

**INSTITUTO NACIONAL DE PESQUISAS NA AMAZÔNIA - INPA**

**PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA**

**ESTRUTURA E COMPOSIÇÃO DA COMUNIDADE DE LIANAS SOB ALTERAÇÕES**

**ESTRUTURAS DE FRAGMENTOS FLORESTAIS NA AMAZÔNIA CENTRAL**

**STRUCTURE AND COMPOSITION OF LIANA COMMUNITY UNDER FOREST**

**STRUCTURAL ALTERATIONS IN FOREST FRAGMENTS IN CENTRAL AMAZONIA**

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Manaus, Amazonas

Outubro, 2023

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ESTRUTURAIS DE FRAGMENTOS FLORESTAIS NA AMAZÔNIA CENTRAL**

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Dissertação de mestrado apresentada no Programa de Pós-Graduação em Ecologia (PPGECO) do Instituto Nacional de Pesquisas na Amazônia (INPA), como parte dos requisitos para obtenção do título de mestre em Biologia (Ecologia).

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## PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA

### ATA DA DEFESA PÚBLICA DA DISSERTAÇÃO DE MESTRADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA DO INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA.

Aos 18 dias do mês de outubro do ano de 2023, às 09:h00min, via videoconferência, reuniu-se a Comissão Examinadora de Defesa Pública, composta pelos seguintes membros: a Dr<sup>a</sup>. **Elisangela Xavier da Rocha**, do Instituto de Pesquisa Ambiental da Amazônia – IPAM, o Dr. **Edson José Vidal da Silva**, da Universidade de São Paulo – USP e o Dr. **Marcel Caritá Vaz**, da Wilkes University (EUA), tendo como suplentes a Dr<sup>a</sup>. Angélica Faria de Resende, da Universidade de São Paulo – USP e a Dr<sup>a</sup>. Veridiana Weiser, da Universidade Estadual Paulista – UNESP, sob a presidência do orientador, a fim de proceder a arguição pública do trabalho de **DISSERTAÇÃO DE MESTRADO de NATHALIA DE TOLEDO MARINHO**, intitulado: “**ESTRUTURA E COMPOSIÇÃO DA COMUNIDADE DE LIANAS SOB ALTERAÇÕES ESTRUTURAIS DE FRAGMENTOS FLORESTAIS NA AMAZÔNIA CENTRAL**”, orientada pelo Dr. José Luís Campana Camargo, do Instituto Nacional de Pesquisas da Amazônia – INPA.

Após a exposição, o(a) discente foi arguido oralmente pelos membros da Comissão Examinadora, tendo recebido o conceito final:

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Nada mais havendo, a presente ata foi lida, lavrada e assinada pelos membros da Comissão Examinadora.

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**Sinopse:**

Estudamos os efeitos da estrutura florestal na estrutura e composição da comunidade de lianas em fragmentos florestais na Amazônia Central. Aspectos como florística, fitossociologia, abundância absoluta, biomassa e diversidade *alpha* e *beta* foram avaliadas, assim como índice de vegetação total e estratificada da floresta, e densidade de árvores finas.

**Palavras-chave:** Floresta tropical, ecologia de comunidades, sensoriamento remoto.

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## **Resumo**

O desmatamento na Amazônia cria paisagens fragmentadas e aumenta a exposição dos remanescentes florestais a padrões microclimáticos alterados, levando a mudanças estruturais florestais que podem alterar a densidade da vegetação e o perfil vertical da floresta fragmentada. As árvores são cruciais para definir a estrutura da floresta tropical, mas as lianas também contribuem com cerca de 25% das espécies e interceptam 10-20% do total de luminosidade da floresta. Entretanto, pouco se sabe sobre os efeitos da fragmentação florestal sobre as lianas. O objetivo deste estudo é entender como a estrutura e composição da comunidade de lianas responde à fragmentação florestal, especialmente em relação às mudanças estruturais florestais e distância da borda, na Amazônia Central. Usamos dados de 1,336 indivíduos ( $DAP \geq 2$  cm) de 172 espécies de lianas em 2 ha de floresta. Então, testamos a relação da abundância, biomassa, número de espécies e composição de espécies em função dos parâmetros estruturais da floresta obtidas através do LiDAR terrestre, uma técnica de sensoriamento remoto 3D, e da distância da borda. Em locais com menor densidade de vegetação de dossel, a abundância e a riqueza de espécies de lianas aumentaram. Contudo, houve aumento da biomassa de lianas e mudanças na composição de espécies de lianas somente nas bordas florestais. Concluímos que fatores não analisados, como a variação microclimática e características intrínsecas das lianas, podem também afetar a composição da comunidade de lianas. A longo prazo, o efeito da redução da densidade do dossel sobre a abundância de lianas, em combinação com as alterações climáticas, poderá causar alterações adicionais na composição das espécies de lianas nos fragmentos florestais.

**Palavras-chave:** floresta tropical; Amazônia; estrutura florestal; fragmentação florestal; estrutura de comunidades.



## **Abstract**

Deforestation in the Amazon creates fragmented landscapes and increases the exposure of forest remnants to altered microclimates, leading to forest structural changes that can alter vegetation density and the forest's vertical profile. Trees are crucial to defining tropical forest structure, but lianas contribute as much as 25% of species and can intercept 10-20% of the total light in forest. While much is known about the effects of forest fragmentation on trees, much less is known about lianas. Our study aimed to understand how the structure and composition of the liana community respond to forest fragmentation, especially forest-structural changes and distance to forest edge, in Central Amazonia. We used data from 1,336 individuals (diameter-at-breast-height  $\geq 2$  cm) of 172 liana species recorded in 2 ha of forest. Then, we tested the relationship between liana abundance, biomass, number of species, and species composition as a function of forest structural parameters obtained through Terrestrial LiDAR, a 3D-remote-sensing technique, and distance to the forest edge. At sites with a lower density of canopy vegetation, liana abundance and species richness both increased. However, increases in liana biomass and changes in liana species composition occurred only near forest edges. We conclude that unanalyzed factors, such as microclimatic variation and intrinsic characteristics of lianas, may be affecting liana community composition. In the long term, the effect of reduced canopy density on liana abundance and climate change may cause further changes in liana species composition in forest fragments.

**Keywords:** tropical forest; Amazonian rainforest; forest structure; forest fragmentation; community structure.

# SUMÁRIO

<b>INTRODUÇÃO GERAL.....</b>	<b>9</b>
<b>CAPÍTULO ÚNICO .....</b>	<b>12</b>
<b>ABSTRACT .....</b>	<b>14</b>
<b>INTRODUCTION.....</b>	<b>15</b>
<b>MATERIALS AND METHODS.....</b>	<b>18</b>
STUDY AREA .....	18
DATABASE AND SAMPLING DESIGN .....	20
STATISTICAL ANALYSIS .....	22
<b>RESULTS.....</b>	<b>24</b>
FLORISTIC AND PHYTOSOCIOLOGICAL ASPECTS OF LIANAS .....	24
FOREST STRUCTURE AND LIANA COMMUNITY .....	25
FOREST STRUCTURE AND TAXONOMIC COMPOSITION OF THE LIANA COMMUNITY .....	27
<b>DISCUSSION .....</b>	<b>30</b>
HIGH DIVERSITY AND SITE EFFECT .....	30
CANOPY STRUCTURE AND DISTANCE TO FOREST EDGE AFFECT LIANA COMMUNITY.....	32
LIANA BIOMASS AND TREE SUPPORT CAPACITY .....	34
<b>CONCLUSION .....</b>	<b>35</b>
<b>REFERENCES.....</b>	<b>38</b>
<b>CONCLUSÃO.....</b>	<b>48</b>
<b>REFERÊNCIAS BIBLIOGRÁFICAS.....</b>	<b>50</b>
<b>ANEXO I .....</b>	<b>53</b>

## **Introdução geral**

As lianas ou trepadeiras lenhosas são organismos chave do componente florestal, possuindo importante papel ecossistêmico, como a contribuição para a biomassa total de uma floresta e para a diversidade, principalmente nas florestas tropicais. A maioria das lianas investe mais em tecidos flexíveis do caule, como o xilema lianescente, caracterizado por vasos grandes, parênquima abundante e poucas fibras, e menos na construção de tecidos fibrosos, que são responsáveis pela autossustentação (Rocha et al. 2022). A fase de vida autossuportaste, na qual geralmente o xilema possui vasos pequenos, pouco parênquima e mais fibras, ocorre em lianas jovens. Assim elas crescem verticalmente sem suporte físico, e após esta fase inicia-se o processo de escalada, utilizando as árvores próximas como suporte físico para acessarem o dossel e desenvolverem sua copa e reproduzir (Rocha et al. 2022).

As lianas também geram impacto no estoque de carbono das florestas (Van der Heijden et al. 2014), porque ao utilizarem as árvores como suporte físico para acessarem o dossel, elas podem reduzir a taxa de crescimento, recrutamento e sobrevivência das árvores hospedeiras. Além disso, árvores e lianas competem por recursos abióticos acima e abaixo do solo, como água, luz e nutrientes (Schnitzer e Bongers 2002; Schnitzer 2018).

Entretanto, as lianas não assumem somente um papel negativo no ecossistema, elas atuam também como recurso alimentar para os animais (Yanoviak and Schnitzer 2013), como aves (Schnitzer et al. 2020) e insetos (Odell et al. 2019), e podem estar relacionadas à manutenção da diversidade, abundância e composição de animais pois promovem o aumento da heterogeneidade do habitat (Schnitzer 2002; Yanoviak and Schnitzer 2013). Além disso, as lianas podem atuar como “para-raios” naturais para as árvores hospedeiras (Gora et al. 2017).

Há praticamente um consenso na literatura que a proliferação de lianas está associada com ambientes degradados, muitas vezes após o processo de fragmentação florestal (Laurance et al. 2001; Schnitzer and Bongers, 2002; Campbell et al. 2018; Schintzer et al. 2021). Mas, nas

últimas décadas, alguns estudos relataram também um aumento da abundância de lianas em florestas primárias, apesar de não ser um consenso na comunidade acadêmica (Phillips et al. 2002; Laurance et al. 2014; Gerolamo et al. 2018; Bongers et al. 2020). A explicação levantada para esse novo padrão no aumento de lianas se ancora nos distúrbios florestais provocados por mudanças climáticas, como aumento de CO<sub>2</sub>, temperatura, deposição de nutrientes e mudança no regime hídrico (Schnitzer e Bongers 2002; Schnitzer, Estrada-Villegas and Wright 2020; Schnitzer et al. 2021; Vogado et al. 2022).

Nas últimas décadas, a investigação dos processos e mecanismos envolvidos na estruturação da comunidade de lianas vem aumentando, tanto em florestas tropicais (Burnham 2002; Schnitzer et al. 2021) quanto em subtropicais (Yang et al. 2018; Li et al. 2022; Ofosu-Bamfo et al. 2023). Entretanto, são poucos os trabalhos que se debruçaram na investigação em como ocorre uma reestruturação das comunidades de lianas diante das perturbações causadas pelo processo de fragmentação florestal, em especial na Amazônia (Laurance et al. 2001; Laurance et al. 2014; Piovesan et al. 2022).

Partindo do princípio clássico de que as lianas são organismos favorecidos por distúrbios (Laurance et al. 2001; Schnitzer et al. 2021), entender como a estruturação e composição da comunidade de lianas ocorrem no contexto de florestas fragmentadas é de extrema importância ecológica, visto que cada vez mais florestas tropicais são desmatadas, criando pequenos fragmentos florestais e aumentando a proporção de floresta contínua que está sob efeito de borda (Haddad et al. 2015; Fischer et al. 2021). Mas vale lembrar que estudos mais recentes, ao considerar a identificação taxonômica das espécies lianescentes, concluíram que a proliferação das lianas nem sempre está associada a ambientes que passaram por alguma degradação (Piovesan et al. 2022; Yuan et al. 2009). Assim como muitas árvores, muitas espécies de lianas são também sensíveis às alterações causadas ou associadas a distúrbios ambientais, o que gera certamente um desequilíbrio na estrutura e composição da assembleia.

Apresentamos este trabalho em capítulo único, em formato de artigo e escrito em inglês e nele exploramos a relação entre os efeitos persistentes das alterações na estrutura florestal e a distância da borda, decorrente da fragmentação florestal, na assembleia de lianas. Para atingirmos este objetivo, o trabalho foi realizado no maior e mais longo experimento de fragmentação florestal tropical, o Projeto de Dinâmica Biológica de Fragmentos Florestais (PDBFF), que mesmo após 40 anos do processo de fragmentação florestal, ainda registra efeitos ou alterações persistentes na estrutura florestal (Almeida et al. 2019; Maeda et al. 2022).

Analisamos e integramos três bancos de dados robustos que estão disponíveis para a área: dados do sensoriamento remoto LiDAR tridimensional da estrutura florestal, dados acurados ao detalhamento de 1 m<sup>3</sup> de resolução, inventário de árvores finas (10-20 cm de DAP) e, por fim, o inventário de lianas ( $\geq 2$  cm de DAP), com dados demográficos e da identificação taxonômica, sendo um dos inventários mais completos para florestas tropicais. Além de poder cruzar as informações estruturais da floresta baseado em parâmetros acurados com a demografia de lianas, pudemos ir além e analisar também se havia mudanças na composição da assembleia de lianas, já que contamos com a identificação dos espécimes por especialista.

Antes de finalizar, temos a consciência que este estudo não seria possível sem a colaboração entre os pesquisadores e a criação de bancos de dados incríveis, muitos vindos de monitoramento de longo prazo. A ideia basal deste estudo poderia ter sido pensada ao nível puramente teórico, mas floresceu por contar com o acúmulo de conhecimento e a generosidade em prol da curiosidade científica de todos que aqui participaram.

## Capítulo Único

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1 **The influence of forest structure on the abundance, biomass, and composition of lianas**  
2 **in tropical forest fragments**

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18           **Abstract**

19           Deforestation in the Amazon creates fragmented landscapes and increases the exposure  
20 of forest remnants to altered microclimates, leading to forest structural changes that can alter  
21 vegetation density and the forest's vertical profile. Trees are crucial to defining tropical forest  
22 structure, but lianas contribute as much as 25% of species and can intercept 10-20% of the total  
23 light in forest. While much is known about the effects of forest fragmentation on trees, much  
24 less is known about lianas. Our study aimed to understand how the structure and composition  
25 of the liana community respond to forest fragmentation, especially forest-structural changes  
26 and distance to forest edge, in Central Amazonia. We used data from 1,336 individuals  
27 (diameter-at-breast-height  $\geq 2$  cm) of 172 liana species recorded in 2 ha of forest. Then, we  
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30 a 3D-remote-sensing technique, and distance to the forest edge. At sites with a lower density of  
31 canopy vegetation, liana abundance and species richness both increased. However, increases in  
32 liana biomass and changes in liana species composition occurred only near forest edges. We  
33 conclude that unanalyzed factors, such as microclimatic variation and intrinsic characteristics  
34 of lianas, may be affecting liana community composition. In the long term, the effect of reduced  
35 canopy density on liana abundance and climate change may cause further changes in liana  
36 species composition in forest fragments.

37           **Keywords:** tropical forest; Amazonian rainforest; forest structure; forest fragmentation;  
38 community structure.



39           **Introduction**

40           In tropical forests, such as the Amazon rainforest, increasing deforestation has led to  
41 increasingly fragmented landscapes, thus increasing the forest area exposed to edge effects  
42 (Haddad et al. 2015; Montibeller et al. 2020; Fischer et al. 2021). Forest edges tend to have  
43 higher intensity and turbulence of winds and exposure to solar radiation, which results in a  
44 drier and warmer environment (Ferreira and Laurance 1997; Briant et al. 2010). Such m  
45 icroclimatic changes modify forest structure and dynamics due to increased mortality rates,  
46 mainly of large trees (Laurance et al. 2000), thereby frequently creating more gaps and initiating  
47 natural regeneration (Fischer et al. 2021).

48           Forest fragmentation leads to changes in the vegetation distribution along the vertical  
49 profile of forests, thus, forest edges tend to have lower structural complexity as compared with  
50 the intact forest interior. Forest edges has a higher density of vegetation in the understory than  
51 in the upper canopy (Maeda et al. 2022) and a more accelerated leaf production and branch  
52 growth of understory trees (Nunes et al. 2022). These changes can also be seen in tree growth  
53 patterns: while the basal area of understory species increases that of canopy species decreases  
54 near the edges (Albiero-Júnior et al. 2019, 2021). Additionally, there is a decrease in mean  
55 canopy height and an increase in the abundance of pioneer species near the edges (Almeida et  
56 al. 2019). Perhaps even more drastic than the changes in tree growth and composition are the  
57 changes in the community of lianas.

58           Lianas are important structural components of tropical forests contributing ~25% to all  
59 woody species (Schnitzer and Bongers 2002; Campbell et al. 2014), can comprise 10 to 20%  
60 of plant area index (PAI) in tropical forest, *i.e.*, how much of the light may be intercepted by  
61 lianas (Rodríguez-Ronderos at al. 2016), but still have received disproportionately less attention  
62 than trees. The liana growth habit is characterized by a stem with little structural supporting  
63 tissue (Rocha et al. 2022), requiring these woody plants to derive physical support from trees

64 to access the forest upper canopy. The liana-tree interaction leads to competition for abiotic  
65 resources above- and below- ground, reducing the growth rate, recruitment, and survival of host  
66 trees and may impact the carbon stock of forests (Schnitzer and Bongers 2002; Van der Heijden  
67 et al. 2014; Schnitzer 2018; Estrada-Villegas and Schnitzer 2018; Meunier et al. 2022). Despite  
68 this, there is no evidence that there is a species-specific relationship between lianas and trees  
69 (Garrido-Perez and Burnham 2010; Li et al. 2022; Ofadu-Bamfo et al. 2022), but some trees  
70 are more susceptible to the presence of lianas (Laurance et al. 2001; Song et al. 2023), which  
71 could cause selective tree mortality.

72         There are many studies showing a positive relationship between lianas proliferation and  
73 forest disturbance, with liana biomass inversely associated with tree biomass (Laurance et al.  
74 2001; Campbell et al. 2014; Schnitzer et al. 2021). However, fewer studies disentangled that  
75 processes embedded at edge effects has more influence on liana community (Campbell et al.  
76 2018). Unfortunately, studies on liana ecology often lack the refinement of taxonomic  
77 identification of individuals, which prevents us from understanding how species respond  
78 ecologically to environmental disturbances, and how much they contribute to the structure, or  
79 even to the changes caused in the composition of the liana community (Burnham 2004).

80         Considering taxonomic identification, Piovesan et al. (2022) found that congeneric  
81 species of *Machaerium*, a relevant genus to liana community, did not have a homogeneous  
82 response to forest fragmentation: most species were not affected and some responded  
83 negatively, while the community responded positively. A similar pattern of liana responses to  
84 forest fragmentation was found to other species and genus in subtropical secondary forests of  
85 southwest China (Yuan et al. 2009) and in degraded tropical forests of Ghana (Ofosu-Bamfo et  
86 al. 2022). Considering these findings, we ask in this study: How do forest fragmentation affect  
87 liana community structure and composition? Does distance to the forest edge and forest  
88 structure, have the same degree of influence on liana community?

89 Forest fragmentation causes structural changes that impact several aspects of the tree  
90 community (Blanchard et al. 2023), then we hypothesize that lianas are strongly affected by  
91 these forest structure changes too. The “new” forest structure should define the spatial  
92 distribution, structure, and composition of the liana community. Hence with respect to liana  
93 structure, we predict an increasing abundance and biomass of lianas in more degraded locals,  
94 associated with thinner trees, related to greater availability of support for liana growth; more  
95 open canopies and higher proportion of vegetation at lower layers of forest, related to  
96 penetration of the light. The degraded locals may be gaps into forest fragment, or forest edges.

97 Furthermore, it is reasonable to expect that not all liana species respond positively to the  
98 process of forest fragmentation and associated forest disturbances (Schnitzer 2018; Piovesan et  
99 al. 2022). Thus, to liana composition, we hypothesize that some species would respond  
100 positively while others would respond negatively to structural changes in the forest and distance  
101 to edge, whereas most species may show a neutral pattern (Piovesan et al. 2022), i.e., generalist  
102 species able to develop in all types of environments. Finally, we hypothesize that forest  
103 structure has more influence on liana community than distance to the edge, because forest  
104 structure mediates edge effects and is affected by other forest disturbances that may be  
105 independent of forest fragmentation.

106 To access the complexity of forest structure at forest fragments, we used Terrestrial Laser  
107 Scanning (TLS), a remote sensing LiDAR (Light Detection and Ranging). This technology  
108 allows us to measure the 3D forest structural traits such as plant area density (PAD) and indices  
109 of plant vegetation (PAI). These traits are closely linked to ecological processes and help us to  
110 understand the distribution of vegetation with a three-dimensional perspective (Almeida et al.  
111 2019; Calders et al. 2020; Maeda et al. 2022; Nunes et al. 2022; Blanchard et al. 2023).

112 However, most of forest structure studies focus on the spatial allocation of vegetation,  
113 without distinguishing plant types, and its influence on tree community (Blanchard et al. 2022).

114 There are fewer studies involving remote sensing and lianas, as Schnitzer et al. (2021) that  
115 quantified canopy disturbance using LiDAR data and related it to increasing liana abundance,  
116 and Rodríguez-Ronderos et al. (2016) showed that lianas can comprise 10 to 20% of plant area  
117 index in tropical forest, *i.e.*, how much of the total light is intercepted by lianas. And there are  
118 studies, in early stages, that are developing techniques to extract lianas from remote sensing  
119 data (Sánchez-Azofeifa et al. 2017; Krishna et al. 2019; Han and Sánchez-Azofeifa 2022),  
120 which, in the future, could provide us more accurate estimates of liana biomass, for example.

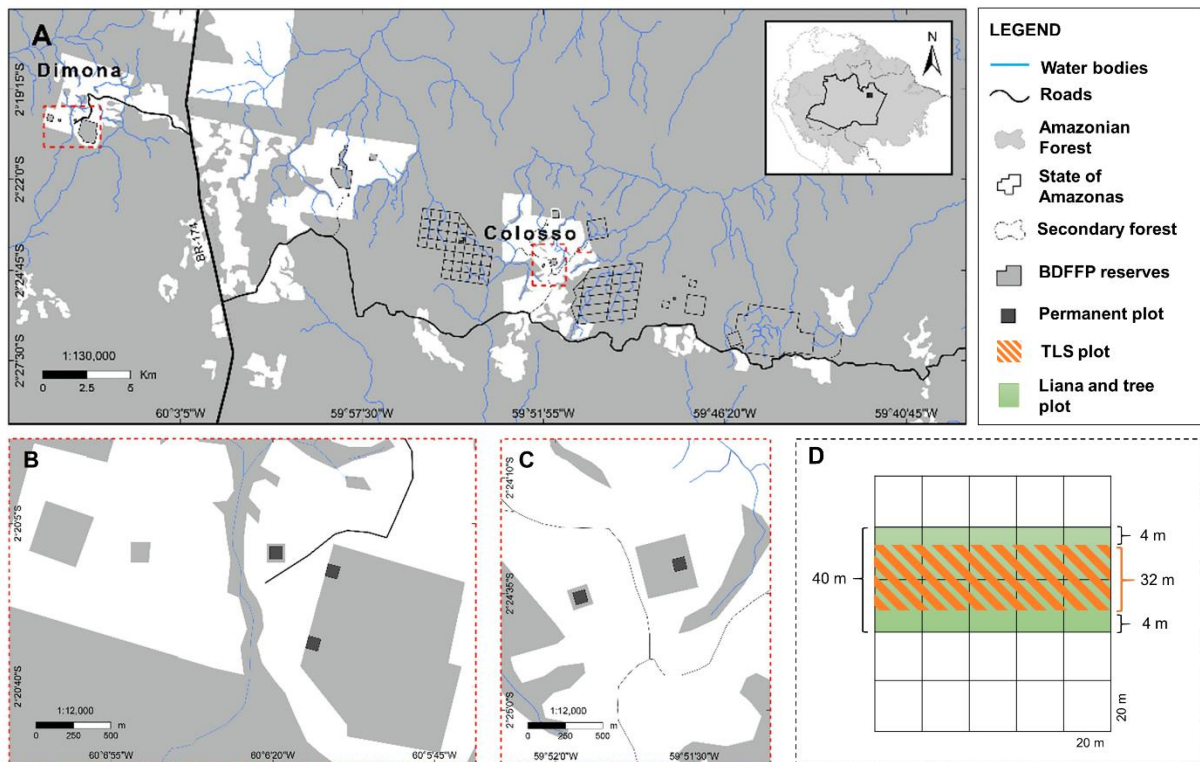
## 121 **Materials and Methods**

### 122 Study area

123 The study was carried out in a permanent plot system of the Biological Dynamics of  
124 Forest Fragments Project (BDFFP – INPA) located in the Area of Relevant Ecological Interest  
125 BDFFP (ARIE – BDFFP), 80 km North of Manaus, Amazonas, Brazil. In addition to continuous  
126 primary forest control areas, the ARIE maintains experimental forest fragments of 1, 10, and  
127 100 ha and has 69 1-ha permanent plots spread across several reserves (Lovejoy et al. 1986;  
128 Laurance et al. 2011, **Fig. 1**). The permanent plots are subdivided into 25 subplots (20 x 20 m).  
129 For this study, we concentrated data collection on a smaller area comprising ten subplots in five  
130 permanent plots in the Colosso and Dimona sampling sites, which are *ca.* 25 km apart. The  
131 matrix surrounding the forest fragments comprises old pastures and regenerating secondary  
132 forests. Forest fragments have been maintained isolated by clear-cutting a 100 m wide strip of  
133 secondary forest around each forest fragment (Lovejoy et al. 1986; Laurance et al. 2018).

134 The climate in the ARIE – BDFFP area is classified as tropical humid (Af; Koeppen,  
135 1948), with a mean annual temperature of 26°C and annual rainfall of 2500-2800 mm. The rainy  
136 season extends from November to May/June, while the driest season is from July to October  
137 (monthly average less than 100 mm of rain) (Laurance et al. 2011). The soil is classified as Alic

138 Yellow Latosol, the most common latosols in the Amazon basin, predominantly clayey, with  
 139 high water retention capacity, acidic, low fertility, and high aluminum concentration (Fearnside  
 140 and Leal-Filho, 2020).



141 Fig. 1 (a) ARIE – PDBFF, located ca. 80 km north of Manaus, Central Amazon, Brazil. Dark gray  
 142 represents mature terra-firme forest, and white patches correspond to deforested areas covered by  
 143 secondary-growth forests. The two site samples are highlighted in red. (b) Dimona (1 and 100 ha  
 144 reserves) and (c) Colosso (1 and 10 ha reserves). Black squares represent 100 x 100 m permanent plots  
 145 (d) Field study design in permanent plots in which absolute abundance, biomass, and composition of  
 146 lianas and density of thinner trees were recorded in the green subplots (20 x 20 m). Forest structure  
 147 parameters obtained by Terrestrial Laser Scanning was derived from the area with orange stripes (100  
 148 x 32 m). Figure adapted from Piovesan et al. (2022)

149  
 150 The forest is terra-firme type (non-flooded) and under undisturbed conditions has a  
 151 vertical structure of four strata: understory, sub-canopy, canopy, and emergent trees. The  
 152 canopy reaches 25 to 35 m, with emergent trees up to more than 45 m (Albiero-Júnior et al.

153 2019). Tree composition ( $\geq 10$  cm diameter-at-breast-height, DBH) is highly diverse, with more  
154 than 280 spp.  $ha^{-1}$  (Laurance et al. 2010). Lianas also follow a pattern of high diversity, with an  
155 estimated 160 spp.  $ha^{-1}$  (Piovesan et al. 2022).

#### 156 Database and sampling design

157 We combined taxonomic data from a recent liana inventory done in the BDFFP area with  
158 three-dimensional and high-resolution data of the same forest structure obtained by ground-  
159 based LiDAR remote sensing (Terrestrial Laser Scanning - TLS). To explore whether the forest  
160 structure affects liana community structure, we combined and evaluated three databases: (1)  
161 inventory of lianas, (2) TLS forest structure survey, and (3) demography of 10-20 DBH trees.  
162 Data overlap was restricted to the TLS forest structure survey coverage.

163 **(1) Inventory of lianas:** In 1997 and 2014, 33,896 lianas with  $DBH \geq 2$  cm were located,  
164 measured, and tagged in the 69 permanent plots of the BDFFP, but only in 2016 the botanical  
165 material was collected and identified to the species level. By 2023, 43 plots of 1 ha were  
166 monitored, in which 21,500 individuals were classified into 40 families and at least 360 spp.  
167 with an average density of 500 *ind. ha*<sup>-1</sup> (Robyn Burnham, unpublished data). The species list  
168 may increase by as much as 20% because the material collected is still in the process of  
169 taxonomic identification (Robyn Burnham, unpublished data). In 2017 and 2018, this  
170 inventory was performed in the forest fragments plots of Colosso, and in 2019, the work  
171 continued to Dimona.

172 DBH measurement protocol was adapted from other protocols described by Gerwing et  
173 al. (2006) and Schnitzer et al. (2008). From the diameter data, we estimated the above-ground  
174 biomass (AGB) using an allometric equation exclusive for lianas, proposed by Schnitzer et al.  
175 (2006):  $AGB = \exp[-1.484 + 2.657 \times \ln(DBH)]$ . This equation uses only DBH; AGB is  
176 expressed in kg of dry mass.

177           **(2) Forest structure survey:** In 2019, forest structure data were acquired by Terrestrial  
178 Laser Scanning (TLS), using a RIEGL VZ-400i instrument in an area of 100 x 32 m in 5  
179 permanent plots evaluated in this study (**Fig. 1d**). The point clouds were processed and  
180 registered using RiSCAN PRO software version 2.9 (see Supplementary Material). After that,  
181 voxelization was performed with the AMPVox software, in which the total volume of the point  
182 cloud of each area was divided into voxel (regular grids in three-dimensional space) of 1 m<sup>3</sup>,  
183 and the values of plant area density (PAD, m<sup>2</sup> m<sup>-3</sup>) were estimated for each voxel. From the  
184 PAD the other traits of the forest structure were calculated.

185           The values used for vertical structure traits were obtained from averages for  
186 approximately 20 x 16 m plots. First, the plant area index (PAI, m<sup>2</sup> m<sup>-2</sup>) was estimated for each  
187 vertical column, which is a combination of the leaf and woody area indexes, such as branches  
188 and trunks, and is obtained by the sum of the PAD values in each voxel column. PAI regulates  
189 the capacity of the forest to capture light and exchange gasses and is, therefore, related to forest  
190 productivity, and high values may indicate little light penetration under the canopy (Reich 2012;  
191 Ma et al. 2021). The PAI can be stratified, so we derived the PAI for a range of 15 to 30 m  
192 height and considered it as the canopy; for the range of 0 to 15 m height, we considered it to be  
193 understory, thus simplifying the forest complexity into two strata. We then averaged the PAI  
194 values for each stratum (Nunes et al. 2022).

195           Furthermore, we also calculated the canopy ratio (CR) using the equation:  $CR = (RH98 -$   
196  $RH25) \div RH98$ . RH25 and RH98 represent the relative heights (m) at which 25% and 98% of  
197 the vegetation is in the voxel column (more details in Maeda et al. 2022). The CR reveals a  
198 proportional relationship of plant material distribution in the vertical gradient of the forest.  
199 Values smaller than 0.74 indicate a higher allocation of plant material in the upper strata. In  
200 comparison, values larger than 0.74 indicate that the allocation of material is more strongly



201 localized in the lower strata (Maeda et al. 2022), possibly indicating clearings along the forest  
202 profile.

203 Lianescent growth is characterized by a liana stem being rooted in one location, yet its  
204 crown may be meters away. Thus, we added to the database all lianas present in an additional  
205 4 m beyond the edge in each area covered by the TLS survey. In this case, each sampling area  
206 covered 100 x 40 m (**Fig. 1d**). The liana habit can be apparently erratic or stimulated by light  
207 entry paths through the vertical structure of the forest, which are highly variable in time and  
208 space. Therefore, we extended our analyses to a subplot with twice the area of the TLS survey,  
209 by joining four subplots, creating subplots of 40 x 40 m. Only lianas whose rooting points were  
210 within the subplots were considered. Each stem that is marked with a unique identification tag  
211 was considered an independent individual.

212 **(3) Tree demography:** Between 2015 and 2016, the tree individuals were sampled,  
213 measured, and identified to the species level. In the study sub-plots, there were 1,108 trees, of  
214 which 60.7% were individuals with DBH between 10 and 20 cm (**Supplementary Table 1**).  
215 The density of thin trees indicates the capacity for physical support: the higher the density, the  
216 greater the potential for lianas to climb into the forest canopy and thus obtain better light  
217 conditions for development and reproduction.

### 218 Statistical analysis

219 The independent variables referring to forest structural parameters were: (1) total PAI;  
220 (2) understory PAI (0 to 15 m); (3) canopy PAI (15 to 30 m); (4) canopy ratio (CR); and (5)  
221 density of thin trees (with DBH between 10 and 20 cm). We also considered (6) distance to the  
222 edge (m) and (7) fragment size as predictors of liana composition and abundance. We  
223 performed analyses in R statistical software (v 4.2.1; R Core Team 2022) and the results were  
224 considered significant when P-values were  $\leq 0.05$ .



225 There was a strong correlation, indicated by Pearson correlation, of distance to edge with  
226 total PAI and understory PAI, as well as a moderate correlation between canopy PAI and  
227 understory PAI (**Supplementary Figure 1**). To confirm the correlations on the regression  
228 model, we tested the multicollinearity among the independent variables with  
229 the *performance* package (Lüdecke et al. 2021), and we only kept the variables whose Variance  
230 Inflation Factor (VIF)  $\leq 2$  (**Supplementary Table 1**), thus the variables total PAI and  
231 understory PAI were removed from the models. We selected regression models based on the  
232 lowest Akaike Information Criterion (AIC) values and, when  $\Delta AIC < 2$ , selected the model  
233 with the fewest degree of freedom. All models were fitted with the DHARMA package (Hartig  
234 2022), and  $R^2$  values were obtained by the *r2* function from the *performance* package. For the  
235 selected multiple regression models, we standardized the variables to compare the effect size  
236 of the independent variables on the statistical model.

237 We tested the relationship of liana density and biomass with forest structure parameters  
238 and distance to the edge. For liana abundance, we used the Generalized Linear Mixed Model  
239 (GLMM) with the *glmmTMB* package (Books et al. 2017) and the Negative Binomial 2  
240 distribution (log link). We also used GLMM with Poisson distribution (log link) for alpha  
241 diversity. In both models, only forest fragment size was included as a random factor.

242 For liana biomass, we used the Generalized Linear Model (GLM) because the conditional  
243  $R^2$  in the GLMM models were very close (difference of less than 1%) to marginal, so there was  
244 no variation related to any of the spatial autocorrelation variables tested (site, reserve size, and  
245 permanent plots). The distribution used was Gamma (log link). We also excluded the biomass  
246 of one individual that was an outlier (*Abuta velutina* - DBH = 44.7 cm). With this individual in  
247 the subplot, the regression model had poor quality and it did not fit statistically, presenting  
248 significant dispersion (dispersion = 2.70;  $p = 0.01$ ). Without it, the model was fitted and had a  
249 non-significant dispersion (dispersion = 1.49;  $p = 0.16$ ).

250 To evaluate liana composition, we estimated the variation in species diversity  $\beta$  among  
251 subplots using Bray-Curtis dissimilarity matrix (relative abundance per subplot), and then we  
252 performed a Principal Coordinates Analysis (PCoA; Legendre and Legendre 1998). The first  
253 two axes of PCoA were tested as a function of forest structure parameters and distance to edge,  
254 using GLMM (Gaussian distribution, identity link). To understand how the species were related  
255 to the significant independent variable of the model, we performed a direct ordination with the  
256 “poncho” function (Dambros 2020). The functions used were “deconstand” e “vegdist” from  
257 the *vegan* package (Oksanen et al. 2022) and “cmdscale” from R's native statistical functions.

## 258 **Results**

### 259 Floristic and phytosociological aspects of lianas

260 We characterized the floristic and phytosociology, aspects of liana community structure  
261 and composition, from 1,336 individuals with an average density of 668 ind. ha<sup>-1</sup> (485 - 872.5  
262 ind. ha<sup>-1</sup>), of which 82% were identified to species and 1.3% (18 ind.) not identified to family.  
263 We recorded 123 spp. and 49 morphotypes representing 69 genera and 26 plant families. Our  
264 study encompasses *ca.* 50% of the liana diversity so far encountered at the BDFFP (see the  
265 species list in **Supplementary Table 7**).

266 Bignoniaceae, with 32 spp. and 408 ind. was the most diverse and abundant family,  
267 followed by Fabaceae (29 spp. and 363 ind.), Celastraceae (15 spp. and 80 ind.), Connaraceae  
268 (5 spp. and 73 ind.), Dilleniaceae (5 spp. and 39 ind.), and Apocynaceae (12 spp. 38 ind.). The  
269 most diverse genus was *Adenocalymma* (Bignoniaceae, 12 spp. and 157 ind.), followed by  
270 *Strychnos* (Loganiaceae, 10 spp. and 20 ind.), *Machaerium* (Fabaceae, 9 spp. and 112 ind.),  
271 *Moutabea* (Polygalaceae, 8 morphotypes and 27 ind.) and *Coccoloba* (Polygonaceae 8  
272 morphotypes and 14 ind.).

273 The rank order of genus changes when we consider the highest frequency of occurrence.  
274 *Adenocalymma* has the highest frequency (90%), followed by *Machaerium*, *Deguelia*,  
275 *Bignonia*, *Rourea* and *Fridericia*, with *Bignonia* comprising only *Bignonia aequinoctialis*.  
276 Each one of these six genera was present in more than 52% of the sub-plots, with all of them  
277 having absolute density above 35.5 *ind. ha*<sup>-1</sup> (**Supplementary Table 8**).

278 The highest absolute density was *Bignonia aequinoctialis* (48.5 *ind. ha*<sup>-1</sup>), representing  
279 8.1% of all the individuals identified. It is followed by *Deguelia negrensis* (44.5 *ind. ha*<sup>-1</sup>),  
280 *Rourea paraensis* (26 *ind. ha*<sup>-1</sup>), *Fridericia prancei* (22.5 *ind. ha*<sup>-1</sup>) and *Machaerium*  
281 *hoehneanum* (18.5 *ind. ha*<sup>-1</sup>). These five species contribute around 25% of all individuals, and  
282 17 species collectively contribute 50% (**Supplementary Table 9**). The first three species with  
283 the highest density also have the highest absolute frequency, present in at least half of the  
284 subplots.

285 About 79.6% species are considered rare, as they occur less than 5 *ind. ha*<sup>-1</sup> and are  
286 naturally infrequent (**Supplementary Table 9**). They are present in less than 10% of the  
287 subplots, following the same patterns of rarity of the hectares from which they are drawn, thus  
288 we conclude that our subplots are representative.

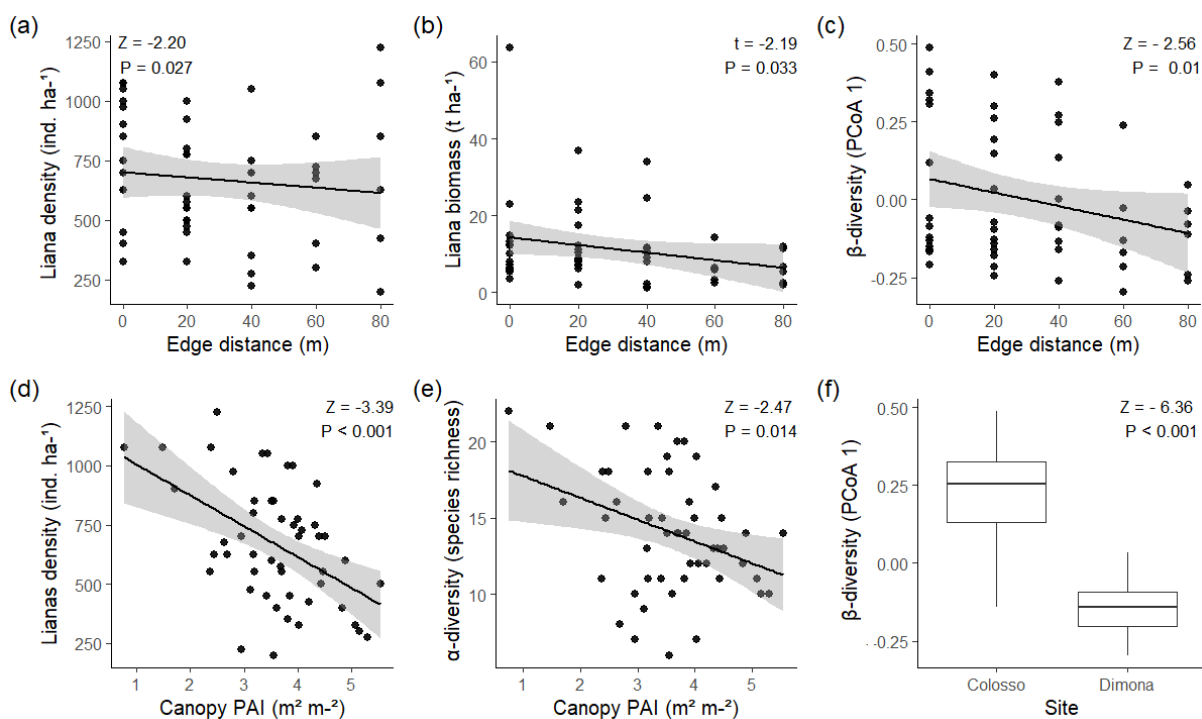
### 289 Forest structure and liana community

290 The liana community structure, represented by absolute abundance, was only related to  
291 canopy PAI ( $Z = -3.39$ ;  $p < 0.001$ ) and distance to the edge ( $Z = -2.20$ ;  $p = 0.028$ ), as indicated  
292 by the results of the most parsimonious model (model 1 in **Supplementary Table 3**). Thus, we  
293 observed a greater abundance of lianas in sites with low canopy PAI values compared to more  
294 structurally complex sites (**Fig. 2d**). The same negative relationship occurs with distance to the  
295 edge: the closer to the edge, the greater the abundance of lianas (**Fig. 2a**). However, after  
296 standardizing the fixed variables in the model, the strength of the effect of canopy PAI ( $b = -$

297 0.40) was 1.6 times greater than that of distance from the edge ( $b = -0.25$ ). The fixed variables  
 298 explained only 22.5% of the abundance of lianas in the forests studied, while fragment size was  
 299 responsible for explaining 25.2%.

300 On the other hand, the absolute biomass of lianas was only related to distance from the  
 301 edge and not to the forest structure parameters (model 1 in **Supplementary Table 4**). The closer  
 302 to the edge, the higher the absolute biomass of lianas (**Fig. 2b**;  $t = -2.193$ ;  $p = 0.033$ ;  $r^2 = 12.9\%$ ).

303



304 **Fig. 2** Relationship of forest structure and distance to edge on the structure (abundance and biomass)  
 305 and species composition (diversity  $\alpha$  and diversity  $\beta$ ) of the liana community ( $n = 50$ ) in forest fragments  
 306 at BDFFP in Central Amazonia, Brazil. (a, d) Liana abundance (ind.) as a function of distance from the  
 307 forest edge and canopy area index (canopy PAI); (b) Liana biomass (kg) as a function of distance to the  
 308 edge; (c, f) Diversity  $\beta$  (PCoA1) as a function of distance to the edge and reserves; (e) Diversity  $\alpha$   
 309 (number of species) as a function of canopy PAI. Regressions were performed by GLMM (abundance  
 310 and composition) and GLM (biomass). The trendlines have a 95% confidence interval (CI)

311

312 Due to the lianescent growth habit, which can appear to be erratic, we decided to analyze,  
313 even if we lost degrees of freedom, whether our results would change if we increased the  
314 sampling area by doubling the size of the 40 x 40 m subplots. However, the most parsimonious  
315 model for the density and biomass of lianas was the null model, so by increasing the size of the  
316 subplots, the structural parameters and distance from the edge were no longer predictors that  
317 explained the variation in the abundance and biomass of lianas (**Supplementary Table 5**).

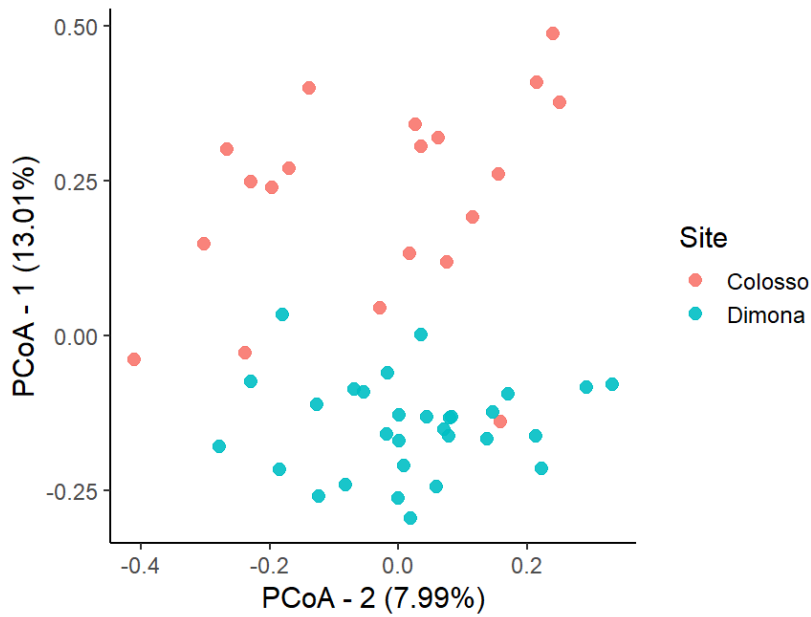
### 318 Forest structure and taxonomic composition of the liana community

319 Following our assessment of the influence of forest structure on liana community  
320 structure, we also investigated if the taxonomic composition of the community could be  
321 associated with or affected by forest structural parameters and distance to the forest edge.

322 For  $\beta$ -diversity, PCoA based on the presence and abundance of all liana species captured  
323 21% of the variation in species composition. The subplots in Dimona were more clustered,  
324 indicating greater similarity in composition. In contrast, in Colosso, the subplots were  
325 dispersed, indicating a species composition difference within this sites (**Fig. 3**).

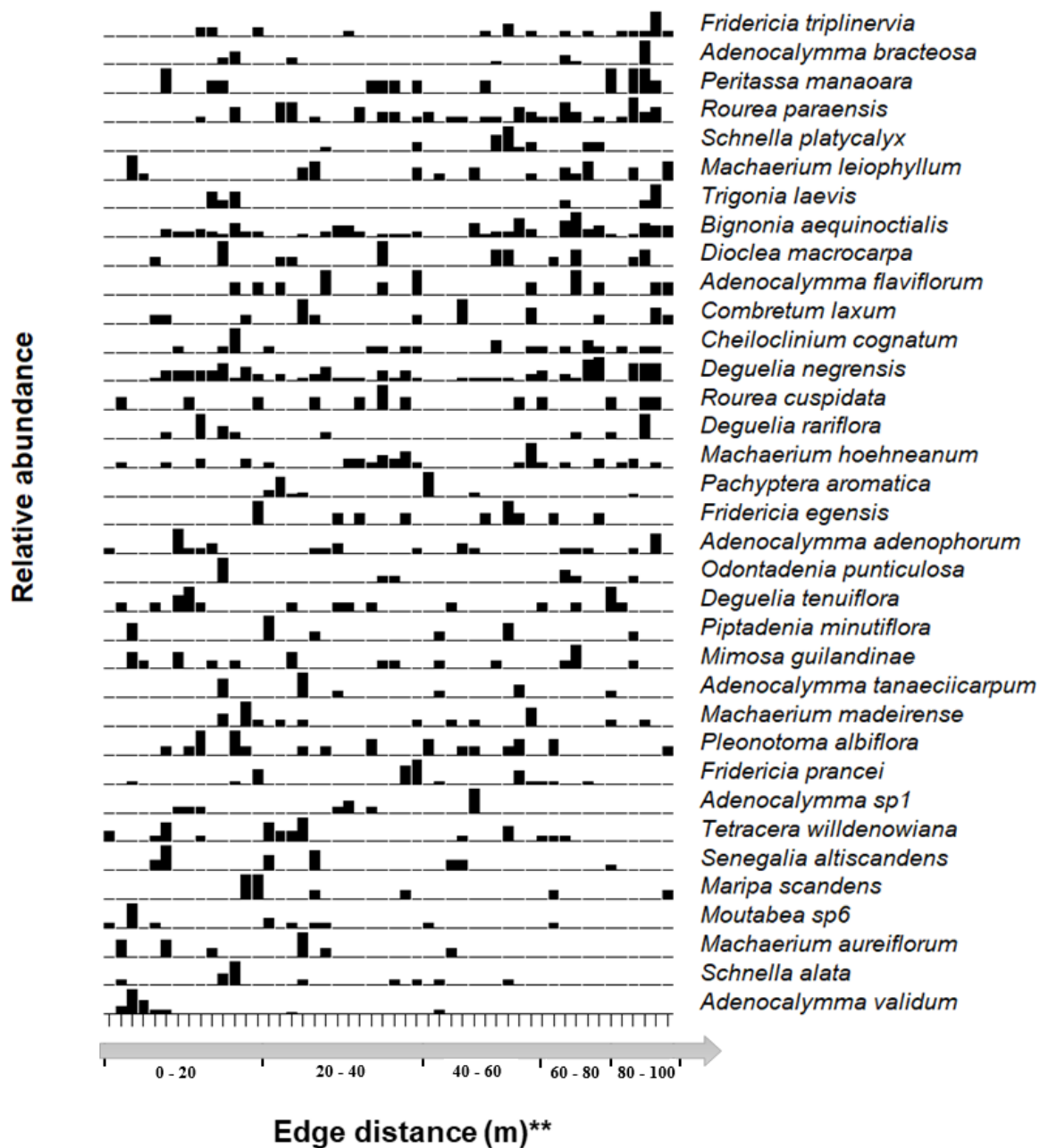
326 The most parsimonious model (model 2 in **Supplementary Table 6**) showed that PCoA  
327 1 is strongly related to the sampling sites (**Fig. 2f**;  $Z = -6.332$ ;  $p < 0.001$ ; **Supplementary**  
328 **Information**). Therefore, the species composition varies significantly across sites. It also varied  
329 significantly along the edge-interior gradient (**Fig. 2c**;  $Z = -2.56$ ;  $p = 0.01$ ). PCoA 2 showed no  
330 significant relationship with the forest's structural parameters.

331 For  $\alpha$  diversity, represented by the diversity of species in the subplots, the most  
332 parsimonious model was the one related only to the canopy PAI (**Fig. 2e**;  $Z = -2.47$ ;  $P = 0.014$ ),  
333 showing a negative relationship, similar to results on the abundance of lianas.



334 **Fig. 3** Principal Coordinate Analysis (PCoA), using Bray-curtis dissimilarity, of liana  
 335 composition community (n= 50) in forest fragments of two sites at BDFFP in Central Amazonia, Brazil.  
 336

337 We directly ordered the species composition to better understand the relationship between  
 338 the abundance of each species and distance to the edge. However, this time, we only included  
 339 species with absolute density  $\geq 5$  ind. ha<sup>-1</sup> (35 spp.), as the distribution and rarity of the other  
 340 species would make any plausible interpretation impossible. The result demonstrated that,  
 341 based on distance to the edge, some species are more common in forest interiors or in forest  
 342 edges within the forest fragment. While the most abundant species, *Bignonia aequinoctialis*,  
 343 *Deguelia negrensis*, and *Rourea paraensis*, were distributed across the entire edge-interior  
 344 gradient, their highest relative abundance is found in the interior of the forest fragments (**Fig.**  
 345 **4**).



346 **Fig. 4** Distribution of liana species, considering only species with absolute density  $\geq 5 \text{ ind. ha}^{-1}$  along  
 347 the gradient of distance from the edge (in m) in the forest fragments at BDFFP in Central Amazonia,  
 348 Brazil. Subplots (n = 50) are 0-20, 20-40, 40-60 and 80-100 m from the forest edge. Vertical bars  
 349 represent the relative abundance of species (0 to 1). \*\* P = 0.01. PCoA 1 ~ distance to the edge  
 350 performed by GLMM

351 **Discussion**

352 In this study, we investigated the effects of forest structure and distance to the forest edge  
353 on the liana community in a fragmented tropical forest. We found that changes in forest  
354 structure arising from forest fragmentation, particularly canopy PAI, strongly influenced the  
355 species composition of lianas. High total PAI values could indicate lower light under the canopy  
356 (Ma et al. 2021), higher understory PAI in the understory (Maeda et al. 2022; **Supplementary**  
357 **Figure 1**), and greater structural complexity of the vegetation, so the restricted occurrence of  
358 some species in these sites could indicate a lower tolerance to shading (Lomwong et al. 2023).

359 However, distance from the edge had a direct or indirect influence, mediated by canopy  
360 PAI, on the liana community's abundance, biomass, and number of species ( $\alpha$  diversity). In  
361 contrast, distance from the edge only influenced composition ( $\beta$  diversity).

362 High diversity and site effect

363 In this study, we evaluated 123 spp. and 49 morphotypes, corresponding to half of the  
364 species and 65% of the families recorded throughout the BDFFP area, even though the area  
365 sampled represents only 4.6% of the entire area inventoried for lianas. In Central Amazonia,  
366 there are few studies with taxonomic identification of lianas, one of them it is Laurance et al.  
367 (2001) research, which founded 82 species, in 2.88 ha. In addition, for a region 80 km away, at  
368 the Ducke Reserve, Rocha et al. (2022) founded 115 species in 18 ha.

369 We found a strong site effect during exploring and analyzing the species composition data  
370 (**Supplementary Information**). This effect has already been described for trees, palms, and  
371 bats in the BDFFP (Laurance et al. 2017). Before forest fragmentation, the sites located to the  
372 East, West, and Central areas of the Conservation Unit already showed differences in species  
373 composition and dynamics, and the successional trajectory after forest fragmentation made  
374 these parameters even more distinct. This process has been attributed to the different matrices  
375 of each site (Laurance et al. 2017). We propose two other possible explanations to understand



376 the divergence in liana composition based on the distribution and dispersal of species by  
377 drainage basins and by different topographic characteristics.

378 The sampling sites are in different hydrographic basins. The drainage of Colosso is via  
379 the rivers Preto da Eva and Urubu (Uatumã basin) while for Dimona drainage is to the Cuieiras  
380 river (Rio Negro basin) (Amazonas 2019; Costa et al. 2023). In the Ducke Reserve (80 km away  
381 from the location of this study), there is also a difference in composition among various  
382 taxonomic groups, mainly trees, shrubs, lianas, birds, frogs, and fish. This difference was  
383 explained by the distributions of these organisms in the different drainage basins, with rare  
384 species or those with a restricted distribution occurring in only one or another drainage basin  
385 (Costa et al. 2008), roughly the same basins as the BDFFP.

386 Another possible explanation raised, but not tested, is the difference in altitude of the  
387 terrains, which may consequently be related to a hydrological, soil texture and fertility  
388 gradient (Schiatti et al. 2014), with Dimona at lower elevation and Colosso at a higher elevation.  
389 For the BDFFP areas, Laurance et al. (2001) found that the abundance of lianas varied with soil  
390 edaphic factors, such as fertility, texture, and slope. In the Ducke Reserve, terrain height above  
391 nearest drainage (HAND) is a compositional descriptor for two of the most representative liana  
392 families: Bignoniaceae and Fabaceae (Schiatti et al. 2014; Gerolamo et al. 2022; Rocha et al.  
393 2022). In the studies mentioned above, *Bignonia aequinoctialis* (Bignoniaceae) was found at  
394 shorter distances from the water table. In our study, around 91% of the *B. aequinoctialis*  
395 occurred in the Dimona reserve. *Adenocalymma validum* (Bignoniaceae) is only present at  
396 Colosso and is found at larger distances from HAND (Gerolamo et al. 2022). This is also true  
397 for *Senegalia altiscandens* (Fabaceae), which has a high abundance in plots at Colosso as  
398 compared to all 43 ha of the BDFFP (Robyn Burnham, unpublished data).

399 Canopy structure and distance to forest edge affect liana community

400 Forest edge creation is one of the crucial factors in understanding the structure and  
401 composition of the liana community in fragmented tropical forests, with direct and indirect  
402 relationships mediated by forest structure altered by forest fragmentation. Edge creation drives  
403 forest structural changes (Maeda et al. 2022), leading to a collapse in tree biomass (Laurance et  
404 al. 2017), as well as changes in microclimate patterns found in forest fragments (Camargo and  
405 Kapos 1995; Nunes et al. 2022). There is evidence that these transformations are persistent and  
406 can be detected even if the process of forest fragmentation occurred decades ago, which is the  
407 case in our study area (Almeida et al. 2019; Maeda et al. 2022).

408 Our study reinforces the negative relationship between the absolute abundance of lianas  
409 and distance from the edge, which has been repeatedly recorded (Laurance et al. 2001; Magrath  
410 et al. 2014; Campbell et al. 2018; Ofosu-Bamfo et al. 2022; Piovesan et al. 2022). However, we  
411 also found that liana abundance is slightly more related to canopy structure than to distance to  
412 edge. Laurance et al. (2001), despite reinforcing the relationship with distance from the edge,  
413 already suggested that the relationship was not as strong as they expected, with tree biomass  
414 and the rate of change of tree biomass being more critical factors in that context, and these  
415 factors are related to the structure of the forest canopy. Considering the changes in forest  
416 structure caused by forest fragmentation and edge creation, the structure of the liana community  
417 seems to be highly influenced by forest structure, and may be less influenced by others effects  
418 mediated by distance to the edge, such microclimate changes (Blanchard et al. 2023).

419 Forest disturbances, such as the opening of clearings and consequent increased light  
420 penetration, can enhance the regrowth capacity of some species (Ledo and Schnitzer 2014;  
421 Rocha et al. 2020). In synergy with the process of forest fragmentation (Almeida et al. 2019),  
422 this could explain the greater abundance of lianas in these regions with less complex canopies,  
423 *i.e.*, more open, and less dense canopies. Lianas would act as gap maintainers and niche

424 constructors (Schnitzer et al. 2021), given that in these regions, there is a higher abundance of  
425 lianas and a higher number of species. The success in increasing the liana's abundance  
426 (Laurance et al. 2014) and density of stems, while potentially spreading intensely and shading  
427 all or part of the tree canopy, reduces the growth rate of trees, keeping the canopy low (Rocha  
428 et al. 2020). In this way, the increased abundance of lianas is influenced by, and influences,  
429 forest structure and tree species composition (Schnitzer et al. 2021).

430         Despite the influence of canopy PAI on the abundance of lianas, when we consider  
431 species composition, this relationship disappears, and only the negative relationship with  
432 distance to edge remains. Thus, the direct effect of distance to edge may be mediated by other  
433 processes not analyzed in this study, such as the microclimatic variations that exist in the  
434 gradient of distance related to the edge (Camargo and Kapos 1995).

435         Edge effects are one of the factors responsible for changes in forest structure after the  
436 death of large trees, and it is also responsible for a decrease in humidity and an increase in  
437 temperature in forest fragments because of physical damage caused by strong winds and  
438 desiccation (Camargo and Kapos 1995). The edge effect can also be exacerbated by the effect  
439 of seasonality on the leaf phenology of canopy trees, reducing canopy vegetation and allowing  
440 higher light penetration into the lower strata, creating an even hotter environment (Nunes et al.  
441 2022).

442         Functional traits related to the ability to tolerate microclimatic variations, such as  
443 variations in soil moisture and temperature, are essential factors in tree distribution, leading to  
444 a shift in forest dynamics (Engelbrecht et al. 2007). As liana species composition varies along  
445 the edge-interior gradient, there may be functional traits that mediate different responses to  
446 microclimatic variations, modulating the occurrence of species. Understanding these responses  
447 will be important to future approaches, especially related to climate change (Vogado et al.

448 2022), increased seasonality due to extreme events such as El Niño, and increased forest  
449 fragmentation.

450 Finally, comparing the results obtained for alpha and beta diversity with another study  
451 carried out in the same area, we found opposite patterns: 22 years ago, there were more  
452 species at the edge, but the composition did not change in the edge-interior gradient  
453 (Laurance et al. 2011). However, it is essential to note that the context of forest fragmentation  
454 at that time differs from what we find now. Although persistent, the effects of the forest  
455 fragmentation process have been attenuated over the years (Almeida et al. 2019), even with the  
456 periodic cutting of the matrix vegetation to maintain the isolation of the forest fragments.

457 Therefore, it is possible that more than four decades after the beginning of the forest  
458 fragmentation process, the fragments have reached a more dynamic equilibrium, with the age  
459 of the edge being an essential factor in the dynamics of the liana community (Laurance et al.  
460 2001).

#### 461 Liana biomass and tree support capacity

462 This work sheds light on the importance of forest structure as an indirect effect of forest  
463 fragmentation on the structure and composition of the liana community. The influence of the  
464 factors analyzed was low for all analyses performed, so other environmental factors may have  
465 a more substantial influence on the liana community.

466 For liana biomass, studies are showing that it is related to edaphic characteristics, such as  
467 soil fertility and texture, and in the second instance, to the rate of change in above-ground tree  
468 biomass (Laurance et al. 2001), which may explain the relationship we found with distance to  
469 the forest edge. For the diversity and distribution of liana species, there is a strong relationship  
470 with the abiotic environmental characteristics, such as topographic gradient, water availability,  
471 and solar radiation, both in tropical forests (Schietti et al. 2014; Gerolamo et al. 2022; Rocha et  
472 al. 2022) and subtropical forests (Li et al. 2022).

473 We expected that the higher availability of thin trees would increase the physical support  
474 capacity for lianas to grow and develop, thus increasing liana abundance and biomass.  
475 However, we were unable to validate this pattern. Van der Heijden and Phillips (2008) found a  
476 positive but weak relationship between the abundance of lianas and the density of thin trees  
477 (DBH  $\geq$  10 cm), and the explanation for this finding was that, at a geographical scale, this  
478 predictor did not seem important, but perhaps locally it could be. In our study, we did not find  
479 this importance even locally.

480 Based on the literature, we concluded that the influence of the availability of physical  
481 support on the abundance and distribution of lianas tends to depend on a topographic gradient  
482 between lowlands and plateaus because of the functional traits of the lianas's stem (Rocha et  
483 al. 2022) and life stage (Nogueira et al. 2011). In addition, the climbing guild is an essential  
484 parameter to analyze because there may be a significant relationship with tree size for the  
485 population of some species whose climbing strategy is based on tendrils and hooks (Laurance  
486 et al. 2001; Campbell et al. 2018; Yang et al. 2018).

487 Lianas are a highly heterogeneous group of organisms that respond differently to forest  
488 fragmentation (Piovesan et al. 2022), have distinct functional and hydraulic traits (Meunier et  
489 al. 2021; Coppieters et al. 2022; Rocha et al. 2022) and growth strategies (Cai et al. 2007), so  
490 detecting community-level relationships is a significant challenge. Studies based on lower  
491 taxonomic levels, such as genus and species, combined with exploring functional traits, are the  
492 most promising path towards a better understanding of the other mechanisms involved in  
493 increasing the density and distribution of liana species.

## 494 **Conclusion**

495 In the context of fragmented forests in Central Amazonia, we tested whether forest  
496 structure affects the structure and composition of the liana community and whether forest

497 structure and distance to the edge have the same effect on lianas. We found that forest structure  
498 was related to species richness and absolute abundance of lianas, with this relationship being  
499 slightly stronger than the distance to edge. Species composition was only influenced by distance  
500 to the edge, suggesting that other processes related to the creation of the edge, such as  
501 microclimatic variation, may influence the distribution of liana species.

502 We conclude that forest structural parameters related to light penetration impact the  
503 absolute abundance of lianas but not their composition. Furthermore, the age of the forest  
504 fragment edge is essential for analyzing aspects of the liana's community. As the forest  
505 fragment ages, it may reach a more dynamic equilibrium. Therefore, the patterns of composition  
506 and richness may shift when compared to younger forest edges and fragments. Meanwhile,  
507 liana abundance seems to increase, not only due to distance to the edge but also due to canopy  
508 of the vegetation affected by forest fragmentation.

509 The effect of the lower density of canopy vegetation on the liana abundance, together  
510 with microclimatic changes and extreme events of regional climatic oscillations, may shift the  
511 composition of the liana species. These changes and oscillations may increase the average  
512 temperature and extend the dry season. The compositional shift of lianas may occur because of  
513 competition between coexisting species and increased species density. Newly added species  
514 with functional traits better adapted to new microclimate conditions, may prevail. The simple  
515 increase in density and dominance of just a few liana species may be far reaching on forest and  
516 ecosystem function. Under this future scenario, our knowledge of the response of lianas is  
517 extremely important to a holistic understanding of the forest dynamics.

518

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525

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### 537 Declarations

538 **Competing interests** The authors have no competing interests to declare that are relevant  
539 to the content of this article

540 **Ethics approval** Ethics approval was not required for this study according to local  
541 legislation

542 **Consent to participate** Not applicable

543 **Consent for publication** Not applicable

544 **Availability of data and material** The datasets used and analyzed during the current  
545 study are available from the corresponding author on reasonable request.

546 **Code availability** study is available from the corresponding author on reasonable request.

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## **Conclusão**

No contexto de florestas fragmentadas na Amazônia Central, testamos se a estrutura da floresta afeta a estrutura e a composição da comunidade de lianas, e se a estrutura da floresta e a distância da borda têm o mesmo efeito sobre as lianas. Constatamos que o índice de vegetação do dossel estava relacionado à riqueza de espécies e à abundância absoluta de lianas, sendo essa relação foi ligeiramente mais forte do que a distância da borda. A composição das espécies foi influenciada apenas pela distância da borda, sugerindo que outros processos relacionados à criação da borda, como a variação microclimática, podem influenciar a distribuição das espécies de lianas.

Concluimos que os parâmetros estruturais da floresta associados à penetração de luz afetam a abundância absoluta de lianas, mas não sua composição. Além disso, a idade da borda do fragmento florestal é um fator essencial para a análise dos aspectos das comunidades de lianas: à medida que o fragmento florestal envelhece, ela pode vir a atingir um maior equilíbrio dinâmico e, portanto, os padrões de composição e riqueza podem mudar quando comparados a bordas e fragmentos florestais mais jovens. Enquanto a abundância de lianas parece aumentar, não apenas devido à distância da borda, mas também devido à vegetação do dossel menos densa afetada pela fragmentação da floresta.

O efeito da menor densidade da vegetação do dossel sobre a abundância de lianas, juntamente com as mudanças microclimáticas e os eventos extremos das oscilações climáticas regionais, pode alterar a composição das espécies de lianas. Essas mudanças e oscilações incluem um aumento na temperatura e uma estação seca mais longa. A mudança na composição das lianas pode ocorrer como resultado da competição entre espécies coexistentes devido ao aumento da densidade de espécies. As espécies recém adicionadas, com características funcionais mais bem adaptadas às novas condições microclimáticas,

podem prevalecer. O simples aumento da densidade, e da dominância de apenas algumas espécies de lianas, pode ter um grande impacto na funcionalidade florestal e ecossistêmica. Nesse cenário futuro, nosso conhecimento sobre a resposta das lianas é extremamente importante para uma compreensão holística da dinâmica da floresta.

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## ANEXO I

### SUPPLEMENTARY INFORMATION

#### **The influence of forest structure on the abundance, biomass, and composition of lianas in tropical forest fragments**

Marinho NT<sup>1,4</sup>, Burnham RJ<sup>2</sup>, Maeda EE<sup>3,6</sup>, Nunes MH<sup>3,7</sup>, Laurance WF<sup>5</sup>, Laurance SG<sup>5</sup>, Andrade AC<sup>4</sup>, Camargo JLC<sup>1,4</sup>

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#### **LiDAR collecting, configurations and processing.**

The LiDAR survey of forest structure was conducted on seven transects installed perpendicular to the edge of the forest fragments by Maeda et al. (2022). Three scan lines were used on each transect to provide a three-dimensional representation of the canopy. In forest fragments larger than 10 ha, the length of each transect was 100 m, and for fragments of 1 ha, the transect was 50 m. The measuring points were spaced every five meters, as the occlusion of dense vegetation in tropical forests could reduce the accuracy of the data acquired (Maeda et al. 2022). Four transects were conducted in the two 1 ha forest fragments, so the transects almost met each other in the center of the hectare.

Given that the equipment has a zenith angle between 30° and 130°, there would be a blind spot above the equipment (130°-180°), so an additional scan was carried out at each measurement point with the scanner tilted 90° from the vertical position, making it possible to scan the hemisphere in each position thoroughly. Therefore, a total of 624 scans were carried out.

The TLS settings used in all the scans were: (1) Vertical and horizontal resolution: 40 mdeg (the angle between the laser beams) so that at a distance of 20 m from the equipment, the points are 14 mm apart. (2) Laser pulse repetition rate: 600 kHz (600 thousand pulses per second), allowing the laser beams to reach up to 350 m, and (3) The beam divergence was 0.35mrad, which is a fixed equipment setting. For further information about these methodologies and data acquisition, see Maeda et al. (2022).

### **Regression models: PCoA, sites and forest structure parameters**

In the process of analyzing the relationship between species composition and forest structure parameters and distance from the edge, we tested models combining random factors (permanent plot, fragment size, and sampling site) with fixed factors following the steps described in the Material and Methods in the body of the article.

The regression models involving the first axis of the PCoA did not fit well, but when we added sampling site as a fixed variable, we obtained a good model fit. The P values previously obtained for forest structure and distance from the edge did not change with the inclusion of this variable, but the R<sup>2</sup> value of the fixed (marginal) factors increased from 6.8% to 78%, and the sites showed a significant relationship with species composition (<0.001). In addition, models with permanent plots or permanent plots and sampling sites as random factors did not change the results, so that the sampling sites were not strong spatial auto-correlation factors for the model.



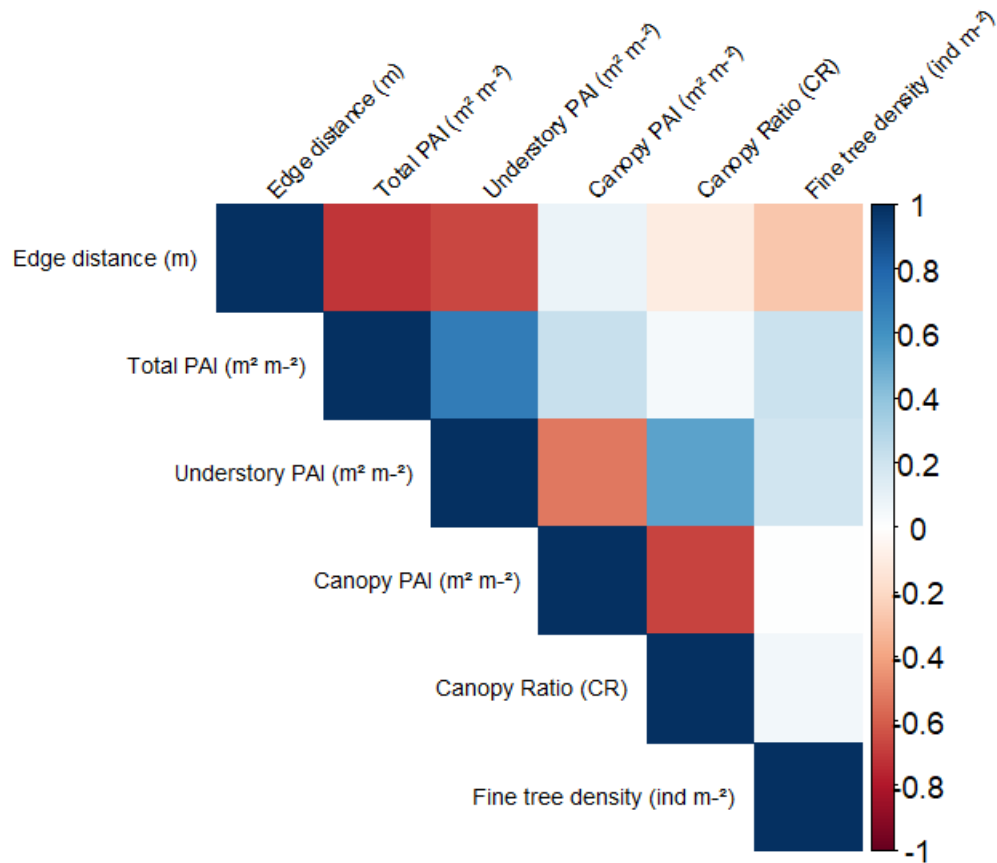
Therefore, to select the model with the best fit and considering the maintenance of the relationships between the variables, we included the sampling site as a fixed variable.

**Regression models: PCoA, sites, and forest structure parameters.**

In the process of analyzing the relationship between species composition and forest structure parameters and distance from the edge, we tested models combining random factors (permanent plot, fragment size, and sampling site) with fixed factors following the steps described in the Material and Methods in the main body of the article.

The regression models involving the first axis of the PCoA did not fit well, but when we added the sampling site as a fixed variable, we obtained a good model fit. The P values previously obtained for forest structure and distance from the edge did not change with the inclusion of this variable. However, the R<sup>2</sup> value of the fixed (marginal) factors increased from 2.4% to 67.3%, and the sites showed a significant relationship with species composition (<0.001). In addition, models with permanent plots or permanent plots and sampling sites as random factors did not change the results, so the sampling sites were not vital spatial auto-correlation factors for the model.

Therefore, we included the sampling site as a fixed variable to select the model with the best fit and consider the maintenance of the relationships between the variables.



**Supplementary Figure 1** Correlogram plot of structure variables (total PAI, understory PAI, canopy PAI, canopy ratio, thinner tree density) and distance to edge. The colors grading means values between -1 and 1; red means negative correlation (-1), blue positive correlation and white no correlation (0). The intensity of color in grading shows if correlation is weak or strong.

**Supplementary Table 1** Proportion of tree stems (10 – 20 cm DBH) in permanent plots of the forest fragments at BDFFP, Central Amazonia.

Reserve (plot)	n. stems ≥ 10 cm	n. stems 10-20 cm	Proportion (%) ± SD
Colosso 1 ha	176	105	59.7 ± 15.7
Colosso 10 ha (2)	196	116	59.2 ± 7.9
Dimona 1 ha	283	171	60.4 ± 7.5
Dimona 100 ha (1)	213	123	57.7 ± 11.8
Dimona 100 ha (3)	240	158	65.8 ± 7.5

<b>Total</b>	<b>1,108</b>	<b>673</b>	<b>60.7</b>
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**Supplementary Table 2** Variance Inflation Factor (VIF) of the fixed variable for models with lianas density and biomass as response variable tested by *performance* package in R.

When  $VIF > 2$ , we excluded and test again until all fixed variables were  $VIF < 2$ .

Response variable	Distance to edge	Total PAI	Canopy PAI	Understory PAI	Thinner tree	CR
Density	2.52	38.13	27.48	52.05	1.17	2.00
	2.51	2.68	2.23	-	1.15	1.99
	1.13	-	1.72	-	1.14	1.68
Biomass	2.59	43.51	30.75	53.61	1.11	2.11
	2.56	2.79	2.53	-	1.09	2.11
	1.09	-	1.85	-	1.85	1.09

**Supplementary Table 3** Model selection results for liana absolute abundance using Generalized linear mixed model (Negative Binomial 2 link log) in 50 subplots (2 ha) at the forest fragments in BDFFP, Central Amazonia. AIC: Akaike Information Criterion.

Response variable	Model	Fixed variables	AIC	$\Delta$ AIC
Absolute abundance	<b>1</b>	<b>Distance to edge + Canopy PAI</b>	<b>358.29</b>	<b>0.00</b>
	2	Distance to edge + Canopy PAI + CR	359.12	0.83
	3	Distance to edge + Canopy PAI + Fine Tree	360.29	2.00
	4	Canopy PAI	360.93	2.64
	5	Distance to edge + CR	360.95	2.65
	6	Distance to edge + Canopy PAI + CR + Fine Tree	361.12	2.83
	7	Canopy PAI + CR	361.78	3.49
	8	Canopy PAI + Fine Tree	362.32	4.02
	9	Distance to edge + CR + Fine Tree	362.90	4.61
	10	Canopy PAI + CR + Fine Tree	363.20	4.91
	11	1	363.71	5.42
	12	CR + Fine Tree	365.44	7.15
	13	Distance to edge	366.88	8.58
	14	Distance to edge + Fine Tree	368.68	10.39
	15	Fine Tree	369.78	11.49
	16	CR	371.69	13.40

Forest fragment size was the random factor for all models.

**Supplementary Table 4** Model selection results for liana biomass using a Generalized linear model (Gamma link log)-in 50 subplots (2 ha) at the forest fragments in BDFFP, Central Amazonia. AIC: Akaike Information Criterion.

<b>Response variable</b>	<b>Model</b>	<b>Fixed variables</b>	<b>AIC</b>	<b><math>\Delta</math> AIC</b>
Biomass	<b>1</b>	<b>Distance to edge</b>	<b>704.79</b>	<b>0.00</b>
	2	Distance to edge + Canopy PAI	704.98	0.19
	3	Distance to edge + Thinner Tree	705.97	1.18
	4	Distance to edge + Canopy PAI + Thinner Tree	706.20	1.41
	5	Distance to edge + Canopy PAI + CR	706.52	1.73
	6	Distance to edge + CR	706.53	1.74
	7	Distance to edge + CR + Fine Tree	707.61	2.82
	8	Distance to edge + Canopy PAI + CR + Thinner Tree	707.90	3.11
	9	Canopy PAI + CR	708.26	3.47
	10	Canopy PAI + Thinner Tree	708.26	3.47
	11	1	708.44	3.65
	12	CR + Thinner Tree	709.57	4.78
	13	Canopy PAI	710.23	5.45
	14	CR	710.43	5.64
	15	Thinner Tree	711.51	6.73
	16	Canopy PAI + CR + Thinner Tree	712.20	7.41

**Supplementary Table 5** The most parsimonious generalized linear mixed model (negative binominal link log) and generalized linear model (gamma link log) for the influence of forest structure on liana abundance and biomass in subplots (40 x 40 m). The significant p-value is in bold. GLMM: Generalized Linear Mixed Model; GLM: Generalized Linear Model; AIC: Akaike Information Criterion.

<b>Response variable (marginal r<sup>2</sup>)</b>	<b>AIC</b>		<b>Estimate</b>	<b>SE</b>	<b>Z value</b>	<b>p</b>
GLMM abundance (11,1%)	103.8	(Intercept)	5.7096	1.282	4.452	<b>&lt;0.001</b>
		Total PAI	-0.0865	0.104	-0.834	0.404
		Canopy PAI	-0.0732	0.113	-0.645	0.519
		Thinner tree dens.	0.0022	0.009	0.247	0.805
<b>Response variable (r<sup>2</sup>)</b>			<b>Estimate</b>	<b>SE</b>	<b>t value</b>	<b>p</b>
GLM Biomass (7%)	163.80	(Intercept)	0.0044	0.002	2.653	<b>0.045</b>
		Total PAI	0.0000	0.000	0.092	0.930
		Canopy PAI	-0.0002	0.000	-1.384	0.225
		CR	-0.0060	0.003	-1.970	0.106
		Thinner tree dens.	0.0000	0.000	1.625	0.165

**Supplementary Table 6** Model selection results for liana composition (PCoA 1 –  $\beta$  diversity) using a Generalized linear mixed model (Gaussian link identity) in 50 subplots (2 ha) at the forest fragments in BDFFP, Central Amazonia. AIC: Akaike Information Criterion.

Response variable	Model	Fixed variables	AIC	$\Delta$ AIC
PCoA 1	1	Site + Edge distance + Canopy PAI + CR + Thinner Tree	-77.52	0.00
	2	<b>Site + Edge distance</b>	<b>-76.77</b>	<b>0.75</b>
	3	Site + Edge distance + Canopy PAI + CR	-76.33	1.20
	4	Site + edge distance + Canopy PAI	-74.84	2.68
	5	Site + CR	-73.21	4.31
	6	Site	-72.54	4.98
	7	Site + Canopy PAI + CR	-72.05	5.47
	8	Site + Thinner Tree	-71.17	6.35
	9	Site + Canopy PAI	-70.66	6.86
	10	Site + Canopy PAI	-70.66	6.86
	11	Site + Canopy PAI + CR + Thinner Tree	-70.51	7.01
	12	Edge distance + Thinner Tree	-68.89	8.63
	13	Edge distance + Canopy PAI + CR + Thinner Tree	-68.10	9.43
	14	Edge distance	-67.75	9.77
	15	Edge distance + CR	-67.54	9.98
	16	Edge distance + Canopy PAI + CR	-67.21	10.32
	17	Edge distance + Canopy PAI	-65.77	11.75
	18	1	-64.37	13.16
	19	Canopy PAI + CR	-63.58	13.94
	20	CR	-63.03	14.49
	21	Thinner Tree	-63.03	14.49
	22	CR + Thinner Tree	-62.58	14.94
	23	Canopy PAI	-62.37	15.16
	24	Canopy PAI + CR + Thinner Tree	-62.09	15.44
	25	Canopy PAI + Thinner Tree	-61.06	16.47

Permanent plot was the random factor for all models.

**Supplementary Table 7** Floristic list and absolute abundance of liana species recorded in the forest fragments (Colosso and Dimona sites) of the BDFFP in Central Amazonia, Brazil, see map (Fig 1) in the main text, detailing the location of the two sampling sites.

<b>Family/Species</b>	<b>Colosso</b>	<b>Dimona</b>
<b>Acanthaceae</b>	<b>1</b>	
<i>Mendoncia hoffmannseggiana</i> Nees	1	
<b>Annonaceae</b>	<b>1</b>	
<i>Annona</i> sp. 1	1	
<b>Apocynaceae</b>	<b>12</b>	<b>21</b>
<i>Forsteronia acouci</i> (Aubl.) A.DC.	1	
<i>Forsteronia duckei</i> Markgr.	1	
<i>Forsteronia manausana</i> B.F.Hansen		2
<i>Forsteronia</i> sp. 1		1
<i>Forsteronia</i> sp. 2	1	3
<i>Odontadenia puncticulosa</i> (Rich.) Pulle		10
<i>Odontadenia</i> sp. 1	5	3
<i>Odontadenia</i> sp. 3	3	
<i>Odontadenia</i> sp. 4	1	
<i>Odontadenia verrucosa</i> (Willd. ex Roem. & Schult.) K.Schum. ex Markgr.		2
<b>Bignoniaceae</b>	<b>120</b>	<b>288</b>
<i>Adenocalymma adenophorum</i> (Sandwith) L.G.Lohmann	5	21
<i>Adenocalymma albiflorum</i> (Salzm. ex DC.) B.M. Gomes & L.H. Fonseca	8	15
<i>Adenocalymma bracteosum</i> (DC.) L.G.Lohmann	2	19
<i>Adenocalymma flaviflorum</i> (Miq.) L.G.Lohmann	3	11
<i>Adenocalymma impressum</i> (Rusby) Sandwith	1	4
<i>Adenocalymma longilineum</i> (A.Samp.) L.G.Lohmann	1	2
<i>Adenocalymma moringifolium</i> (DC.) L.G.Lohmann	1	6
<i>Adenocalymma</i> sp. 1		11
<i>Adenocalymma</i> sp. 2		1
<i>Adenocalymma subincanum</i> Huber	4	
<i>Adenocalymma tanaeciicarpum</i> (A.H.Gentry) L.G.Lohmann	6	6
<i>Adenocalymma validum</i> L.G.Lohmann	30	
<i>Amphilophium magnoliifolium</i> (Kunth) L.G.Lohmann		1
<i>Amphilophium parkeri</i> (DC.) L.G.Lohmann	5	
<i>Amphilophium pulverulentum</i> (Sandwith) L.G.Lohmann		4
<i>Amphilophium trailii</i>		1
<i>Anemopaegma oligoneuron</i> (Sprague & Sandwith) A.H.Gentry		3
<i>Anemopaegma robustum</i> Bureau & K.Schum.		2
<i>Anemopaegma</i> sp. 1		2
<i>Bignonia aequinoctialis</i> L.	7	90
<i>Callichlamys latifolia</i> (Rich.) K.Schum.	3	
<i>Fridericia chica</i> (Bonpl.) L.G.Lohmann		3
<i>Fridericia cinnamomea</i> (DC.) L.G.Lohmann	1	1
<i>Fridericia egenis</i> (Bureau & K.Schum.) L.G.Lohmann	1	10

<i>Fridericia nigrescens</i> (Sandwith) L.G.Lohmann	1	
<i>Fridericia prancei</i> (A.H.Gentry) L.G.Lohmann	4	41
<i>Fridericia trailii</i> (Sprague) L.G.Lohmann		6
<i>Fridericia triplinervia</i> (Mart. ex DC.) L.G.Lohmann	1	23
<i>Macfadyena</i> sp. 1		1
<i>Martinella iquitoensis</i> A.Samp.		1
<i>Pachyptera aromatica</i> (Barb.Rodr.) L.G.Lohmann	29	3
<i>Tynanthus panurensis</i> (Bureau) Sandwith	7	
<b>Celastraceae</b>	<b>24</b>	<b>55</b>
<i>Anthodon</i> sp. 1	1	6
<i>Anthodon</i> sp. 2	3	
<i>Cheiloclinium belizense</i> (Standl.) A.C. Sm.	2	3
<i>Cheiloclinium cognatum</i> (Miers) A.C.Sm.	3	19
<i>Cheiloclinium gleasonianum</i> (A.C. Sm.) A.C. Sm.		2
<i>Cheiloclinium hippocrateoides</i> (Peyr.) A.C.Sm.	2	1
<i>Peritassa glabra</i> (A.C. Sm.) Lombardi		1
<i>Peritassa manaoara</i> Lombardi	4	12
<i>Prionostemma asperum</i> (Lam.) Miers	4	3
<i>Pristimera tenuiflora</i> (Mart. ex Peyr.) A.C. Sm.	2	4
<i>Salacia impressifolia</i> (Miers) A.C. Sm.		1
<i>Salacia insignis</i> A.C. Sm.	1	
<i>Salacia multiflora</i> subsp. <i>mucronata</i> (Rusby) Mennega	1	
<i>Tontelea mauritioides</i> (A.C. Sm.) A.C. Sm.	1	3
<b>Combretaceae</b>	<b>9</b>	<b>8</b>
<i>Combretum laxum</i> Jacq.	9	8
<b>Connaraceae</b>	<b>23</b>	<b>50</b>
<i>Pseudoconnarus macrophyllus</i> (Poepp.) Radlk.		2
<i>Rourea amazonica</i> (Baker) Radlk.	3	
<i>Rourea cuspidata</i> Benth. ex Baker	4	9
<i>Rourea krukovii</i> Steyerem.		3
<i>Rourea paraensis</i> Forero	16	36
<b>Convolvulaceae</b>	<b>3</b>	<b>13</b>
<i>Dicranostyles densa</i> Spruce ex Meisn.		2
<i>Dicranostyles laxa</i> Ducke		1
<i>Maripa glabra</i> Choisy	1	2
<i>Maripa scandens</i> Aubl.	2	8
<b>Dichapetalaceae</b>	<b>1</b>	<b>1</b>
<i>Dichapetalum rugosum</i> (Vahl) Prance	1	
<i>Dichapetalum</i> sp. 1		1
<b>Dilleniaceae</b>	<b>27</b>	<b>12</b>
<i>Davilla rugosa</i> Poir.	1	
<i>Doliocarpus magnificus</i> Sleumer	1	
<i>Doliocarpus spraguei</i> Cheeseman	2	3
<i>Tetracera amazonica</i> Kubitzki		4
<i>Tetracera willdenowiana</i> Steud.	23	5
<b>Fabaceae</b>	<b>116</b>	<b>247</b>
<i>Bauhinia</i> sp. 2		6
<i>Bauhinia</i> sp. 4		1



<i>Clitoria leptostachya</i> Benth.	1	
<i>Clitoria</i> sp. 1	1	
<i>Deguelia amazonica</i> Killip	1	
<i>Deguelia negrensis</i> (Benth.) Taub.	17	72
<i>Deguelia rariflora</i> (Mart. ex Benth.) G.P.Lewis & Acev.-Rodr.	3	12
<i>Deguelia tenuiflora</i> R.A. Camargo, R.J. Burnham & V.F. Mansano	9	10
<i>Derris floribunda</i> (Miq.) Benth.	1	
<i>Dioclea</i> sp. 1	1	
<i>Machaerium aureiflorum</i> Ducke	9	1
<i>Machaerium ferox</i> (Mart. ex Benth.) Ducke	4	3
<i>Machaerium hoehneanum</i> Ducke	5	32
<i>Machaerium latifolium</i> Rusby	4	13
<i>Machaerium leiophyllum</i> (DC.) Benth.	11	16
<i>Machaerium macrophyllum</i> Benth.	3	5
<i>Machaerium myrianthum</i> Spruce ex Benth.		1
<i>Machaerium quinata</i> (Aubl.) Sandwith		4
<i>Machaerium</i> sp. 1		1
<i>Macropsychanthus macrocarpus</i> (Huber) L.P.Queiroz & Snak	4	15
<i>Mimosa guilandinae</i> (DC.) Barneby	6	12
<i>Mimosa guilandinae</i> var. <i>extensissima</i> (Ducke) Barneby		9
<i>Piptadenia uaupensis</i> Spruce ex Benth.	7	3
<i>Schnella alata</i> (Ducke) Wunderlin	3	9
<i>Schnella guianensis</i> (Aubl.) Wunderlin		3
<i>Schnella platycalyx</i> (Benth.) Wunderlin	1	19
<i>Schnella</i> sp. 1	5	
<i>Schnella</i> sp. 2	1	
<i>Senegalia altiscandens</i> (Ducke) Seigler & Ebinger	19	
<b>Gnetaceae</b>	<b>2</b>	<b>7</b>
<i>Gnetum nodiflorum</i> Brongn.	2	7
<b>Hernandiaceae</b>	<b>1</b>	
<i>Sparattanthelium acreanum</i> Pilg.	1	
<b>Icacinaceae</b>	<b>1</b>	<b>6</b>
<i>Casimirella rupestris</i> (Ducke) R.A.Howard		2
<i>Pleurisanthes parviflora</i> (Ducke) Howard	1	4
<b>Loganiaceae</b>	<b>9</b>	<b>11</b>
<i>Strychnos asperula</i> Sprague & Sandwith	2	1
<i>Strychnos glabra</i> Sagot ex Progel	1	
<i>Strychnos jobertiana</i> Baill.	2	3
<i>Strychnos mitscherlichii</i> M.R.Schomb.	1	2
<i>Strychnos parviflora</i> Spruce ex Benth.		2
<i>Strychnos parvifolia</i> A.DC.	1	
<i>Strychnos</i> sp. 1		1
<i>Strychnos</i> sp. 2		2
<i>Strychnos</i> sp. 3	2	
<b>Malpighiaceae</b>	<b>2</b>	<b>11</b>
<i>Bronwenia wurdackii</i> (B.Gates) W.R.Anderson & C.C.Davis	1	
<i>Dicella conwayi</i> Rusby	1	
<i>Heteropterys</i> sp. 1		2

<i>Hiraea reclinata</i> Jacq.		3
<i>Hiraea villosa</i> Poepp. ex Nied.		1
<i>Mezia includens</i> (Benth.) Cuatrec.		3
<i>Mezia mariposa</i> W.R.Anderson		2
<b>Menispermaceae</b>	<b>5</b>	<b>28</b>
<i>Abuta grandifolia</i> (Mart.) Sandwith		1
<i>Abuta grisebachii</i> Triana & Planch.		1
<i>Abuta panurensis</i> Eichler		2
<i>Abuta rufescens</i> Aubl.	3	3
<i>Abuta velutina</i> Gleason		9
<i>Curarea tecunarium</i> Barneby & Krukoff	1	3
<i>Telitoxicum krukovii</i> Moldenke		6
<i>Telitoxicum minutiflorum</i> (Diels) Moldenke	1	3
<b>Olacaceae</b>	<b>1</b>	
<i>Heisteria scandens</i> Ducke	1	
<b>Passifloraceae</b>	<b>2</b>	<b>1</b>
<i>Dilkea johannesii</i> Barb.Rodr.	1	
<i>Dilkea retusa</i> Mast.	1	
<i>Passiflora ernestii</i> Harms		1
<b>Polygalaceae</b>	<b>14</b>	<b>14</b>
<i>Diclidanthera penduliflora</i> Mart.		1
<i>Moutabea</i> sp. 1		1
<i>Moutabea</i> sp. 2		2
<i>Moutabea</i> sp. 3		3
<i>Moutabea</i> sp. 5		1
<i>Moutabea</i> sp. 6	14	
<i>Moutabea</i> sp. 7		1
<i>Moutabea</i> sp. 8		3
<i>Moutabea</i> sp. 9		2
<b>Polygonaceae</b>	<b>6</b>	<b>8</b>
<i>Coccoloba</i> sp. 1		1
<i>Coccoloba</i> sp. 2		1
<i>Coccoloba</i> sp. 3		1
<i>Coccoloba</i> sp. 4		1
<i>Coccoloba</i> sp. 5		2
<i>Coccoloba</i> sp. 6		1
<i>Coccoloba</i> sp. 7	1	1
<i>Coccoloba</i> sp. 9	5	
<b>Rhamnaceae</b>	<b>3</b>	
<i>Ampelozizyphus amazonicus</i> Ducke	3	
<b>Rubiaceae</b>	<b>1</b>	
<i>Manettia</i> sp. 1	1	
<b>Sapindaceae</b>	<b>1</b>	<b>10</b>
<i>Paullinia clavigera</i> Schtdl.		1
<i>Paullinia ingifolia</i> Rich. ex Juss.		2
<i>Paullinia</i> sp. 1		1
<i>Paullinia</i> sp. 5	1	
<i>Paullinia</i> sp. 6		2

<i>Paullinia</i> sp. 7		2
<i>Serjania paucidentata</i> DC.		2
<b>Trigoniaceae</b>	<b>3</b>	<b>15</b>
<i>Trigonia laevis</i> Aubl.		10
<i>Trigonia</i> sp. 1	1	
<i>Trigonia</i> sp. 2	1	
<i>Trigonia</i> sp. 3	1	
<i>Trigonia spruceana</i> Benth. ex Warm.		5
<b>Verbenaceae</b>	<b>1</b>	<b>1</b>
<i>Aegiphila</i> sp. 1	1	
<i>Petrea bracteata</i> Steud.		1

**Supplementary Table 8** Phytosociological parameters of the lianas genus recorded in the forest fragments (n = 50; 2 ha) of the BDFFP in Central Amazonia, Brazil. Decreasing order of absolute density, and genus with absolute density  $\geq 35.5$  ind. ha<sup>-1</sup> are in bold. AF: absolute frequency; RF: relative frequency; AD: absolute density; RD: relative density.

Genus	Abundance	Sub-plot	AF	RF (%)	AD (ind.ha <sup>-1</sup> )	RD (%)
<i>Adenocalymma</i>	<b>157</b>	<b>45</b>	<b>0.9</b>	<b>7.92</b>	<b>78.5</b>	<b>13.06</b>
<i>Deguelia</i>	<b>124</b>	<b>41</b>	<b>0.82</b>	<b>7.22</b>	<b>62.0</b>	<b>10.32</b>
<i>Machaerium</i>	<b>112</b>	<b>43</b>	<b>0.86</b>	<b>7.57</b>	<b>56.0</b>	<b>9.32</b>
<i>Bignonia</i>	<b>97</b>	<b>33</b>	<b>0.66</b>	<b>5.81</b>	<b>48.5</b>	<b>8.07</b>
<i>Fridericia</i>	<b>92</b>	<b>26</b>	<b>0.52</b>	<b>4.58</b>	<b>46.0</b>	<b>7.65</b>
<i>Rourea</i>	<b>71</b>	<b>30</b>	<b>0.6</b>	<b>5.28</b>	<b>35.5</b>	<b>5.91</b>
<i>Schnella</i>	41	19	0.38	3.35	20.5	3.41
<i>Cheilochlinium</i>	32	23	0.46	4.05	16.0	2.66
<i>Tetracera</i>	32	15	0.3	2.64	16.0	2.66
<i>Pachyptera</i>	32	7	0.14	1.23	16.0	2.66
<i>Mimosa</i>	27	18	0.36	3.17	13.5	2.25
<i>Moutabea</i>	27	17	0.34	2.99	13.5	2.25
<i>Odontadenia</i>	24	16	0.32	2.82	12.0	2.00
<i>Strychnos</i>	20	16	0.32	2.82	10.0	1.66
<i>Abuta</i>	19	13	0.26	2.29	9.5	1.58
<i>Macropsychanthus</i>	19	11	0.22	1.94	9.5	1.58
<i>Senegalia</i>	19	7	0.14	1.23	9.5	1.58
<i>Trigonia</i>	18	9	0.14	1.23	9.0	1.50
<i>Peritassa</i>	17	12	0.24	2.11	8.5	1.41
<i>Combretum</i>	17	11	0.22	1.94	8.5	1.41
<i>Coccoloba</i>	14	12	0.24	2.11	7.0	1.16
<i>Maripa</i>	13	8	0.16	1.41	6.5	1.08
<i>Forsteronia</i>	12	9	0.18	1.58	6.0	1.00
<i>Amphilophium</i>	11	5	0.1	0.88	5.5	0.92
<i>Anthodon</i>	10	7	0.14	1.23	5.0	0.83

<i>Telotoxicum</i>	10	7	0.14	1.23	5.0	0.83
<i>Piptadenia</i>	10	6	0.12	1.06	5.0	0.83
<i>Paullinia</i>	9	7	0.14	1.23	4.5	0.75
<i>Gnetum</i>	9	6	0.12	1.06	4.5	0.75
<i>Prionostemma</i>	7	6	0.12	1.06	3.5	0.58
<i>Anemopaegma</i>	7	5	0.1	0.88	3.5	0.58
<i>Bauhinia</i>	7	4	0.08	0.70	3.5	0.58
<i>Tynanthus</i>	7	4	0.08	0.70	3.5	0.58
<i>Doliocarpus</i>	6	6	0.12	1.06	3.0	0.50
<i>Pristimera</i>	6	5	0.1	0.88	3.0	0.50
<i>Pleurisanthes</i>	5	5	0.1	0.88	2.5	0.42
<i>Mezia</i>	5	4	0.08	0.70	2.5	0.42
<i>Tontelea</i>	5	3	0.06	0.53	2.5	0.42
<i>Curarea</i>	4	4	0.08	0.70	2.0	0.33
<i>Hiraea</i>	4	3	0.06	0.53	2.0	0.33
<i>Ampelozizyphus</i>	3	3	0.06	0.53	1.5	0.25
<i>Callichlamys</i>	3	3	0.06	0.53	1.5	0.25
<i>Dicranostyles</i>	3	3	0.06	0.53	1.5	0.25
<i>Salacia</i>	3	3	0.06	0.53	1.5	0.25
<i>Casimirella</i>	2	2	0.04	0.35	1.0	0.17
<i>Clitoria</i>	2	2	0.04	0.35	1.0	0.17
<i>Condylocarpon</i>	2	2	0.04	0.35	1.0	0.17
<i>Dichapetalum</i>	2	2	0.04	0.35	1.0	0.17
<i>Dilkea</i>	2	2	0.04	0.35	1.0	0.17
<i>Pseudoconmarus</i>	2	2	0.04	0.35	1.0	0.17
<i>Heteropterys</i>	2	1	0.02	0.18	1.0	0.17
<i>Serjania</i>	2	1	0.02	0.18	1.0	0.17
<i>Aegiphila</i>	1	1	0.02	0.18	0.5	0.08
<i>Annona</i>	1	1	0.02	0.18	0.5	0.08
<i>Bronwenia</i>	1	1	0.02	0.18	0.5	0.08
<i>Davilla</i>	1	1	0.02	0.18	0.5	0.08
<i>Derris</i>	1	1	0.02	0.18	0.5	0.08
<i>Dicella</i>	1	1	0.02	0.18	0.5	0.08
<i>Diclidanthera</i>	1	1	0.02	0.18	0.5	0.08
<i>Dioclea</i>	1	1	0.02	0.18	0.5	0.08
<i>Heisteria</i>	1	1	0.02	0.18	0.5	0.08
<i>Macfadyena</i>	1	1	0.02	0.18	0.5	0.08
<i>Manettia</i>	1	1	0.02	0.18	0.5	0.08
<i>Martinella</i>	1	1	0.02	0.18	0.5	0.08
<i>Mendoncia</i>	1	1	0.02	0.18	0.5	0.08
<i>Passiflora</i>	1	1	0.02	0.18	0.5	0.08
<i>Petrea</i>	1	1	0.02	0.18	0.5	0.08
<i>Sparattanthelium</i>	1	1	0.02	0.18	0.5	0.08
<b>TOTAL</b>	<b>1,202</b>	<b>50</b>	<b>11.36</b>	<b>100.00</b>	<b>601.00</b>	<b>100</b>

**Supplementary Table 9** Phytosociological parameters of the species and morphotypes of lianas recorded in the forest fragments (n = 50; 2 ha) of the BDFFP in Central Amazonia, Brazil. Decreasing order of absolute density, and species with absolute density  $\geq 5$  *ind. ha*<sup>-1</sup> are in bold. AF: absolute frequency; RF: relative frequency; AD: absolute density; RD: relative density.

Species	Abundance	Sub-plot	AF	RF (%)	AD ( <i>ind. ha</i> <sup>-1</sup> )	RD (%)
<i>Bignonia aequinocialis</i>	97	33	0.66	4.7	<b>48.50</b>	<b>8.07</b>
<i>Deguelia negrensis</i>	89	35	0.70	5.0	<b>44.50</b>	<b>7.40</b>
<i>Rourea paraensis</i>	52	25	0.50	3.6	<b>26.00</b>	<b>4.33</b>
<i>Fridericia prancei</i>	45	11	0.22	1.6	<b>22.50</b>	<b>3.74</b>
<i>Machaerium hoehneanum</i>	37	20	0.40	2.8	<b>18.50</b>	<b>3.08</b>
<i>Pachyptera aromatica</i>	32	7	0.14	1.0	<b>16.00</b>	<b>2.66</b>
<i>Adenocalymma validum</i>	30	7	0.14	1.0	<b>15.00</b>	<b>2.50</b>
<i>Tetracera willdenowiana</i>	28	13	0.26	1.9	<b>14.00</b>	<b>2.33</b>
<i>Machaerium leiophyllum</i>	27	13	0.26	1.9	<b>13.50</b>	<b>2.25</b>
<i>Adenocalymma adenophorum</i>	26	16	0.32	2.3	<b>13.00</b>	<b>2.16</b>
<i>Fridericia triplinervia</i>	24	14	0.28	2.0	<b>12.00</b>	<b>2.00</b>
<i>Pleonotoma albiflora</i>	23	15	0.30	2.1	<b>11.50</b>	<b>1.91</b>
<i>Cheiloclinium cognatum</i>	22	17	0.34	2.4	<b>11.00</b>	<b>1.83</b>
<i>Adenocalymma bracteosa</i>	21	7	0.14	1.0	<b>10.50</b>	<b>1.75</b>
<i>Schnella platycalyx</i>	20	8	0.16	1.1	<b>10.00</b>	<b>1.66</b>
<i>Deguelia tenuiflora</i>	19	14	0.28	2.0	<b>9.50</b>	<b>1.58</b>
<i>Dioclea macrocarpa</i>	19	11	0.22	1.6	<b>9.50</b>	<b>1.58</b>
<i>Senegalia altiscandens</i>	19	7	0.14	1.0	<b>9.50</b>	<b>1.58</b>
<i>Mimosa guilandinae</i>	18	13	0.26	1.9	<b>9.00</b>	<b>1.50</b>
<i>Combretum laxum</i>	17	11	0.22	1.6	<b>8.50</b>	<b>1.41</b>
<i>Machaerium madeirense</i>	17	11	0.22	1.6	<b>8.50</b>	<b>1.41</b>
<i>Peritassa manaoara</i>	16	12	0.24	1.7	<b>8.00</b>	<b>1.33</b>
<i>Deguelia rariflora</i>	15	8	0.16	1.1	<b>7.50</b>	<b>1.25</b>
<i>Adenocalymma flaviflorum</i>	14	11	0.22	1.6	<b>7.00</b>	<b>1.16</b>
<i>Moutabea</i> sp. 6	14	9	0.18	1.3	<b>7.00</b>	<b>1.16</b>
<i>Rourea cuspidata</i>	13	12	0.24	1.7	<b>6.50</b>	<b>1.08</b>
<i>Adenocalymma tanaeciicarpum</i>	12	6	0.12	0.9	<b>6.00</b>	<b>1.00</b>
<i>Schnella alata</i>	12	8	0.16	1.1	<b>6.00</b>	<b>1.00</b>
<i>Adenocalymma</i> sp. 1	11	7	0.14	1.0	<b>5.50</b>	<b>0.92</b>
<i>Fridericia egensis</i>	11	9	0.18	1.3	<b>5.50</b>	<b>0.92</b>
<i>Machaerium aureiflorum</i>	10	6	0.12	0.9	<b>5.00</b>	<b>0.83</b>
<i>Maripa scandens</i>	10	6	0.12	0.9	<b>5.00</b>	<b>0.83</b>
<i>Odontadenia puniculosa</i>	10	6	0.12	0.9	<b>5.00</b>	<b>0.83</b>
<i>Piptadenia minutiflora</i>	10	6	0.12	0.9	<b>5.00</b>	<b>0.83</b>

<b><i>Trigonía laevis</i></b>	<b>10</b>	<b>6</b>	<b>0.12</b>	<b>0.9</b>	<b>5.00</b>	<b>0.83</b>
<i>Abuta velutina</i>	9	7	0.14	1.0	4.50	0.75
<i>Gnetum nodiflorum</i>	9	6	0.12	0.9	4.50	0.75
<i>Mimosa guilandinae</i> v. <i>extensissima</i>	9	5	0.10	0.7	4.50	0.75
<i>Machaerium macrophyllum</i>	8	5	0.10	0.7	4.00	0.67
<i>Odontadenia</i> sp. 1	8	7	0.14	1.0	4.00	0.67
<i>Adenocalymma moringifolium</i>	7	5	0.10	0.7	3.50	0.58
<i>Anthodon</i> sp. 1	7	4	0.08	0.6	3.50	0.58
<i>Machaerium ferox</i>	7	7	0.14	1.0	3.50	0.58
<i>Prionostemma aspera</i>	7	6	0.12	0.9	3.50	0.58
<i>Tynanthus panurensis</i>	7	4	0.08	0.6	3.50	0.58
<i>Abuta rufescens</i>	6	6	0.12	0.9	3.00	0.50
<i>Bauhinia</i> sp. 2	6	4	0.08	0.6	3.00	0.50
<i>Fridericia trailii</i>	6	3	0.06	0.4	3.00	0.50
<i>Pristimera tenuifolia</i>	6	5	0.10	0.7	3.00	0.50
<i>Telitoxicum krukovii</i>	6	4	0.08	0.6	3.00	0.50
<i>Adenocalymma impressum</i>	5	2	0.04	0.3	2.50	0.42
<i>Amphilophium parkeri</i>	5	2	0.04	0.3	2.50	0.42
<i>Cheiloclinium belizense</i>	5	5	0.10	0.7	2.50	0.42
<i>Coccoloba</i> sp. 9	5	5	0.10	0.7	2.50	0.42
<i>Doliocarpus spraguei</i>	5	5	0.10	0.7	2.50	0.42
<i>Pleurisanthes parviflora</i>	5	5	0.10	0.7	2.50	0.42
<i>Schnella</i> sp. 1	5	4	0.08	0.6	2.50	0.42
<i>Trigonía spruceana</i>	5	2	0.04	0.3	2.50	0.42
<i>Adenocalymma subincanum</i>	4	3	0.06	0.4	2.00	0.33
<i>Amphilophium pulverulentum</i>	4	1	0.02	0.1	2.00	0.33
<i>Curarea tecunarium</i>	4	4	0.08	0.6	2.00	0.33
<i>Forsteronia</i> sp. 2	4	2	0.04	0.3	2.00	0.33
<i>Machaerium quinata</i>	4	4	0.08	0.6	2.00	0.33
<i>Strychnos jobertiana</i>	4	3	0.06	0.4	2.00	0.33
<i>Telitoxicum minutiflorum</i>	4	4	0.08	0.6	2.00	0.33
<i>Tetracera amazonica</i>	4	2	0.04	0.3	2.00	0.33
<i>Tontelea mauritioides</i>	4	2	0.04	0.3	2.00	0.33
<i>Adenocalymma longilineum</i>	3	2	0.04	0.3	1.50	0.25
<i>Ampelozizyphus amazonicus</i>	3	3	0.06	0.4	1.50	0.25
<i>Anemopaegma oligoneuron</i>	3	1	0.02	0.1	1.50	0.25
<i>Anthodon</i> sp. 2	3	3	0.06	0.4	1.50	0.25
<i>Callichlamys latifolia</i>	3	3	0.06	0.4	1.50	0.25
<i>Cheiloclinium hippocrateoides</i>	3	3	0.06	0.4	1.50	0.25
<i>Forsteronia gracilis</i>	3	2	0.04	0.3	1.50	0.25
<i>Fridericia chica</i>	3	2	0.04	0.3	1.50	0.25
<i>Hiraea reclinata</i>	3	2	0.04	0.3	1.50	0.25
<i>Maripa glabra</i>	3	3	0.06	0.4	1.50	0.25
<i>Mezia includens</i>	3	3	0.06	0.4	1.50	0.25
<i>Moutabea</i> sp. 3	3	2	0.04	0.3	1.50	0.25
<i>Moutabea</i> sp. 8	3	2	0.04	0.3	1.50	0.25
<i>Odontadenia</i> sp. 3	3	2	0.04	0.3	1.50	0.25
<i>Rourea amazonica</i>	3	2	0.04	0.3	1.50	0.25

<i>Rourea krukovii</i>	3	3	0.06	0.4	1.50	0.25
<i>Schnella guianensis</i>	3	2	0.04	0.3	1.50	0.25
<i>Strychnos asperula</i>	3	3	0.06	0.4	1.50	0.25
<i>Strychnos mitschlerlichii</i>	3	3	0.06	0.4	1.50	0.25
<i>Abuta panurensis</i>	2	2	0.04	0.3	1.00	0.17
<i>Anemopaegma robustum</i>	2	2	0.04	0.3	1.00	0.17
<i>Anemopaegma</i> sp. 1	2	2	0.04	0.3	1.00	0.17
<i>Casimirella rupestris</i>	2	2	0.04	0.3	1.00	0.17
<i>Cheiloclinium gleasonianum</i>	2	1	0.02	0.1	1.00	0.17
<i>Coccoloba</i> sp. 5	2	2	0.04	0.3	1.00	0.17
<i>Coccoloba</i> sp. 7	2	2	0.04	0.3	1.00	0.17
<i>Condylcarpon pubiflorum</i>	2	2	0.04	0.3	1.00	0.17
<i>Dicranostyles densa</i>	2	2	0.04	0.3	1.00	0.17
<i>Forsteronia manausana</i>	2	2	0.04	0.3	1.00	0.17
<i>Fridericia cinnamomea</i>	2	2	0.04	0.3	1.00	0.17
<i>Heteropterys</i> sp. 1	2	1	0.02	0.1	1.00	0.17
<i>Mezia mariposa</i>	2	1	0.02	0.1	1.00	0.17
<i>Moutabea</i> sp. 2	2	2	0.04	0.3	1.00	0.17
<i>Moutabea</i> sp. 9	2	1	0.02	0.1	1.00	0.17
<i>Odontadenia verrucosa</i>	2	2	0.04	0.3	1.00	0.17
<i>Paullinia ingiifolia</i>	2	2	0.04	0.3	1.00	0.17
<i>Paullinia</i> sp. 6	2	1	0.02	0.1	1.00	0.17
<i>Paullinia</i> sp. 7	2	1	0.02	0.1	1.00	0.17
<i>Pseudoconnarus macrophyllus</i>	2	2	0.04	0.3	1.00	0.17
<i>Salacia impressifolia</i>	2	2	0.04	0.3	1.00	0.17
<i>Serjania paucidentata</i>	2	1	0.02	0.1	1.00	0.17
<i>Strychnos parviflora</i>	2	2	0.04	0.3	1.00	0.17
<i>Strychnos</i> sp. 2	2	1	0.02	0.1	1.00	0.17
<i>Strychnos</i> sp. 3	2	2	0.04	0.3	1.00	0.17
<i>Abuta grandifolia</i>	1	1	0.02	0.1	0.50	0.08
<i>Abuta griesbachii</i>	1	1	0.02	0.1	0.50	0.08
<i>Adenocalymma</i> sp. 2	1	1	0.02	0.1	0.50	0.08
<i>Aegiphila</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Amphilophium magnoliifolium</i>	1	1	0.02	0.1	0.50	0.08
<i>Amphilophium trailii</i>	1	1	0.02	0.1	0.50	0.08
<i>Annona</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Bauhinia</i> sp. 4	1	1	0.02	0.1	0.50	0.08
<i>Bronwenia wurdackii</i>	1	1	0.02	0.1	0.50	0.08
<i>Clitoria leptostachya</i>	1	1	0.02	0.1	0.50	0.08
<i>Clitoria</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Coccoloba</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Coccoloba</i> sp. 2	1	1	0.02	0.1	0.50	0.08
<i>Coccoloba</i> sp. 3	1	1	0.02	0.1	0.50	0.08
<i>Coccoloba</i> sp. 4	1	1	0.02	0.1	0.50	0.08
<i>Coccoloba</i> sp. 6	1	1	0.02	0.1	0.50	0.08
<i>Davilla rugosa</i>	1	1	0.02	0.1	0.50	0.08
<i>Deguelia amazonica</i>	1	1	0.02	0.1	0.50	0.08
<i>Derris floribunda</i>	1	1	0.02	0.1	0.50	0.08

<i>Dicella conwayi</i>	1	1.00	0.02	0.1	0.50	0.08
<i>Dichapetalum rugosum</i>	1	1	0.02	0.1	0.50	0.08
<i>Dichapetalum</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Diclidanthera penduliflora</i>	1	1	0.02	0.1	0.50	0.08
<i>Dicranostyles laxa</i>	1	1	0.02	0.1	0.50	0.08
<i>Dilkea johanesii</i>	1	1	0.02	0.1	0.50	0.08
<i>Dilkea retusa</i>	1	1	0.02	0.1	0.50	0.08
<i>Dioclea</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Doliocarpus magnificus</i>	1	1	0.02	0.1	0.50	0.08
<i>Forsteronia acouci</i>	1	1	0.02	0.1	0.50	0.08
<i>Forsteronia duckei</i>	1	1	0.02	0.1	0.50	0.08
<i>Forsteronia</i> sp1	1	1	0.02	0.1	0.50	0.08
<i>Fridericia nigrescens</i>	1	1	0.02	0.1	0.50	0.08
<i>Heisteria scandens</i>	1	1	0.02	0.1	0.50	0.08
<i>Hiraea vilosa</i>	1	1	0.02	0.1	0.50	0.08
<i>Macfadyena</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Machaerium multifoliolatum</i>	1	1	0.02	0.1	0.50	0.08
<i>Machaerium</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Manettia</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Martinella iquitosensis</i>	1	1	0.02	0.1	0.50	0.08
<i>Mendoncia hoffmanseggiana</i>	1	1	0.02	0.1	0.50	0.08
<i>Moutabea</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Moutabea</i> sp. 5	1	1	0.02	0.1	0.50	0.08
<i>Moutabea</i> sp. 7	1	1	0.02	0.1	0.50	0.08
<i>Odontadenia</i> sp. 4	1	1	0.02	0.1	0.50	0.08
<i>Passiflora ernestii</i>	1	1	0.02	0.1	0.50	0.08
<i>Paullinia clavigera</i>	1	1	0.02	0.1	0.50	0.08
<i>Paullinia</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Paullinia</i> sp. 5	1	1	0.02	0.1	0.50	0.08
<i>Peritassa glabra</i>	1	1	0.02	0.1	0.50	0.08
<i>Petrea bracteata</i>	1	1	0.02	0.1	0.50	0.08
<i>Salacia insignis</i>	1	1	0.02	0.1	0.50	0.08
<i>Salacia multiflora</i> subsp. <i>mucronata</i>	1	1	0.02	0.1	0.50	0.08
<i>Schnella</i> sp. 2	1	1	0.02	0.1	0.50	0.08
<i>Sparattanthelium acreanum</i>	1	1	0.02	0.1	0.50	0.08
<i>Strychnos glabra</i>	1	1	0.02	0.1	0.50	0.08
<i>Strychnos jubertiana</i>	1	1	0.02	0.1	0.50	0.08
<i>Strychnos parvifolia</i>	1	1	0.02	0.1	0.50	0.08
<i>Strychnos</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Trigonía</i> sp. 1	1	1	0.02	0.1	0.50	0.08
<i>Trigonía</i> sp. 2	1	1	0.02	0.1	0.50	0.08
<i>Trigonía</i> sp. 3	1	1	0.02	0.1	0.50	0.08
<b>TOTAL</b>	<b>1,202</b>	<b>50</b>	<b>14.04</b>	<b>100.0</b>	<b>601</b>	<b>100</b>