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Heterogeneity of tree species communities along edge gradients in fragments of Araucaria Forest in Southern Brazil

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ABSTRACT

Background: Although the scientific literature includes abundant and diverse studies conducted in tropical regions, little is known about the influence of edges in subtropical forest fragments. **Objective:** This study aimed to evaluate the floristic-structural organization of tree communities along edge gradients in Araucaria Forest fragments in Southern Brazil. **Results:** We observed a high floristic and structural heterogeneity among fragments. This heterogeneity is a result of the species turnover that occurs in the region. It was possible to detect the influence of edge gradients on tree community organization in two fragments. **Conclusion:** We conclude that edge gradients can represent an important source of floristic-structural heterogeneity in Araucaria Forest fragments. However, the various response patterns observed for the tree communities indicate the complex nature of edge effects and suggest that the influence of edge gradients cannot be generalized for this forest formation.

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INTRODUCTION

The Atlantic Araucaria Forest occurs in eastern South America in high-altitude areas of the subtropical region under a mesothermic and humid climate (Bertoncello *et al.*, 2011). Although *Araucaria angustifolia* is the dominant species in the canopy, the understory shows a relatively high richness, with Myrtaceae as the most representative family, and a high floristic turnover among different areas in response to environmental gradients (e.g., altitude) (Higuchi *et al.*, 2012; Silva *et al.*, 2012). Part of this forest formation occurs as natural fragments inserted in a dominant grassland matrix, which is considered a relict vegetation type surviving from past glacial cycles (Behling *et al.*, 2004). In fact, studies have demonstrated that the forest component initiated an ongoing intense expansion from the drainage network over the grassland ca. 1,000 years ago (Behling, 1997; Behling *et al.*, 2004). However, due to the historical process of landscape occupation in recent centuries, characterized by the exploitation of timber and non-timber tree species and the expansion of agriculture and cattle-raising activities, the forest areas have been markedly reduced and the process of forest expansion inhibited. Nevertheless, there is evidence that the forest formations would tend to expand into the open areas in a hypothetical situation in which anthropogenic factors, such as cattle raising and human-caused fires, were absent (Behling and Pillar, 2007).

In this scenario of expansion and retraction of vegetation elements due to climate change and anthropogenic pressure, the understanding of the processes occurring in the interface between the forest and the non-forest matrix is of great interest for a better comprehension of the landscape dynamics and ecology. Thus, investigations of the ways in which vegetation changes along forest edge-interior gradients could contribute to this purpose. Commonly, a higher light incidence and air temperature and a more intense wind regime are observed in the edge than in the interior (Bierregaard Junior *et al.*, 1992). As a consequence of these microclimatic differences, the floristic composition of forest fragments may be modified as a consequence of local extinctions of non-adapted species and the spread of light-demanding and pioneer species (Murcia, 1995; Laurance *et al.*, 2006). The intensity of this process, described as the edge effect, varies primarily as a function

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of the distance from the edge, the degree of environmental heterogeneity and the surrounding matrix (Kapos, 1989; Laurance *et al.*, 2002). Although certain authors consider that edge effects can occur up to 400 m into the forest (Laurance *et al.*, 2002), these effects are more intense in the first few meters (Rodrigues, 1998).

Although the scientific literature includes abundant and diverse studies conducted in tropical regions (Araújo and Espírito-Santo Filho, 2012; Santos-Filho *et al.*, 2012; Guerra *et al.*, 2013), little is known about the influence of edges in subtropical forest fragments such as the South American Atlantic Araucaria Forest (e.g. Baldissera and Ganade, 2005). Given that each vegetation physiognomy has fundamental differences in terms of species, ecological relationships, disturbance history and landscape dynamics over time, the influence of the edge on fragments cannot be generalized. Because of this specificity, research on seldom-studied forest formations is needed. Thus, to test the hypothesis of different patterns of arboreal response to edge effects in forest fragments, the present study aimed to evaluate the structure and the organization of the floristic composition of tree communities along edge-interior gradients in three Araucaria Forest fragments along an altitudinal gradient in Southern Brazil.

MATERIALS AND METHODS

This study was conducted in three Araucaria Forest remnants located along an altitudinal gradient in Santa Catarina State, Southern Brazil, at 950 m (27°44'16"S; 50°34'51"W, area = 281 ha), 1,050 m (27°51'15"S; 50°09'58"W; area = 153 ha) and 1,300 m (28°20'13"S; 49°37'29"W, area = 252 ha). The regional climate is Cfb according to the Koppen classification (Pandolfo *et al.*, 2002), and the topography is characterized as gentle-undulate and undulate terrain. All fragments are located in the same hydrographic basin, are inserted in a grassland matrix disturbed by anthropogenic factors, such as cattle raising and agriculture, had the same past disturbance history (selective logging) and are in an advanced successional phase.

Five 20x100 m transects, separated by at least 100 m to incorporate environmental variation, were allocated per fragment and placed perpendicular to the edges, totaling 3 ha of sampling area. The transects were subdivided into 10 10x20 m subplots within which all living trees with a diameter at breast height (dbh) greater than or equal to 5 cm were measured (circumference at breast height –cbh) with a metric tape and identified. The species were classified in botanical families according to the APG III system (Angiosperm Phylogeny Group, 2009).

The community structure was described by importance values (IVs), which synthesize the relative values of density, dominance and frequency (Mueller-Dombois and Ellemberg, 1974). The data (tree species abundance in each subplot) were ordinated by non-metric multidimensional scaling (NMDS) (Minchin, 1987). The suitability of ordinations for interpretation was assessed with stress (Standard Residuals Sum of Squares) values. The floristic-structural differences among the fragments were verified with a non-parametric multivariate analysis of variance (NPMANOVA). The influence of the distance from the edge on the floristic-structural organization of each fragment was evaluated with generalized additive models of the ordinations with thin plate splines smoothing using the “ordisurf” function of the “vegan” package (Oksanen *et al.*, 2013) of the R statistical programming language. All analyses were conducted with R (R Development Core Team, 2013).

RESULTS

The distribution of plots in the ordination analysis (Stress = 0.19) (Figure 1) indicated structural differences and elevated tree species turnover among the fragments, as confirmed by a NPMANOVA ($p = 0.001$). From the low- to the high-altitude areas, a total of 1,536, 1,516 and 1,457 individuals, belonging to 83, 67 and 55 species, respectively, were sampled. In the three areas, the richest families were Myrtaceae (25), Asteraceae (10) and Lauraceae (6). In the lower-altitude fragment (950 m), the basal area was 33.78 m².ha⁻¹, with *Matayba elaeagnoides* Radlk (17.61%), *Lithraea brasiliensis* Marchand (5.32%) and *Araucaria angustifolia* (Bertol.) Kuntze (4.88%) as the species with the highest importance values (IV). The richest families and genera were, respectively, (17 species) Asteraceae (7) and Lauraceae (5), and *Myrcia* (5), *Ilex* (3), *Myrceugenia* (3) and *Solanum* (3). In the middle-altitude fragment (1,050 m), a basal area of 36.11 m².ha⁻¹ was observed, with *Araucaria angustifolia* (13.79%), *Lithraea brasiliensis* (5.63%) and *Podocarpus lambertii* Klotzsch ex Endl. (5.38%) as the most important species (IV). The richest families were Myrtaceae (15) and Salicaceae (5); *Eugenia* (4), *Myrcia* (4), *Ilex* (4) and *Myrsine* (3) were the richest genera. In the fragment at the highest altitude (1,300 m), a basal area of 44.49 m².ha⁻¹ was found. *Dicksonia sellowiana* Hook. (13.22%), *Lithraea brasiliensis* (9.11%) and *Araucaria angustifolia* (8.98%) were the most important species. The richest families were Myrtaceae (10), Asteraceae (5), Anacardiaceae (4) and Lauraceae (4), and the richest genera were *Myrceugenia* (4) and *Schinus* (3).

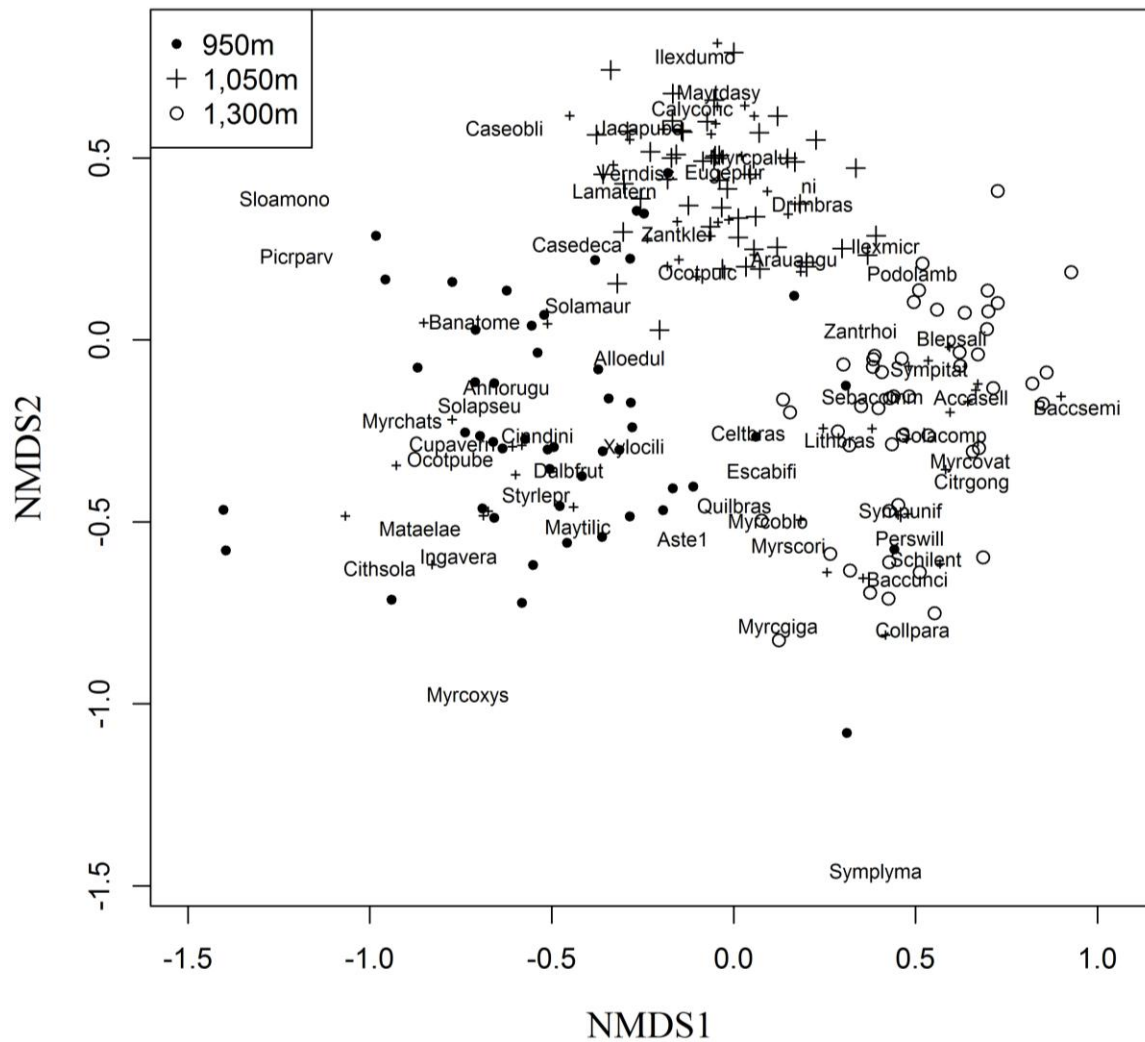


Fig. 1: Plot ordination, obtained with a NMDS analysis, of Araucaria Forest fragments located at different altitudes levels in Southern Brazil.

Although no influence of edge distance on tree community organization was observed in the highest-altitude fragment (1,300 m), the edge gradient significantly explained ($p < 0.02$) part of the variation in the tree component in the lower-altitude fragments at 950 and 1050 m, 31.6 and 33.2%, respectively (Figure 2). The fitted models showed no linear relationship between the ordination axis and edge distance. In the fragment at 950 m, *Baccharis semiserrata* DC. (Baccsemi) and *Baccharis uncinella* DC. (Baccunci), typical short-lived pioneer species, occurred close to the edge (<20 m), whereas *Sloanea monosperma* Vell. (Sloamono) and *Picramnia parvifolia* Engl. (Picrparv), which are more shade tolerant, occurred at a distance of >65 m. In the fragment at 1,050 m, *Xylosma tweediana* (Clos) Eichler (Xyloctwee), *Symplocos uniflora* (Pohl) Benth. (Sympunif), *Symplocos tetrandra* (Mart.) Miq. (Symptetr) and *Blepharocalyx salicifolius* (Kunth) O.Berg (Blepsali), light-demanding species, occurred close to the edge (<35 m), and *Eugenia uruguayensis* Cambess., (Eugeurug) shade-tolerant, and *Sebastiania commersoniana* (Baill.) L.B.Sm. & Downs (Sebacomm), light-demanding, occurred at a distance of >70 m.

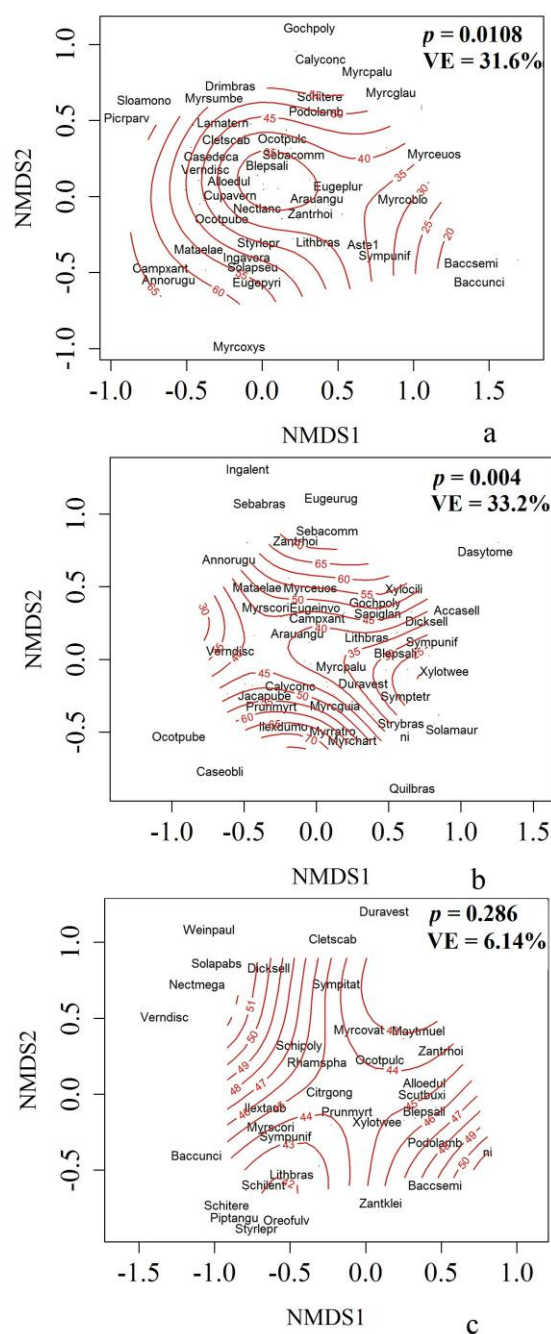


Fig. 2: Edge distance fitted by generalized additive model to NMDS ordinations, with values of significance (p) and explained variation (VE) for *Araucaria Forest* fragments along an altitudinal gradient [950 m (A), 1,050 m (B) and 1,300 m (C)] in Southern Brazil

DISCUSSION

Although several similarities were evident, such as the richest family (Myrtaceae) and the presence of *Araucaria angustifolia* and *Lithraea brasiliensis* among the most important species, the three fragments showed a high floristic and structural heterogeneity, demonstrated by the variation in families and genera richness and the relative importance of the most important species. This result indicates an increased turnover of tree species at the regional scale, as expected because the fragments were located at different altitudes. In different forest formations, tree species turnover along an altitudinal gradient is a common pattern (e.g. Gentry, 1998; Lieberman *et al.*, 1996; Oliveira-Filho and Fontes, 2000; Homeier *et al.*, 2010) and can be explained by climatic (e.g., temperature and fog) and edaphic changes along the gradient.

At the local scale, the edges were confirmed as an important source of floristic-structural heterogeneity for the lower-altitude fragments. This result suggests that biotic and abiotic variation may occur even in a short

distance (<100 m) along an edge gradient (Murcia, 1995; Baldissera and Ganade, 2005), changing the pattern of tree species dynamics (Laurance *et al.*, 1998; Oliveira-Filho *et al.*, 2007) and resulting in the establishment of different species along the edge gradient. Furthermore, variation in tree species among plots at the same distance from the edge was observed, indicating the complex nature of the edge effect on tree species communities (Mesquita *et al.*, 1999; Laurance *et al.*, 2007).

CONCLUSION

We conclude that at the regional scale, the studied fragments showed high floristic-structural heterogeneity, indicating high beta diversity, and that at the local scale, edge gradients may represent an important source of floristic and structural variation in Araucaria Forest fragments. However, the varied patterns of tree species community response indicate the complex nature of the edge effect and suggest that its influence should not be generalized for subtropical Araucaria Forests.

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REFERENCES

- Angiosperm Phylogeny Group, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of Linnean Society*, 161(2): 105-121.
- Araújo, W.S. and K. Espírito-Santo Filho, 2012. Edge effect benefits galling insects in the Brazilian Amazon. *Biodiversity and Conservation*, 21(11): 2991-2999.
- Baldissera, R. and G. Ganade, 2005. Predação de sementes ao longo de uma borda de Floresta Ombrófila Mista e pastagem. *Acta Botanica Brasilica*, 19(1): 161-165.
- Behling, H., 1997. Late Quaternary vegetation, climate and fire history of the Araucaria forest and campos region from Serra Campos Gerais, Paraná State (South Brazil). *Review of Palaeobotany and Palynology*, 97(1-2): 109-121.
- Behling, H., V.P. Pillar, L. Orlóci and S.G. Bauermann, 2004. Late Quaternary Araucaria forest, grassland (Campos), fire and climate dynamics, studied by high-resolution pollen, charcoal and multivariate analysis of the Cambará do Sul core in southern Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 203(3-4): 277-297.
- Behling, H. and V.P. Pillar, 2007. Late Quaternary vegetation, biodiversity and fire dynamics on the southern Brazilian highland and their implication for conservation and management of modern Araucaria forest and grassland ecosystems. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 362(1478): 243-251.
- Bertoncello, R., K. Yamamoto, D.L. Meireles and G.J. Shepherd, 2011. A phytogeographic analysis of cloud forests and other forest subtypes amidst the Atlantic forests in south and southeast Brazil. *Biodiversity and Conservation*, 20(14): 3413-3433.
- Bierregaard Junior, R.O., T.E. Lovejoy, V. Kapos, A.A. Santos and R.W. Hutchings, 1992. The biological dynamics of tropical rainforest fragments: a prospective comparison of fragment and continuous forest. *Bioscience*, 42(11): 859-866.
- Gentry, A.H., 1988. Changes in Plant Community Diversity and Floristic Composition on Environmental and Geographical Gradients. *Annals of the Missouri Botanical Garden*, 75(1): 1-34.
- Guerra, T.N.F., M.J.N. Rodal, A.C.B. Lins e Silva, M. Alves, M.A.M. Silva and P.G.A. Mendes, 2013. Influence of edge and topography on the vegetation in an Atlantic Forest remnant in northeastern Brazil. *Journal of Forest Research*, 18(2): 200-208.
- Higuchi, P., A.C. Silva, T.S. Ferreira, S.T. Souza, J.P. Gomes, K.M. Silva and K.F. Santos, 2012. Floristic composition and phytogeography of the tree component of Araucaria Forest fragments in southern Brazil. *Brazilian Journal of Botany*, 35(2): 145-157.
- Homeier, J., S. Breckle, S. Günter, R.T. Rollenbeck and C. Leuschner, 2010. Tree diversity, forest structure and productivity along altitudinal and topographical gradients in a species-rich Ecuadorian Montane Rain Forest. *Biotropica*, 42(2): 140-148.
- Kapos, V., 1989. Effects of isolation on the water status of forest patches in the Brazilian Amazon. *Journal of Tropical Ecology*, 5(2): 173-185.
- Laurance, W.F., L.V. Ferreira, J.M. Rankin-de Merona and S.G. Laurance, 1998. Rain forest fragmentation and the dynamics of Amazonian tree communities. *Ecology*, 79(6): 2032-2040.

Laurance, W.F., T.E. Lovejoy, H.L. Vasconcelos, E.M. Bruna, R.K. Didham, P.C. Stouffer, C. Gascon, R.O. Bierregaard, S.G. Laurance and E. Sampaio, 2002. Ecosystem decay of Amazonian forest fragments: a 22-year investigation. *Conservation Biology*, 16(3): 605-618.

Laurance, W.F., H.E.M. Nascimento, S.G. Laurance, A. Andrade, J.E.L.S. Ribeiro, J.P. Giraldo, T.E. Lovejoy, R. Condit, J. Chave, K.E. Harms and S. D'Angelo, 2006. Rapid decay of tree-community composition in Amazonian forest fragments. *Proceedings of the National Academy of Sciences*, 103(50): 19010-19014.

Laurance, W.F., H.E.M. Nascimento, S.G. Laurance, A. Andrade, R.M. Ewers, K.E. Harms, R.C.C. Luizão and J.E. Ribeiro, 2007. Habitat fragmentation, variable edge effects, and the landscape-divergence hypothesis. *PLoS ONE*.

Lieberman, D., M. Lieberman, R. Peralta and G.S. Hartshorn, 1996. Tropical Forest Structure and Composition on a Large-Scale Altitudinal Gradient in Costa Rica. *Journal of Ecology*, 84(2): 137-152.

Mesquita, R.C.G., P. Delamônica and W.F. Laurance, 1999. Effects of surrounding vegetation on edge-related tree mortality in Amazonian forest fragments. *Biological Conservation*, 91(2-3): 129-134.

Minchin, P.R., 1987. An evaluation of the relative robustness of techniques for ecological ordination. *Vegetatio*, 69(1-3): 89-107.

Mueller-Dombois, D. and H. Ellenberg, 1974. *Aims and Methods of vegetation ecology*. New York: John Wiley & Sons.

Murcia, C., 1995. Edge effects in fragmented forest: implications for conservation. *Trends in Ecology and Evolution*, 10(2): 58-62.

Oksanen, J., F.G. Blanchet, R. Kindt, P. Legendre, P.R. Minchin, R.B. O'Hara, G.L. Simpson, P. Solymos, H.H. Stevens and H. Wagner, 2013. *Vegan: Community Ecology Package*. R package version 2.0-8.

Oliveira-Filho, A.T. and M.A.L. Fontes, 2000. Patterns of Floristic Differentiation among Atlantic Forests in Southeastern Brazil and the Influence of Climate. *Biotropica*, 32(4b): 793-810.

Oliveira-Filho, A.T., W.A.C. Carvalho, E.L.M. Machado, P. Higuchi, V. Appolinário, G.C. Castro, A.C. Silva, R.M. Santos, L.F. Borges, B.S. Corrêa and J.M. Alves, 2007. Dinâmica da comunidade e populações arbóreas de borda e interior de um remanescente florestal na Serra da Mantiqueira, Minas Gerais, em um intervalo de cinco anos (1999-2004). *Brazilian Journal of Botany*, 30(1): 149-161.

Pandolfo, C., H.J. Braga, V.P. Silva Jr, A.M. Massignam, E.S. Pereira, V.M.R. Thomé, F.V. Valci, 2002. *Atlas climáticos digital do Estado de Santa Catarina*. Epagri.

R Development Core Team, 2013. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria.

Rodrigues, E., 1998. Edge effects on the regeneration of Forest fragments in North Paraná, Ph.D Thesis, Harvard University, Cambridge, MA.

Santos-Filho, M., C.A. Peres, D.J. Silva and T.M. Sanaiotti, 2012. Habitat patch and matrix effects on small-mammal persistence in Amazonian forest fragments. *Biodiversity and Conservation*, 21(4): 1127-1147.

Silva, A.C., P. Higuchi, M.D. Aguiar, M. Negrini, J. Fert Neto and A.F. Hess, 2012. Relações florísticas e fitossociologia de uma Floresta Ombrófila Mista Montana secundária em Lages, Santa Catarina. *Ciência Florestal*, 22(1): 193-206.