., Nepstad, D.C., Brando, P.M., Curran, L.M., Portela, O., Carvalho-Jr.,  
468 O. & Lefebvre, P. (2008) Negative fire feedback in a transitional forest of  
469 southeastern Amazonia. *Global Changes Biology* **14**: 1-12.
- 470 Bell, G., 2001. Neutral macroecology. *Science* **293**: 2413.
- 471 Campbell, D.G., Daly, D.C., Prance, G.T. & Maciel, U.N. (1986) Quantitative  
472 ecological inventory of terra firme and varzea tropical forest on the Rio Xingu,  
473 Brazilian Amazon. *Brittonia* **38**: 369-393.
- 474 Castro, A.A.J.F, Martins, F.R., Tamashiro, J.Y. & Shepherd, G.J. (1999) How rich  
475 is the flora of Brazilian Cerrados? *Annals of the Missouri Botanical Garden* **86**:  
476 192-224.
- 477 Condit, R., Pitman, N., Leigh Jr., E.G., Chave, J., Terborgh, J. Foster, R.B., Núñez  
478 V., Aguilar, S., Valencia, R., Villa, G., Muller-Landau, H.C., Losos, E. & Hubbell,  
479 S.P. (2002) Beta-diversity in tropical forest trees. *Science* **295**: 666-669.
- 480 Condit, R., Ashton, P., Balslev, H., Brokaw, N., Bunyavejchewin, S., Chuyong, G.,  
481 Co, L., Dattaraja, H., Davies, S., Esufali, S., Ewango, C., Foster, R., Gunatilleke,  
482 S., Gunatilleke, N., Hernandez, C., Hubbell, S. P., John, R., Kenfack, D.,  
483 Kiratiprayoon, S., Hall, P., Hart, T., Itoh, A., LaFrankie, J., Liengola, I.,  
484 Lagunzad, D., Lao, S., Losos, E., Magard, E., Makana, J., Manokaran, N.,  
485 Navarrete, H., Mohammed Nur, S., Okhubo, T., Pérez, R., Samper, C., Seng,  
486 L. H., Sukumar, R., Svenning, J., Tan, S., Thomas, D., Thomson, J., Vallejo,  
487 M., Villa Muñoz, G., Valencia, R., Yamakura, T. & Zimmerman, J. (2005)

- 488 [Tropical tree  \$\alpha\$ -diversity: results from a worldwide network of large plots.](#)  
489 [Biologiske Skrifter \*\*55\*\*: 565–582.](#)
- 490 Costa, L.P. (2003) The historical bridge between the Amazon and the Atlantic  
491 Forest of Brazil: a study of molecular phylogeography with small mammals.  
492 *Journal of Biogeography* **30**: 71-86.
- 493 Davidson, E.A., Araújo, A.C., Artaxo, P., Balch, J.K., Brown, I.F., Bustamante,  
494 M.M.C., Coe, M.T., DeFries, R.S., Keller, M., Longo, M., Munger, J.W.,  
495 Schroeder, W., Soares-Filho, B.S., Sousa-Jr, C.M. & Wofsy, S.C. (2012) The  
496 Amazon basin in transition. *Nature* **481**: 321-328.
- 497 FAO (2006) *Guidelines for Soil Descriptions*, 5th ed. Food and Agricultural  
498 Organization of United Nations, Rome, Italy.
- 499 Fearnside, P.M. (2005) Deforestation in Brazilian Amazonia: History, Rates, and  
500 Consequences. *Conservation Biology* **19**: 680-688.
- 501 Fiaschi, P. & Pirani, J.R. (2009) Review of plant biogeographic studies in Brazil.  
502 *Journal of Systematics and Evolution* **47**: 477-496.
- 503 Francis, A.P. & Currie, D.J. (1998) Global patterns of tree species richness in  
504 moist forests: another look. *Oikos* **81**: 598-602.
- 505 Fu, R., Yin, L., Li, W., Arias, P.A., Dickinson, R.E., Huang, L., Chakraborty, S.,  
506 Fernandes, K., Liebmann, B., Fisher, R. & Myneni, R.B. (2013) Increased dry-  
507 season length over southern Amazonia in recent decades and its implication for  
508 future climate projection. *Proceedings of the National Academy of Sciences* **110**:  
509 18110-18115.
- 510 Gentry, A.H. (1988) Changes in plant community diversity and floristic composition  
511 on environmental and geographical gradients. *Annals of the Missouri Botanical*  
512 *Garden* **75**: 1-34.

- 513 Gurevitch, J., Scheiner, S.M. & Fox, G.A. (2009) *Ecologia vegetal*. 2. ed., Porto  
514 Alegre, RS, Brasil: Artmed.
- 515 Hill, M.O. & Gauch, H.G. (1980) Detrended correspondence analysis: an improved  
516 ordination technique. *Vegetatio* **42**: 47-58.
- 517 Hoffmann, W.A., Geiger, E.L., Gotsch, S.G., Rossatto, D.R., Silva, L.C.R., LAU,  
518 O.L., Haridasan, M. & Franco, A. (2012) Ecological thresholds at the savanna-  
519 forest boundary: how plant traits, resources and fire govern the distribution of  
520 tropical biomes. *Ecology Letters* **15**: 759-768.
- 521 Hubbell, S.P. (2001) *The Unified Neutral Theory of biodiversity and biogeography*.  
522 Princeton, New Jersey, USA: Princeton University Press.
- 523 [Hutchinson, G.E. \(1957\) Concluding remarks. \*Cold Spring Harbor Symp\*, \*\*22\*\*: 415-](#)  
524 [427.](#)
- 525 IBGE - Instituto Brasileiro de Geografia e Estatística. (2012). *Manual Técnico da*  
526 *Vegetação Brasileira*. 2. ed., Rio de Janeiro, RJ, Brasil: Editora IBGE.
- 527 IBGE – Instituto Brasileiro de Geografia e Estatística (2015) Mapa  
528 Geomorfológico. IBGE-Brasília. In  
529 <[ftp://geoftp.ibge.gov.br/mapas\\_tematicos/geomorfologia/unidades\\_federacao/  
530 mt\\_geomorfologia.pdf](ftp://geoftp.ibge.gov.br/mapas_tematicos/geomorfologia/unidades_federacao/mt_geomorfologia.pdf)> (Accessed: 23 november 2015).
- 531 Ivanauskas, N.M., Monteiro, R. & Rodrigues, R.R. (2004a) Estrutura de um trecho  
532 de Floresta Amazônica na Bacia do Alto Rio Xingu. *Acta Amazonica* **34**: 275-  
533 299.
- 534 Ivanauskas, M.M., Monteiro, R. & Rodrigues, R.R. (2004b) Composição florística  
535 de trechos florestais na borda sul-amazônica. *Acta Amazonica* **34**: 399-413.
- 536 Ivanauskas, N.M., Monteiro, R. & Rodrigues, R.R. (2008) Classificação  
537 fitogeográfica das florestas do Alto Rio Xingu. *Acta Amazonica* **38**: 387-402.

- 538 Gurevitch, J., Scheiner, S.M. & Fox, G.A. (2009) *Ecologia vegetal*. 2. ed., Porto  
539 Alegre, RS, Brasil: Editora Artmed.
- 540 Kunz, S.H., Ivanauskas, N.M., Martins, S.V., Silva, E. & Stefanello, D. (2008)  
541 Aspectos florísticos e fitossociológicos de um trecho de Floresta Estacional  
542 Perenifolia na Fazenda Trairão, Bacia do Rio das Pacas, Querência-MT. *Acta*  
543 *Amazonica* **38**: 245-254.
- 544 Lacher, T.E., Alho, C.J.R. (2001) Terrestrial small mammal richness and habitat  
545 associations in an Amazon forest-Cerrado contact zone. *Biotropica* **33**: 171-181.
- 546 Landeiro, V.L., Hamada, N., Godoy, B.S. & Melo, A.S. (2010) Effects of litter patch  
547 area on macroinvertebrate assemblage structure and leaf breakdown in Central  
548 Amazonian streams. *Hydrobiologia* **649**: 355-363.
- 549 Lehmann, C.E.R., Archibald, S.A., Hoffmann, W.A. & Bond, W.J. (2011)  
550 Deciphering the distribution of the savanna biome. *New Phytologist* **191**: 197-  
551 209.
- 552 Lewis, S.L., Brando, P.M., Phillips, O.L., Heijden, G.M.F. & Nepstad, D. (2011)  
553 The 2010 Amazon drought. *Science* **331**: 554.
- 554 Lima-Filho, D.A., Rivilha, J., Amaral, I.L., Matos, F.D.A., Coelho, L.S., Ramos,  
555 J.F., Silva, G.B. & Guedes, J.O. (2004) Aspectos florísticos de 13 hectares da  
556 área de Cachoeira Porteira-PA. *Acta Amazonica* **34**: 415-423.
- 557 Lista de espécies da Flora do Brasil. (2012) Jardim Botânico do Rio de Janeiro. In  
558 <<http://floradobrasil.jbrj.gov.br/2012/>> (Accessed: 20 mar 2014).
- 559 Loarie, S.R., Duffy, P.B., Hamilton, H., Asner, G.P., Field, C.B. & Ackerly, D.D.  
560 (2009) The velocity of climate change. *Nature* **462**: 1052-1055.
- 561 Lopez-Gonzalez, G., Lewis, S.L., Burkitt, M., Baker T.R. & Phillips, O.L. (2009)  
562 ForestPlots.net Database. [www.forestplots.net](http://www.forestplots.net).

- 563 Lopez-Gonzalez, G., Lewis, S.L., Burkitt, M. & Phillips, O.L. (2011)  
564 ForestPlots.net: a web application and research tool to manage and analyse  
565 tropical forest plot data. *Journal of Vegetation Science* **22**: 610-613.
- 566 Marengo, J.A., Tomasella, J., Alves, L.M., Soares, W.R. & Rodriguez, D.A. (2011)  
567 The drought of 2010 in the context of historical droughts in the Amazon region.  
568 *Geophysical Research Letters* **38**: 1-5.
- 569 Marimon, B.S., Felfili, J.M. & Haridasan, M. (2001a) Studies in monodominant  
570 forests in eastern Mato Grosso, Brazil: I. A forest of *Brosimum rubescens* Taub.  
571 *Edinburgh Journal of Botany* **58**: 123-137.
- 572 Marimon, B.S., Lima, E.S., Duarte, T.G., Chieregatto, L.C. & Ratter, J.A. (2006)  
573 Observations on the vegetation of northeastern Mato Grosso, Brazil. IV. An  
574 analysis of the Cerrado-Amazonian Forest ecotone. *Edinburgh Journal of*  
575 *Botany* **63**: 323-341.
- 576 Marimon-Junior, B.H. & Haridasan, M. (2005) Comparação da vegetação arbórea  
577 e características edáficas de um cerradão e um cerrado sensu stricto em áreas  
578 adjacentes sobre solo distrófico no leste de Mato Grosso, Brasil. *Acta Botanica*  
579 *Brasilica* **19**: 913-926.
- 580 Marimon, B.S., Marimon-Junior, B.H., Feldpausch, T.R., Oliveira-Santos, C.,  
581 Mews, H.A., Lopez-Gonzalez, G., Franczak, D.D., Oliveira, E.A., Maracahipes,  
582 L., Miguel, A., Lenza, E. & Phillips, O.L. (2014) Disequilibrium and hyperdynamic  
583 tree turnover at the forest-savanna transition zone in southern Amazonia. *Plant*  
584 *Ecology & Diversity* **7**: 281-292.
- 585 McCune, B. & Grace, J.B. (2002) *Analysis of Ecological Communities*. Glenden  
586 Beach, Oregon, USA: MjM Software Design.
- 587 McCune, B. & Mefford, M.J. (2006) *PC-ORD – multivariate analysis of ecological*  
588 *data, version 5.0*. Glenden Beach, Oregon, USA: MjM Software Design.



- 589 Méio, B.B., Freitas, C.V., Jatobá, L., Silva, M.E.F., Ribeiro, J.F. & Henriques,  
590 R.P.B. (2003) Influência da flora das florestas amazônica e atlântica na  
591 vegetação do cerrado sensu stricto. *Revista Brasileira de Botânica* **26**: 437-444.
- 592 Mews, H.A., Marimon, B.S., Pinto, J.R.R. & Silvério, D.V. (2011) Dinâmica  
593 estrutural da comunidade lenhosa em Floresta Estacional Semidecidual na  
594 transição Cerrado-Floresta Amazônica, Mato Grosso, Brasil. *Acta Botanica*  
595 *Brasilica* **25**: 845-857.
- 596 Murphy, B.P. & Bowman, D.M.J.S. (2012) What controls the distribution of tropical  
597 forest and savanna? *Ecology Letters* **15**: 748-758.
- 598 Oliveira, A.N. & Amaral, I.L. (2004) Florística e fitossociologia de uma floresta de  
599 vertente na Amazônia Central, Amazonas, Brasil. *Acta Amazonica* **34**: 21-34.
- 600 Oliveira, A.N., Amaral, I.L., Ramos, M.B.P., Nobre, A.D., Couto, L.B. & Sahdo,  
601 R.M. (2008) Composição e diversidade florístico-estrutural de um hectare de  
602 floresta densa de terra firme na Amazônia Central, Amazonas, Brasil. *Acta*  
603 *Amazonica* **38**: 627-642.
- 604 Oliveira, C.M., Santos, J.B. & Santos-Costa, M.C. (2010) Os animais da Tanguro,  
605 Mato Grosso: diversidade na zona de transição entre a Floresta Amazônica e o  
606 Cerrado. Ed UFPA, Belém, PA.
- 607 Oliveira-Filho, A.T. & Ratter, J.A. (1995) A study of the origin of central Brazilian  
608 forests by the analysis of plant species distribution patterns. *Edinburgh Journal*  
609 *of Botany* **52**: 141-194.
- 610 Pereira, B.A.S., Venturoli, F. & Carvalho, F.A. (2011) Florestas estacionais no  
611 cerrado: uma visão geral. *Pesquisa Agropecuária Tropical* **41**: 446-455.
- 612 Peterson, A.T. & Watson, D.M. (1998) Problems with areal definitions of  
613 endemism: the effects of spatial scaling. *Diversity and Distributions* **4**: 189-194.

- 614 Phillips, O.L., Martinez, R.V., Vargas, P.N., Monteagudo, A.L., Zans, M.C.,  
615 Sánchez, W.G. & Rose, S. (2003) Efficient plot-based floristic assessment of  
616 tropical forests. *Journal of Tropical Ecology* **19**: 629-645.
- 617 Phillips, O.L., Aragão, L.E.O.C., Lewis, S.L., Fisher, J.B., López-González, G.,  
618 Malhi, Y., Monteagudo, A., Peacock, J., Quesada, C.A., Van Der Heijden, G.,  
619 Almeida, S., Amaral, I., Arroyo, L., Aymard, G., Baker, T.R., Bánki, O., Blanc, L.,  
620 Bonal, D., Brando, P.M., Chave, J., Oliveira, A.C.A., Cardozo, N.D., Czimczik,  
621 C.I., Feldpausch, T.R., Freitas, M.A., Gloor, E., Higuchi, N., Jiménez, E., Lloyd,  
622 G., Meir, P., Mendoza, C., Morel, A., Neill, D.A., Nepstad, D., Patiño, S.,  
623 Peñuela, M.C., Prieto, A., Ramirez, F., Schwartz, M., Silva, J., Silveira, M.,  
624 Thomas, A.S., Ter Steege, H., Stropp, J., Vásques, R., Zelazowski, P., Dávila,  
625 E.A., Andelman, S., Andrade, A., Chao, K.J., Erwin, T., Di Fiore, A., Homorio,  
626 E., Keeling, H., Killeen, T.J., Laurance, W.F., Cruz, A.P., Pitman, N.C.A.,  
627 Vargas, P.N., Ramírez-Angulo, H., Rudas, A., Salamão, R., Silva, N., Terborgh,  
628 J. & Torres-Lezama, A. (2009) Drought sensitivity of the Amazon rainforest.  
629 *Science* **323**: 1344-1347.
- 630 Pinto, J.R.R. & Oliveira-Filho, A.T. (1999) Perfil florístico e estrutura da  
631 comunidade arbórea de uma floresta de vale no Parque Nacional da Chapada  
632 dos Guimarães, Mato Grosso, Brasil. *Revista Brasileira de Botânica* **22**: 53-67.
- 633 [Qian, H. \(1999\) Spatial Pattern of Vascular Plant Diversity in North America North  
634 of Mexico and its Floristic Relationship with Eurasia. \*Annals of Botany\* \*\*83\*\*: 271-  
635 283.](#)
- 636 R Development Core Team. (2014) A language and environment for statistical  
637 computing. <http://www.R-project.org> [ver. 2.13.0]. R Foundation for Statistical  
638 Computing. Vienna, Austria.

- 639 Ratter, J.A., Richards, P.W., Argent, G. & Gifford, D.R. (1973) Observations on the  
640 vegetation of northeastern Mato Grosso: I. The woody vegetation types of the  
641 Xavantina-Cachimbo Expedition area. *Philosophical Transactions of the Royal  
642 Society of London. Series B, Biological Sciences* **266**: 449-492.
- 643 Ratter, J.A., Bridgewater, S. & Ribeiro, J.F. (2003) Analysis of the floristic  
644 composition of the Brazilian cerrado vegetation III: comparison of the woody  
645 vegetation of 376 areas. *Edinburgh Journal of Botany* **60**: 57-109.
- 646 Ribas, C.C., Aleixo, A., Nogueira, A.C.R., Miyaki, C.Y., Cracraft, J. (2011) A  
647 palaeobiogeographic model for biotic diversification within Amazonia over the  
648 past three million years. *Proceedings of the Royal Society B* **279**: 681-689.
- 649 Rosenberg, M.S. & C.D. Anderson, C.D. (2011) PASSaGE: Pattern Analysis,  
650 Spatial Statistics, and Geographic Exegesis. Version 2. *Methods in Ecology and  
651 Evolution* **2**: 229-232.
- 652 Rocha, R.G., Ferreira, E., Martins, I.C.M., Costa, L.P., Fonseca, C. (2014)  
653 Seasonally flooded stepping stones: emerging diversity of small mammal  
654 assemblage in the Amazonia-Cerrado ecotone, central Brazil. *Zoological  
655 Studies* **53**: 2-10.
- 656 Sano, S.M., Almeida, S.P. & Ribeiro, J.F. (2008) *Cerrado: ecologia e flora.*  
657 Brasília, DF, Brasil: Embrapa Cerrados.
- 658 Schwartz, D. & Namri, M. (2002) Mapping the total organic carbon in the soils of  
659 the Congo. *Global and Planetary Change* **33**: 77-93.
- 660 Sick, H. (1955) O aspecto fitofisionômico da paisagem do médio Rio das Mortes,  
661 Mato Grosso, e a avifauna da região. *Arquivos do Museu Nacional* **42**: 541-576.
- 662 Silva, L.C.R. (2015) Seasonal variation in groundwater depth does not explain  
663 structure and diversity of tropical savannas. *Journal of Vegetation Science* **26**:  
664 404-406.

- 665 Staver, A.C., Archibald, S. & Levin, S.A. (2011) The global extent and  
666 determinants of savanna and forest as alternative biome states. *Science* **334**:  
667 230-232.
- 668 Tello, J.C.R., Irmão, M.N., Viana, A.L., Bezerra, S.A.S. & Castro, J.P. (2008)  
669 Composição florística e estrutura fitossociológica da floresta ombrófila densa  
670 sub montana (Platô) face à elaboração do plano de gestão ambiental da área  
671 verde do Campus da Universidade Federal do Amazonas. *Revista Forestal*  
672 *Venezolana* **52**: 149-158.
- 673 ter Steege, H., Pitman, N.C., Phillips, O.L., Chave, J., Sabatier, D., Duque, A.  
674 Molino, J.F., Prévost, M.F., Spichiger, R., Castellanos, H., von Hildebrand, P. &  
675 Vásquez, R. (2006) Continental-scale patterns of canopy tree composition and  
676 function across Amazonia. *Nature* **443**: 444-447.
- 677 Torello-Raventos, M., Feldpausch, T.R., Veenendaal, E., Schrod F., Saiz, G.,  
678 Domingues, T.F., Djagbletey, G., Ford, A., Kemp, J., Marimon, B.S., Marimon-  
679 Junior, B.H., Lenza, E., Ratter, J.A., Maracahipes, L., Sasaki, D., Sonke, B.,  
680 Zapfack, L., Taedoumg, H., Villarroel, D., Schwarz, M., Quesada, C.A., Ishida,  
681 F.Y., Nardoto, G.B., Affum-Baffoe, K., Arroyo, L., Bowman, D.M.J.S., Compaore,  
682 H., Davies, K., Diallo, A., Fyllas, N.M., Gilpin, M., Hien, F., Johnson, M., Killeen,  
683 T.J., Metcalfe, D., Miranda, H.S., Steininger, M., Thomson, J., Sykora, K.,  
684 Mougin, E., Hiernaux, P., Bird, M.I., Grace, J., Lewis, S.L., Phillips, O.L. & Lloyd,  
685 J. (2013) On the delineation of tropical vegetation types with an emphasis on  
686 forest/savanna transitions. *Plant Ecology & Diversity* **6**: 101-137.
- 687 Veenendaal, E.M., Torello-Raventos, M., Feldpausch, T.R., Domingues, T.F.,  
688 Gerard, F., Schrod F., Saiz, G., Quesada, C.A., Djagbletey, G., Ford, A.,  
689 Kemp, J., Marimon, B.S., Marimon-Junior, B.H., Lenza, E., Ratter, J.A.,  
690 Maracahipes, L., Sasaki, D., Sonké, B., Zapfack, L., Villarroel, D., Schwarz, M.,

- 691 Ishida, F.Y., Gilpin, M., Nardoto, G.B., Affum-Baffoe, K., Arroyo, L., Bloomfield,  
692 K., Ceca, G., Compaore, H., Davies, K., Diallo, A., Fyllas, N.M., Gignoux, J.,  
693 Hien, F., Johnson, M., Mougín, E., Hiernaux, P., Killeen, T., Metcalfe, D.,  
694 Miranda, H.S., Steininger, M., Sykora, K., Bird, M.I., Grace, J., Lewis, S.,  
695 Phillips, O.L. & Lloyd, J. (2015) Structural, physiognomic and above-ground  
696 biomass variation in savanna-forest transition zones on three continents - how  
697 different are co-occurring savanna and forest formations? *Biogeosciences* **12**:  
698 2927-2951.
- 699 Werneck, M.S., Sobral, M.E.G., Rocha, C.T.V., Landau, E.C. & Stehmann, J.R.  
700 (2011) Distribution and endemism of Angiosperms in the Atlantic Forest.  
701 *Natureza & Conservação* **9**: 188-193.
- 702
- 703

704 **FIGURE LEGENDS**

705 **Figure 1** Amazonia-Cerrado transition zone and the 'arc of deforestation' in Brazil.

706 The right box indicates the study area and dashed line indicates the boundary  
707 between the watersheds of the Xingu River and the Araguaia River. ARA=  
708 Araguaia River Basin forest, states of Mato Grosso and Pará and XIN= Xingu  
709 River Basin forest, states of Mato Grosso.

710 **Figure 2** 'Compound' graph of species distribution (relative abundance) based on  
711 the weighted average according to the site in the Amazonia-Cerrado transition  
712 zone, Brazil. At the top of the graph, from left to right, the first two and last three  
713 bars are Araguaia River Basin forest (ARA); other bars are Xingu River Basin  
714 forest (XIN). Sites plotted in a latitudinal gradient (from left: southern forests,  
715 nearest the Cerrado domain, to right: northern forests, near the Amazonian  
716 domain).

717 **Figure 3** Floristic classification of the 10 studied forests in the Amazonia-Cerrado  
718 transition zone, based on the TWINSpan method. ARA= Araguaia River Basin  
719 forest and XIN= Xingu River Basin forest.

720 **Figure 4** Ordination by DCA summarizing the floristic patterns of 10 forests in the  
721 Amazonia-Cerrado transition zone, Brazil. ▲ARA-01, ▼ARA-02, ◆ARA-03,  
722 ●ARA-04 and ■ARA-05: Araguaia River Basin forests; ○XIN-01, ◇XIN-02,  
723 □XIN-03, △XIN-04 and ▽XIN-05: Xingu River Basin forests.

724