University of São Paulo
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Forest and landscape restoration at Pontal do Paranapanema: ecological
attributes of forest restoration in a coffee agroforestry system

Carolina Giudice Badari

Dissertation presented to obtain the degree of Master in
Science. Area: Forest Resources. Option in: Conservation
of Forest Ecosystems

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Bachelor in Agroecology

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forest restoration in a coffee agroforestry system

versão revisada de acordo com a resolução CoPGr 6018 de 2011

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DEDICATION

I dedicate this work to all of those who believe in the middle way, where nature and man meet, reconcile and unite. To those who recognize themselves as part of the great mother earth and seek love in all forms of existence and beings: planting, caring and harvesting. To all of those who have immersed themselves in their inner restoration, through the reestablishment of ties between humans and the ecosystem that surrounds and permeates all of us.

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*"Mesmo que só possamos ver uma folha na grama,
mesmo que só tenhamos 20cm de céu para observar,
podemos ver nossos ciclos dentro da natureza e com ela.
Todas nós podemos nadar mar à dentro...."*

“Mulheres que correm com lobos (Women who run with the wolves)”, Clarissa Pinkola Estès

WORK PRESENTATION

The “Forest (and) Landscape Restoration” (FLR) is an approach to forest restoration, which emerged with the purpose of merging the ecological and social visions of restoration initiatives, with awareness that recovery is planned and monitored in an integrated way in the landscape. The pioneer documents describe this approach as a multi-purpose activity, in which heterogeneous landscapes ensure the co-existence, integration and synergies among expected restoration outcomes (such as benefits for biodiversity and climate mitigation, improvement of local livelihoods and engagement of local stakeholders). However, because it has just recently acquired implementation momentum, it still lacks a better understanding of its applicability. Analyses that measure FLR ecological and socioeconomic impacts, aligned with the concepts of FLR can help in guiding the direction of future activities.

In the tropics, Agroforestry Systems (AFS) are aligned with the FLR concepts. However, little is known regarding whether AFS are successful restoration strategies and whether ecological restoration outcomes in AFS are comparable to those from conventional restoration plantings (native tree seedlings plantings). Thus, we aimed to understand how an agroforestry system with shaded coffee performs in terms of forest cover, biomass stock, natural regeneration, and tree species richness and composition. We seek to understand how it performs in comparison with conventional restoration plantings and local reference ecosystems. We also compared AFS ecological indicators values with values in monitoring protocols used to attest tropical forest restoration success. The case study was carried out at the Pontal do Paranapanema, Southeastern Brazil, a region of high land heterogeneity. There, restoration activities are being carried out on a large scale by the IPE and by WeForest. Both are NGOs, aiming to connect the remnants of natural forests within the landscape through the reestablishment of ecological corridors and stepping-stones.

The results show that coffee AFS can perform better than conventional restoration plantings of similar age. Besides, natural regeneration in the AFS understory is more similar with reference forests than is natural regeneration under conventional restoration plantings. Therefore, although located in small areas and distant from each other, AFS are important patches for local biodiversity conservation and carbon sequestration. However, we also observed that natural regeneration density and diversity under shaded coffee AFS is

negatively related to the density of coffee plants. Thus, it suggest the existence of a tradeoff between coffee production and forest restoration outcomes in this system and it is a factor that should be carefully planned over time if we prioritize ecological restoration. In order to assist researchers and professionals working with Ecological Restoration and AFS, and to serve as a tool for the elaboration of protocols for the implementation and monitoring of AFS with shaded coffee in the tropics, we sought to find levels of coffee plantings density that are compatible with ecological restoration expectations.

This thesis contains one chapter. Although the review of FLR has not been fully addressed as an additional chapter of this dissertation, the ecological findings of the review are briefly summarized as an introduction to the central theme of the research. The socioeconomic results of both review and field analysis will be presented by the other master student of this project, Loren Belei, under the guidance of Prof. Carla Morsello at PPG in Environmental Sciences at EACH, University of São Paulo. After the conclusion of the socioeconomic analysis, we aim to cross the information from both dissertations to better understand the relationship between the ecological and the social and economic aspects of the FLR project at Pontal do Paranapanema.

The literature review on FLR, which underlies much of this dissertation, will be published as an article under the title: "The main principles of forest and landscape restoration: a qualitative review". The present document, related to the monitoring of AFS compared to conventional restoration plantings with the same age will be submitted to the Restoration Ecology journal, with the title "Agroforestry systems with shaded coffee as an alternative for tropical forest restoration". The data collected in the field and the results of the research were shared with the partner institutions WeForest, IPE and IPEF, aiming to enable the continuity of this and other studies of FLR at Pontal do Paranapanema. Besides, this study provides a large database of forest restoration monitoring data, assisting in future decision-makings for regional forest restoration initiatives.

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RESUMO

Restauração da paisagem florestal no Pontal do Paranapanema: indicadores ecológicos em sistemas agroflorestais com café sombreado

Um reflexo direto do crescimento desordenado da população humana e das atividades antrópicas é a diminuição e a fragmentação da área ocupada por ecossistemas nativos e sua substituição por áreas agrícolas. Neste cenário, os sistemas agroflorestais (SAF) podem ser uma alternativa para conciliar restauração, conservação e produção agrícola local. No entanto, tendo em vista a diversidade de SAFs, sua adoção como estratégia de restauração florestal ainda carece de estudos que avaliem os níveis de indicadores ecológicos de cada sistema. Neste sentido, comparamos os indicadores ecológicos de sistemas agroflorestais com café e espécies arbóreas nativas no Pontal do Paranapanema, com os de plantios convencionais de restauração florestal de mesma idade (12-15 anos) e ecossistemas de referência regionais. Medimos a densidade e a riqueza da regeneração natural, a cobertura do solo por espécies nativas e a biomassa acima do solo e as comparamos entre as áreas pela análise de variância ANOVA seguida da comparação de médias pelo teste de Tukey. Buscando compreender os fatores que influenciam os indicadores ecológicos da restauração florestal no SAF, analisamos modelos lineares generalizados, tendo biomassa, porcentagem de árvores zoocóricas, distância do remanescente florestal mais próximo, densidades de café, riqueza e densidade de árvores nativas como variáveis preditoras, e porcentagem de cobertura do dossel, densidade e riqueza da regeneração natural como variáveis respostas. As florestas de referência tiveram os maiores valores para indicadores de estrutura florestal, seguidas pelos SAFs e pelos plantios convencionais de restauração florestal. Entretanto, encontramos elevada diversidade de espécies arbóreas nos SAFs e valores próximos aos das florestas de referência para a diversidade da regeneração natural. Embora a densidade de plantas de café influencie negativamente a regeneração natural, os SAFs apresentaram um melhor desempenho ecológico que as áreas de restauração convencional, correspondendo à uma alternativa viável para restauração florestal. Desta forma, concluímos que os sistemas agroflorestais estudados desempenham um papel ecológico importante na restauração da paisagem florestal no Pontal do Paranapanema, conciliando produção com restauração florestal.

Palavras-chave: *Coffea arabica* L.; Café sombreado; Monitoramento da restauração ecológica; Indicadores ecológicos; Restauração florestal; Regeneração natural; Restauração ecológica; Sistema agroflorestal

ABSTRACT

Forest and landscape restoration at Pontal do Paranapanema: ecological indicators of forest restoration in a coffee agroforestry system

A direct consequence of disorganized human population growth and the indiscriminate use of natural resources are the reduction of area and the fragmentation of native ecosystems, as they transform into agricultural areas. In this scenario, agroforestry systems (AFS) may be an alternative to reconcile restoration, conservation and local agricultural production. However, there is a diversity of AFS, and its use as a forest restoration strategy is still uncertain, mainly because we lack evaluations based on ecological indicators from those systems. Thus, we compared ecological indicators measured in a coffee agroforestry system in the Pontal do Paranapanema with those in conventional restoration plantings of the same age and with regional reference ecosystems. We measured natural regeneration density and richness; canopy cover by native species and aboveground biomass and compared among sites using an ANOVA, followed by Tukey's test for mean comparison. Aiming to understand the factors influencing the ecological indicators of forest restoration in coffee AFS, we performed generalized linear models (GLM) using density of coffee and native trees, biomass, percentage of animal-dispersed trees, distance to the nearest forest remnant and richness of tree species as predictor variables and percentage of canopy cover and density and richness of natural regeneration as response variables. The reference forests had the highest values for forest structure indicators, followed by AFS and finally by the conventional restoration plantings. However, we found a greater diversity of tree species planted in the AFS and a natural regeneration similar to that found in the reference ecosystems. Despite coffee density in the AFS negatively influencing natural regeneration, the coffee AFS had greater ecological performance than the conventional restoration, being a viable alternative for forest restoration. We conclude that AFS with coffee and native tree species play an important ecological role in the FLR in Pontal do Paranapanema, reconciling productivity with forest restoration.

Keywords: *Coffea arabica* L.; Shade-grown coffee; Ecological restoration monitoring; Ecological indicators; Forest restoration; Natural regeneration; Ecological restoration; Agroforestry system

ABBREVIATIONS AND ACRONYMS LIST

AFS	Agroforestry System
AGB	Above ground biomass
CRP	Conventional Restoration Planting
DBH	Diameter at breast height
ES	Ecosystem Services
FLR	Forest and Landscape Restoration

REVIEW OF ECOLOGICAL OUTCOMES IN FOREST LANDSCAPE RESTORATION

Although without a conclusive definition, “landscape” is often understood as a heterogeneous mosaic of different land uses, including vegetation of different types, anthropogenic land uses (e.g., urban areas, livestock and agriculture at rural areas) and degraded lands (Van Oosten 2013; Lamb et al. 2005; Ianni & Geneletti 2010; FAO & Global Mechanism of the UNCCD 2015), across large areas of land or a watershed (FAO & Global Mechanism of the UNCCD 2015). Inside a mosaic of land uses research agrees that restoration interventions should result in a win-win scenario in terms of biodiversity conservation, and the maintenance of heterogeneous landscapes (Brancalion & Chazdon 2017; Sabogal et al. 2015; Aronson & Alexander 2013; Ianni & Geneletti 2010).

In this scenario, the concept of Forest and Landscape Restoration (FLR) emerged as “a planned process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes” (WWF & IUCN 2000; Laestadius et al. 2015). Throughout FLR projects, where a key feature is a combination of forest and non-forest ecosystems land uses, restoration approaches can be accommodated within a landscape to achieve, ecological, social and economic benefits. The ecological benefits are related to ecosystem service provisioning, mitigation of climate change, ecological connectivity, forest protection and biodiversity conservation at a landscape level (Chazdon et al. 2017; Brancalion & Chazdon 2017; Berglund et al. 2014). Expected economic outcomes are related to increases in land productivity, job creation (Adams et al. 2016) and income generation, through Payments for Ecosystem Services (PES), for example (Schuyt 2005). Yet, the social and livelihood benefits are basically improvements in human well-being, food security (Caughlin et al. 2016; Chazdon et al. 2017; Dudley 2005), and capacity to promote conflict resolution by including local people in decision-making (Hampson et al. 2017).

Among the interventions directly linked with the generation of ecological and socioeconomic benefits, agroforestry systems (AFS) are the most cited and studied ones, mainly when trees that have valuable use (e.g. fodder, fuel wood, or timber) are mixed with agricultural crops that generate cash income to landowners (FAO 2016a; IUFRO 2017). Aiming to assess how the expected ecological outcomes of FLR are met through AFS, we present below a review of the main ecological principles of FLR found in the literature:

Biodiversity conservation

Using native species in silviculture has a relevant recognition in ecosystem restoration as a way to regain biodiversity (Gregorio et al. 2017; Coello et al. 2015; Brancalion & Chazdon 2017; Budiharta et al. 2014). Although, attention must be taken to the maintenance of genetic diversity in the planting, as well as in the quality of the planting material employed (as those two aspects are shown to significantly contribute to the success of restoration as a biodiversity conservation activity) (Pistorius et al. 2017; Gregorio et al. 2017; Brancalion & Chazdon 2017; Coello et al. 2015). In addition, it is important to ensure the existence of a good source population (e.g., patches of remnant native trees) inside the landscape that can act as source populations of species for the restoration plantations (Burgin et al. 2005; Budiharta et al. 2014; Coello et al. 2015). Remnant forest patches can also support a network of seed collectors that can provide quality, and biodiverse material for the restoration (Hanson, Buckingham, Dewitt, et al. 2015; FAO & Global Mechanism of the UNCCD 2015).

Considering that not all species are adapted and able to persist in degraded or even early succession forests (Budiharta et al. 2014; Coello et al. 2015), the conservation of native remnants in the landscape is a key criteria of FLR needed to guarantee the protection of threatened and endangered species. Aiming for the sustainability of these areas in the long term, the control of superabundant and invasive species, the protection against unwanted animals (e.g., uncontrolled grazing livestock and other ruminants), and the enrichment of secondary forests appear as important complementary activities for the conservation of biological diversity and ecological functionality in the landscape (Lamb et al. 2005; Zhou et al. 2008).

In this context, it is important to highlight that biodiversity conservation in a landscape may depend more on the diversity of functional groups (e.g., nitrogen fixers, fauna-attracting species and fast- or slow- growing canopy trees) and on diversity of functional responses within these groups than on the number of tree species used in a plantation (Lamb et al. 2005; Ostertag et al. 2015). Beyond that, the resilience of a forest is ensured by the ecological processes at the landscape level (Newton et al. 2012). Wherefore it is demonstrably dependent on a dynamic interaction within and among species, and among them and physical-chemical aspects of the environment. These processes and interactions are, therefore, the main guide to a long-term maintenance of ecosystems, habitats, and consequently biodiversity (Jögriste et al. 2014; Coello et al. 2015; Barrow 2014; Maginnis & Jackson 2003; Schlaepfer 2005).

In highly fragmented, degraded and eroded landscapes, restoration can be seen as a long-term solution to regain biodiversity, ecological functionality and also increase landscape productivity (Maginnis & Jackson 2003; ITTO 2006), while reducing the pressure on remnant forests, increasing their buffer zones and improving forest connectivity at a landscape level (ITTO 2006; Zhou et al. 2008; Lamb et al. 2005; FAO 2016; Maginnis & Jackson 2003).

Considering the maintenance of ecological functions and forest production, using exotic species in FLR (mainly in AFS) is frequent to generate benefits for carbon sequestration, soil protection, economic production and water infiltration (Souza et al. 2016; Brancalion & Chazdon 2017). However, it is crucial to delineate where, when and which species to use, highlighting and advertising the dangerous conversion of native forests to monocultures, that may lead to a cryptic loss of carbon stocks, as well as of biodiversity and ecosystem services (Brancalion & Chazdon 2017).

Climate Change Mitigation and Adaptation

Through improving the physical and structural aspects of the landscape, FLR projects have the great potential to protect watersheds and enhance water resources, prevent land degradation, combat desertification, as well as avoid erosion and promote afforestation of former agricultural lands (Coello et al. 2015; Hanson, Buckingham, Dewitt, et al. 2015; Pistorius et al. 2017; ITTO 2006). In this context, the physical and structural improvements of the landscape via FLR can act in the mitigation of the effects of climate change.

The global need for actions that mitigate climate change show us the significant opportunity for developing and implementing FLR initiatives all around the world (Brancalion & Chazdon 2017; Coello et al. 2015; Schulz & Schröder 2017; ITTO 2006). This argument has high potential to attract investors and funders concerned with the global environmental impacts of human activities (Brancalion & Chazdon 2017). Moreover, those initiatives have the potential to help vulnerable communities to adapt to the impacts of climate change. Through the promotion of soil stabilization, adequate nutrient cycling, sustainable use of raw materials, wind protection, clean water provision, and carbon sequestration, it is possible to create and maintain resilient landscapes to adverse changes (Adams et al. 2016; ITTO 2006; Maillot et al. 2015; Báez et al. 2011; Souza et al. 2016; Buck & Bailey 2014; Sabogal et al. 2015).

In this perspective, some authors support that FLR projects might then be composed of areas protected for watershed management and nature conservation. Therefore, landscapes should have well-managed plantations, tree buffers zones along hillsides and hilltops, rivers and other water sources, protecting them against flood and erosion, conserving water and soil quality (Saint-Laurent & Carle 2006; Lamb et al. 2005) especially in tropical regions, which generally exhibit high precipitation and weathering.

Ecosystem Services

Some authors sustain that people's motivations for restoring their land are directly related to the need of environmental goods and services (e.g. water, soil conservation, wind protection, and landscape preservation) (Báez et al. 2011). In this context, arise the concept of ecosystem services (ES), which is the integration of benefits that people obtain from ecosystems (Millennium Ecosystem Assessment 2002).

Ecosystem services can be divided into provisioning, cultural, regulating and supporting services (Millennium Ecosystem Assessment 2002). These ES encompass carbon stocks (Brancalion & Chazdon 2017; Budiharta et al. 2014; Souza et al. 2016; Pistorius et al. 2017; Uriarte & Chazdon 2016; Hanson, Buckingham & Sean Dewitt 2015; Laestadius et al. 2011; Sabogal et al. 2015), natural pest control (Uriarte & Chazdon 2016), pollination (Buck & Bailey 2014; Mansourian et al. 2017; Orsi et al. 2011), ecotourism (Dudley 2005; FAO 2016; Saint-laurent 2009; ITTO 2006; Buck & Bailey 2014), provision of food and water in quality and resources (Báez et al. 2011; Maginnis & Jackson 2003; ITTO 2006; Souza et al. 2016), timber and non-timber forest products (Maginnis & Jackson 2003; ITTO 2006) (Adams et al. 2016; Barrow 2014; Sabogal et al. 2015; Brancalion & Chazdon 2017).

In order to succeed in an FLR initiative, balancing these different ecosystem services to minimize tradeoffs is a key (Uriarte & Chazdon 2016; Latawiec et al. 2015). Currently, some studies and software have been developed to assist in the monitoring and valuation of ES. One example of a valuation methodology is the Ecosystem Valuation Toolkit, a spatially explicit database of ecosystem service values released by the Earth Economics, which has wide applicability and may assist in large-scale restoration efforts, especially in areas with large urban populations (Aronson & Alexander 2013).

Some other examples, that can assist in monitoring changes in water, soil and carbon resources are the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), a free and open-source that is suited for large spatial-scales, and the Sediment Delivery Ratio (SDR) that can infer potential improvement in water quality by calculating the difference in sediment loss under different scenarios (Gourevitch et al. 2016). Nevertheless, there is a huge demand for ES studies in the different realities of FLR projects.

Landscape Multifunctionality

Landscape multifunctionality means synergies and complementarities in a landscape with multiple land uses, each one valued by different stakeholders in different ways (Schulz & Schröder 2017). Hence, the landscape multifunctionality by its nature needs to be planned and implemented on a far broader scale than an individual forest patch (Mansourian & Dudley 2005; Dudley et al. 2005).

Applying the concepts of Landscape Multifunctionality in FLR enhances the coexistence of different land uses; meeting a wide range of different stakeholders groups interests (Brown 2005). Analogous to results from ES studies (Berglund et al. 2014; Brancalion & Chazdon 2017; Chazdon, Pedro H.S. Brancalion, et al. 2017), landscape multifunctionality has different spatial patterns, tradeoffs and synergies (Schulz & Schröder 2017). The perception of functional synergies on a larger scale must be thought of not only as multifunctional overlaps, but also considering complementary areas to achieve functional restoration targets operating on different scales (Lamb et al. 2005).

The integrative effort to restore multiple functions on a landscape scale, means the creation of a “mosaic”, where protected areas, managed forest patches, other forms of tree cover and productive uses are combined and connected (Dudley 2005), which is one of the major differences between a local-topic ecological restoration and FLR. Any project of FLR will be a set of site-based techniques whose combined and integrated will provide significant landscape-level impacts (Maginnis 2005).

Connectivity is viewed as an important component to conserve and improve biodiversity and increase heterogeneity in a local and landscape level (Zhou et al. 2008; Lamb et al. 2005; Brancalion & Chazdon 2017; Newton et al. 2012). Additionally, the more connected the habitats are, the greater the options for increasing resilience and adaptability of existing farming systems

(Maginnis & Jackson 2003; FAO 2016). Agricultural production may also be benefited from higher forest cover that enhance the provision of a more dependable water streamflow during the dry season and lower stream sediment loads in the wet season (Báez et al. 2011).

Since FLR attempts to address both, conservation and production issues at a landscape level, the transition towards sustainable and heterogeneous landscapes is necessary, enabling restoration of functions and processes that enhance ecosystem integrity, productivity, and resilience (Aronson & Alexander 2013). The choice of land uses should be made taking into account the bio-physical characteristics and the ecological, socio-economic and cultural aptitudes of the landscape. Because of that, identifying degraded land cover through multi-stakeholder consultations and reviewing relevant land use and cover maps and statistics is an essential issue (Lamb et al. 2005; Pistorius et al. 2017; Schulz & Schröder 2017).

Management and monitoring

To be successful, the monitoring scheme must incorporate appropriate indicators at site and landscape scales and predict actions for different timescales (IUCN 2014). For cost-effectiveness, the monitoring should use the smallest number of indicators, and they must be measured simply and easily (IUFRO 2017). It must also be applicable by trained natural and social scientists and by local communities or untrained forest workers (IUCN 2014; Sacande et al. 2015).

Data collection for monitoring can be made by the use of questionnaires, interviews, site visits and disclosure by progress reports (U.S. Forest Service 2017; Chng 2005; Nigel Dudley 2005; Ianni & Geneletti 2010; Gregorio et al. 2017; Walpole et al. 2017). The reports might include information such as description of areas under restoration activities, evaluation of project performance/progress, achievement of community benefits, summary of the costs of treatments (Schultz et al. 2014). Schultz et al. (2014) also argue that the monitoring must reflect the relevant restoration objectives and activities for each landscape, because each project develops a set of ecological and socio-economical metrics and desired conditions to evaluate progress within the FLR.

Ecological monitoring protocols should include a diverse set of indicators to provide robustness against the inevitable changes in conditions, expectations, and priorities over time. Some indicators could be extent of forest cover forest composition, structure and connectivity; carbon storage (in aboveground and belowground components); water yield and quality; groundwater

recharge and quality; biodiversity (floral and faunal); list of threatened species found; key flora and fauna habitats (e.g., closed forest, woodlands, dead wood, forest edges, trees outside forests in agroforestry systems, streams, lakes, meadows); and compiling baseline information on conditions of the system and the degree of human intervention (intactness) (IUCN 2017).

Although, the principle should consider the assessment of the landscape configuration and subsequent changes, including forest connectivity and enhancement of forest cover; diversification and heterogeneity of land uses; habitat permeability and flow of species and other elements (e.g. disturbance factors).

Besides, being a way of measuring success, several authors highlight that monitoring must allow adaptive management over time, in order to promote learning, improving practices over time, understanding the challenges and identifying solutions (Apostol & Shlisky 2012; McLain et al. 2017; Dudley & Aldrich 2007; Newton et al. 2012; U.S. Forest Service 2017). Beyond that, FLR is a long-term process and the goals and needs of stakeholders might change over time, so the actions have to be adaptable and flexible (Saint-laurent 2009; ITTO 2006).

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COFFEE AGROFORESTRY SYSTEM AS AN ALTERNATIVE FOR TROPICAL FOREST RESTORATION

1. INTRODUCTION

A direct effect of human population growth is the loss and fragmentation of native ecosystems (Lamb et al. 2005) mainly due to agricultural expansion, which is also an impediment for reestablishing forest cover on degraded sites (Báez et al. 2011). This directly influences biodiversity conservation, by increasing the risks of local and global extinction of species (Ashton 1988; Turner 1996), and ecosystems integrity (Collinge 1996), lately quite observed through the consequences of climate change (Kusters 2015; IUFRO & World Resources Institute; Maillot et al. 2015).

Despite the inexistence of an easy answer to how much area must be restored or be intended to other uses (FAO 2016), the transition towards heterogeneous and more sustainable land uses is necessary to enable restoration of ecosystems functions and processes, productivity, and resilience (Aronson & Alexander 2013). The reflection of this urgent need are the global restoration agreements and their ambitious goals, such as the Bonn Challenge to restore 150 million ha of degraded landscapes by 2020 (Bonn Challenge, 2015), the New York Declaration to halt natural deforestation and restore 200 million ha by 2030 (NY Declaration on Forests, 2014), the 20x20 Initiative in Latin America to restore 20 million ha of forest landscapes by 2020, the Aichi target 15 of the Convention on Biological Diversity to restore 15% of degraded terrestrial ecosystems by 2020, and the voluntary restoration commitments assumed by countries in the Paris Climate Agreement, to be communicated as intended nationally determined contributions (INDCs) for reducing emissions and increasing carbon storage (Chazdon et al. 2017).

All those agreements emphasize the importance of integrating forest restoration initiatives with agricultural activities as a strategy for large-scale restoration (Pohle & Gerique 2008; Latawiec et al. 2015; Chazdon et al. 2017). By merging forest and landscape restoration with production systems we can minimize the costs of forest restoration, reduce the need for more agricultural land, maximize natural regeneration and increase opportunities for forest recovery within agricultural landscapes (Uriarte & Chazdon 2016; Latawiec et al. 2015). Besides, we stimulate forest and landscape restoration by increasing the permeability of native species in fragmented

agricultural landscapes (Harvey et al. 2008) as explained in the land sharing concept for biodiversity conservation (Green et al. 2005; Fischer et al. 2014).

Agroforestry systems (AFS) are among the most representative systems that integrate productive and ecological restoration goals (Lamb et al. 2005; Souza et al. 2016; Schulz & Schröder 2017; IUFRO 2017). Basically, AFS consist of land-uses where woody perennials are raised with agricultural crops in a spatial arrangement or temporal sequence (Hillbrand et al. 2017; FAO 2016). Worldwide, AFS have been cited as a successful option for agricultural production (Besseau et al. 2018). Biodiverse agroforestry systems are also mentioned as an ecological restoration strategy that is cheaper (Ramos et al. 2009) and more likely to succeed than conventional restoration plantings, because of the improvement of livelihood conditions (Besseau et al. 2018) and the provision of goods and services (Orsi & Geneletti 2010; IUFRO 2017). Furthermore, some authors argue that agroforestry systems promote a greater human involvement with forests, providing a reconnection with nature, reflecting higher conservation outcomes (Miller 2005; Folke et al. 2011; Raymond et al. 2013).

However, given the huge amount of agroforestry arrangements (Nair 1985; de Oliveira & Carvalhaes 2016), there are many open questions and limited information about forest restoration outcomes in these ecosystems (de Paula & de Paula 2003; Mercer 2004). The idea that some agroforestry systems can achieve forest restoration success and promote better results than conventional restoration is still a hypothesis to be tested. For this reason, we investigated the ecological outcomes of a shaded coffee AFS. Coffee agroforestry systems are widely used in many regions around the world, and have showed great production and conservation results (De Beenhouwer et al. 2013; Cerda et al. 2017; Nesper et al. 2017; Robusti et al. 2017).

Ecological restoration success is usually assessed by vegetation indicators (Wortley et al. 2013). Canopy cover, density and richness of spontaneously natural regeneration, and aboveground carbon are among the most used indicators to monitor tropical forest restoration (Chaves et al. 2015; Suganuma & Durigan 2015; Viani et al. 2017). Thus, our objective was to evaluate these indicators in shaded coffee AFS, and consider whether values found in this production system are similar to those from native tree seedlings plantings, the conventional and most used forest restoration strategy (Rodrigues et al. 2009), and from regional reference ecosystems. By understanding which factors affect canopy cover and natural regeneration in AFS, we may better design these models for combining both production and ecological outcomes (Colavito 2017). Hence, we also evaluated whether landscape metrics (such as distance from forest remnants),

coffee AFS composition and structure (including density of native trees and coffee plants) are drivers of native trees natural regeneration in coffee agroforestry systems.

More specifically, we addressed the following questions: (i) Can a coffee AFS be an ecological efficient method for forest restoration? (ii) Which and how production and ecological factors influence the responses of ecological indicators in coffee AFS?, and considering that the density of coffee plants may vary within AFS and those plants could compete with native regeneration, (iii) Is there a density of coffee plants that could balance forest restoration and coffee production purposes in this AFS?

2. METHODS

2.1. Study area and sites

The study was carried out at the Pontal do Paranapanema region (Figure 1), municipalities of Teodoro Sampaio and Euclides da Cunha, São Paulo State, Southeastern Brazil. The native vegetation in the region belongs to the Seasonal Semi-deciduous Forest, which is a vegetation type within the Atlantic Forest biome (Ribeiro et al. 2009). The local climate has a hot and rainy season from October to March, with a dry period from April to September. Mean annual precipitation is 1,341 mm and mean temperature is 24.1°C (Alvares et al. 2013).

The altitude in the region varies from 265 to 320 m, and the predominant soil classes are the Ferrasol (Red Latosol) and Ultisol (Red-yellow Argisol) (Rossi 2017; Santos et al. 2018). Because the sandy, clay-poor and deep-drained characteristics of these soil types, the area has a high drainage (Girardi et al. 2002), and is naturally fragile and susceptible to erosion processes, aggravated by deforestation, which suggests the need for soil protection and the use of perennial crops that require little mechanization (Ditt 2002).

Deforestation in Pontal do Paranapanema occurred intensely in the middle of 20th century for cattle production and coffee plantations (Leonidio 2009), which were in the last decades partly replaced by sugarcane plantations. The region has evident landholding heterogeneity, with the presence of rural settlements between large farms and protected areas (Valladares-Padua et al. 2002). Nowadays, forest remnants occupy about 17% of the region, being the largest portion of forest (37,000 ha) belonging to the “Morro do Diabo” State Park, while another 6,200 ha are distributed over four forest remnants that comprises the Nacional Ecological Station of Black Tamarin (Uezu et al. 2008). Other forest fragments, with sizes ranging from 2 ha to 2000 ha, are spread over several private properties and land-reformed settlements (Cullen et al. 2005; Uezu et al. 2008).

In the last 15 years, the study region has been subjected to forest restoration projects coordinated by the Brazilian NGO “Institute of Ecological Research” (IPE). Besides conventional restoration planting, IPE has been implementing, with small farmers, areas of coffee shaded by native trees as a productive and forest restoration system (Cullen et al. 2005).

Figure 1. Figure 1. Locations of the study sites in the Pontal do Paranapanema landscape, São Paulo estate, Brazil. Each black dot is a 400m² study plot.

For the present study, we selected 12-15 years old shaded coffee AFS, 12-15 years old native tree seedlings plantings, as the business as usual method for Atlantic Forest restoration (CRP) (Rodrigues et al. 2011), and old-growth forests within protected areas as reference ecosystems (Ref).

Shaded coffee AFS are all in small farms within rural settlements and all had about 1 ha. They combine double lines of coffee (*Coffea arabica* L.) with about 20 Atlantic Forest native trees species. All sites were fenced to prevent cattle invasion, and fertilized and weeded mechanically and/or chemically in the first two years. Native trees species were randomly planted in 4 m x 4 m spacing (625 trees.ha⁻¹) and no handling or pruning has been carried out on them so far, while the practice of pruning of the coffee was observed in some sites. The initial spacing of coffee was about 1 m x 2,5 m between coffee plants and native trees respectively, resulting in about 4,000 coffee plants.ha⁻¹. However, during data collecting, coffee density varied from site to site because 1) some farmers abandoned the coffee plantations after the first years and left the area only for forest protection, 2) some farmers are still producing coffee, but only for family supplies, and 3)

some still produce coffee more intensively for commercialization (Figure 7, at supplementary files). All shaded coffee AFS were within a radius of 40 km.

Conventional restoration plantings were made in 3 m x 2 m spacing (1,667 trees.ha⁻¹) with 80-100 native tree species, including pioneer and non-pioneer ones. Tree species were randomly distributed in the planting areas, but controlling for the non-repetition of the same species one after another in the planting line. Trees were protected from fire, fenced to prevent cattle invasion, and weeded for two years after planting. Those conventional restoration plantings have been done within big farms, arranged as ecological corridors, aiming to increase connectivity between forest fragments.

Old-growth forests at the National Ecological Stations of Black Tamarin (ESBT) were selected as reference ecosystems. We selected this protected area as a reference ecosystem because its fragments are within the landscape selected for the study and it is no more than 15 km away from the sites we sampled. Moreover, it is a well-conserved patch of Seasonal Semi-deciduous Forest. Within the reference ecosystem, plots were located at least 50 m far from the borders and 150 m far from each other.

2.2. Data collection

We sampled 20 coffee shaded AFS (24 plots), four native tree seedlings plantings (14 plots) and three old-growth forests as reference ecosystem (8 plots), totaling 27 areas and 46 plots of 25 m x 16 m (400 m²) each, randomly distributed. Within each plot we measured diameter at breast height (DBH), height and identified all living rooted trees with DBH $\geq$ 5 cm. Additionally, we installed two 4 m x 25 m subplots inside each plot to analyze canopy cover, and natural regeneration density and richness.

Canopy cover was estimated in percentage by an adaptation of the line interception method (Viani et al. 2018). A 25 m line was placed in the forest floor and the portions of this line covered by the vertical projection of the tree canopies were measured and converted to percentages. To account for the natural regeneration density and richness, we identified and counted all native woody plants with height $>$ 50 cm and DBH $<$ 5 cm, excluding planted seedlings.

All identified species were classified, through secondary data, into seed dispersion syndromes (animal-dispersed or non-biologically dispersed) (Yuka Zama et al. 2012; Silva 2012; Barbosa et

al. 2015; Embrapa 2011), successional group (pioneer or non-pioneer) (Embrapa 2011; Barbosa et al. 2015), origin (native, native endemic from Brazilian forests; exotic cultivated; exotic naturalized; exotic with invasive potential (Brazilian Flora 2020), and threatened status according to the IUCN red list (John Lamoreux et al. 2003) (Table 2, appendix A).

2.3. Data analysis

First, we calculated density and number of species per plot, we carried this separately for trees with DBH > 5 cm and for natural regeneration. We estimated tree aboveground biomass (AGB) of each stem based on the allometric equation developed by Chave et al. (2014) for plots in the reference ecosystem, and on Ferez et al. (2015) for conventional restoration plantings and coffee AFS. Data on wood density for the sampled tree species were obtained from Global Wood Density Data Base (Chave et al. 2009). For unidentified individuals, we added wood density as the average density for the plot. Then, density, canopy cover, mean species per plot and AGB were compared among AFS, reference ecosystem and conventional restoration plantings using ANOVA followed by the Tukey's test for mean *post-hoc* comparison ($\alpha = 0.05$) when data were normally distributed. When data were non-normally distributed we compared them using Kruskal-Wallis followed by the WilCox test for mean comparison ($\alpha = 0.05$). We used R 3.5.1 for all analysis (R Core Team 2018).

For tree species richness comparison, we generated species rarefied curves with individuals identified to species level, using the rarefy function in the R package called 'vegan' (Oksanen et al. 2018). To compare species composition among restoration strategies and reference ecosystems, we calculated Chao-Jaccard dissimilarity index (Chao et al. 2004) between each plot and created a graph using nonmetric multidimensional analysis to visualize dissimilarity among plots using the "mds" function. Finally, to infer about restoration success, we compared coffee AFS values for natural regeneration richness and density, and for canopy cover with reference values (prescribed as adequate, minimum or critical according to the thresholds) used to attest mandatory ecological restoration in São Paulo state, Brazil (Chaves et al. 2014).

To understand which factors affect ecological indicators in the AFS, we made a regression analysis using Generalized Linear Models (GLM). As predictor variables we used coffee density, canopy cover, planted trees richness and density, natural regeneration richness and density, distance for the nearest forest fragment (m), percentage of animal-dispersed species among

planted trees and AGB. We followed Galipaud et al. (2014) and removed those predictors that have high correlation with response variables. We modelled using a negative binomial distribution after comparing Akaike information criteria (AIC) with a Poisson distribution. Our models with a Poisson distribution were overdispersed (Hoef & Boveng 2007). Thus, we used `glm.nb` function with arguments `link = log` in “MASS” package (Venables et al. 2002). Additionally, we used the function `dredge` from “MuMIn” (Barton 2018), which combine all possibility models using the predictor variables. For each model, dredge calculated the Akaike Information Criteria corrected for small samples (AICc), the Akaike weight (w_i) and the adjusted r^2 ($\text{adj } r^2$). Then, we ranked models according to the ΔAICc . Complementarily, we analyzed the predictors individually using `summary` function in R 3.5.

3. RESULTS

3.1. Forest structure indicators

As expected, we found the greatest values for forest structure indicators in the reference ecosystems (Figure 2). Density of trees (ind.ha^{-1}) was higher in reference forests and similar between coffee AFS and conventional restoration planting (Figure 2a). Surprisingly, even with variable numbers of trees (with $\text{DBH} > 5 \text{ cm}$) in the researched areas, we did not find significant differences between them in AGB (Figure 2c).

We found no difference between coffee AFS and reference ecosystem for the percentage of canopy cover, but lower values for conventional restoration plantings (Figure 2d). Density of natural regeneration in coffee AFS was lower than in the reference forest; however, was higher than in the conventional restoration plantings (Figure 2b). According to São Paulo State-Brazil thresholds to attest forest restoration, values of natural regeneration density, and values of canopy cover in the coffee AFS were minimum and adequate, respectively, while conventional restoration plantings values were critical for both indicators (Figure 2b,d; and Table 3, appendix B).

Figure 2. Mean values for a) tree density (DBH > 5 cm); b) natural regeneration density (height > 50 cm, DBH < 5 cm); c) aboveground biomass (AGB), and d) canopy cover in coffee agroforestry system (AFS), reference forests (Ref) and conventional restoration planting (CRP). Different letters above the boxplots indicate difference (Tukey test, $p < 0.05$). Values above the green line are considered **adequate**, between the green and the red lines are considered **minimum**, and below the green line are considered **critical** according to the São Paulo State-Brazil thresholds to attest forest restoration success.

3.2. Species richness and composition

We found 86 native species of natural regeneration in the coffee AFS, with a minimum of 3 and a maximum of 21 species per area. From the 20 coffee AFS we evaluated, 7 had 15 or more species, which is the minimum threshold for natural regeneration richness (of this class of age) to attest forest restoration into São Paulo State, Brazil. For the reference forests and for the conventional restoration plantings we found 98 and 38 regeneration species, respectively, and from the 4 CRP we evaluated, 2 had 15 or more species (Appendix C – Table 4). For trees

species (DBH > 5 cm), we found 85 species in all areas of coffee agroforestry system, 55 in the conventional restoration plantings and 90 in the reference forests. Two vulnerable species (*Cedrela fissilis* and *Apuleia leiocarpa*) were found at the coffee AFS, and three in the conventional restoration plantings (*Zeyheria tuberculosa*, *Cedrela fissilis* and *Apuleia leiocarpa*). Five threatened species were sampled in the reference ecosystem (*Aspidosperma polyneuron*, *Balfourodendron riedelianum*, *Handroanthus impetiginosus*, *Apuleia leiocarpa* and *Zeyheria tuberculosa*).

A greater mean number of species per plot was found in the reference ecosystem, both for trees (DBH > 5 cm) and natural regeneration (DBH < 5 cm and H > 50 cm) (Figure 3a,b). We did not find differences in the mean number of tree species between the coffee AFS and the conventional restoration plantings (Figure 3a). However, for the mean number of species recruiting as natural regeneration, the coffee AFS had intermediate values followed lastly by conventional restoration plantings (Figure 3b). The percentage of animal-dispersed trees did not differ between areas (Figure 3c). On the other hand, mean number of animal-dispersed recruits was lower and had the greatest variation in the conventional restoration plantings (Figure 3d).

Figure 3. Mean a) number of tree species per plot (DBH > 5 cm); b) density of the natural regeneration per plot (height > 50 cm and DBH < 5); c) percentage of animal-dispersed species for planted trees; and d) percentage of animal-dispersed species for natural regeneration, in coffee agroforestry systems (AFS), reference forests (Ref) and convention restoration planting (RPI). Different letters above the boxplots indicate differences (Tukey test, $p < 0.05$).

Rarefied species richness curves indicated a higher number of tree species in the coffee AFS, followed by the reference forests and lastly by the conventional restoration plantings (Figure 4a). For the natural regeneration, species richness was similar between the reference forests and the coffee AFS, and lower in the conventional restoration plantings (Figure 4b).

We observed that reference forest remnants are composed by a particular pool of tree species, widely different from both the conventional restoration plantings and the coffee AFS (Figure 4c), while natural regeneration composition was similar among all areas (Figure 4d). Conventional restoration plantings had the greatest species composition variation for trees and for natural

recruits, without any distribution pattern among its plots (Figure 4c,d). All species found in each ecosystem studied are presented in Table 4 (appendix).

Figure 4. Richness rarefaction curves for a) native tree species (DBH > 5 cm); and b) for natural regeneration (DBH < 5 and H > 50 cm), and two-dimensional nonmetric dimensional scaling plots of Chao-Jaccard dissimilarity index c) for the natural regeneration; and d) for native trees, in coffee agroforestry systems (AFS), reference forests (Ref) and convention restoration planting (RPI) at Pontal do Paranapanema landscape. Dotted lines represent one standard deviation from the mean number of species.

3.3. Factors affecting natural regeneration in the understory of the coffee agroforestry system

The only predictor variable explaining natural regeneration in the understory of coffee AFS was the density of coffee plants (Table 1, $p = 0.0004$, $r^2 = 0.53$). The higher the amount of coffee plants (ind.ha^{-1}), the lower is the density of the natural regeneration (Figure 5).

According to our model, 15 years old coffee AFS would support about 1,100 and 1,600 coffee plants per hectare to maintain a natural regeneration density within the adequate and minimum reference values to attest forest restoration according to São Paulo State requirements (Figure 5). We didn't find predictor variables explaining natural regeneration richness and canopy cover (Table 1). The complete list of models generated can be found in Appendix D.

Table 1. Relations between predictor variables with the natural regeneration density and richness, and with the forest cover in coffee agroforestry systems. The value in bold indicate a negative relationship between the coffee density and the natural regeneration density (GLM).

Predictor variable	Natural regeneration density (p value)	Natural regeneration richness (p value)	Canopy cover (p value)
above ground biomass	0.9296	0.906	0.337
tree richness (DBH > 5 cm)	0.8285	0.164	0.908
tree density (DBH > 5 cm)	0.2215	0.525	0.165
animal dispersed species (%)	0.8465	0.847	0.204
distance from the nearest forest fragment (m)	0.3083	0.231	0.358
canopy cover (%)	0.1973	0.955	-
natural regeneration density (ind.ha^{-1})	-	-	0.582
natural regeneration richness	-	-	0.898
coffee density (ind.ha^{-1})	0.0004 (-)	0.542	0.496

Figure 5. Negative binomial generalized linear model between the natural regeneration density and the coffee abundance in coffee agroforestry systems at Ponta do Paranapanema, São Paulo, Brazil. The green line is the “adequate” threshold, below the red line means “critical” and between lines means “minimum” by São Paulo state legal framework.

4. DISCUSSION

As expected, the forests in the conventional restoration plantings and in the coffee AFS are less structured (have lower tree and natural regeneration abundances) and possess lower tree and natural generation richness than the reference ecosystem. Forests under restoration may take several decades to reach values from reference ecosystems for many ecological indicators, especially when we consider high complex and diverse tropical forests (Suganuma & Durigan 2014; Amazonas et al. 2011). It is also known that levels of biodiversity and provision of ecosystem services are usually lower for restored than reference ecosystems (Rey Benayas et al. 2009). However, we surprisingly did not find differences in AGB, a predictor of biomass and carbon accumulation and an important ES provided by tropical forests (Budiharta et al. 2014). Even with a large mean number of trees per plot, reference forests presented high plot variation in AGB. Probably because of the high canopy closure and high natural regeneration densities, trees compete more often for light and space and consequently most of them presented slower measures of diameter in this environment (Valladares et al. 2016; Farrior et al. 2016) than in coffee AFS and in well-managed forest restoration plantings.

We found, in general, a better forest structure for the coffee AFS than for the conventional restoration plantings. The coffee AFS did not have lower abundances of trees and natural regeneration than the conventional restoration plantings after 15 years, even the conventional restoration plantings (1,667 native trees.ha⁻¹) having more than the double of trees planted in the coffee AFS (625 native trees.ha⁻¹). However, even with almost the same amount of trees per plot after 15 years, the coffee AFS has a higher canopy cover than the conventional restoration plantings.

We also found a richer tree community, for planted and natural regenerating trees, in the coffee AFS than in the conventional restoration plantings. They did not differ for the mean number of species for the coffee AFS and the conventional restoration plantings, despite the higher number of native tree species planted at the conventional restoration plantings in comparison to the coffee AFS. This result showed that the most sensitive species were not well established or have been poorly distributed at conventional restoration planting areas, decreasing the number of species sampled in that method (Hewitt & Kellman 2004). However, the number of species was higher in the coffee AFS than in the conventional restoration plantings. When analyzing accumulation curves and when looking at the natural regeneration community, evidencing the potential capacity of this methodology to increase biodiversity at landscape level when different

actors are involved with forests goods and services (Alexandra & Campbell 2003; IUFRO & World Resources Institute 2011; Reij & Garrity 2016). Finally, we found a greater proportion of animal-dispersed trees in the natural regeneration in the coffee AFS than in conventional restoration planting, which can be related to the attraction of seed-dispersers by coffee plants (Komar 2006; Caudill et al. 2015; Perfecto et al. 2003).

These comparisons between AFS and conventional restoration plantings indicate that trees in the coffee AFS had higher survival rates, better growth performance and canopy closure, probably due the more intensive management in the interrow of the coffee plantation. In the tropics, native trees planted with restoration purposes intensively compete with invasive grasses (Dahler 2003; Powell et al. 2017), which impose a barrier for the success of forest restoration initiatives (Ferez et al. 2015; Campoe et al. 2014; Holl et al. 2000). Intensively managing restoration areas for grasses control positively influence native trees growth and survival (Campoe et al. 2010).

A high mortality rate for trees at the conventional restoration plantings negatively influenced the development of a canopy cover (Rodrigues et al. 2010) and, consequently, limited establishment of the natural regeneration (Gandolfi et al. 2007; Standish et al. 2014). The lack of a forest canopy and scarcity of spontaneously natural regeneration observed in conventional restoration plantings may compromise their future sustainability, which point to the need of urgent actions to improve these areas. This shows us the importance of ecological monitoring of restoration projects, in order to prevent those unfavorable conditions for forest restoration are perpetuated (Holl et al. 2010).

Although not all conventional tropical forest restoration initiatives based on native trees planting lack monitoring and intensive management as we described above, several cases of failure as a consequence of an absence of correct management after planting have been described (Rodrigues et al. 2010). In this sense, our results corroborate the idea that a more constant monitoring carried out by rural producers may be an advantage and a cause for the higher ecological success of AFS than conventional forest restoration plantings where no incomes from agriculture or timber production is expected (Vieira et al. 2009; Brancalion et al. 2012).

If in one hand, coffee plants may attract the dispersing fauna into AFS (Komar 2006; Caudill et al. 2015; Perfecto et al. 2003), on the other, they can compete with the seedlings arriving via natural regeneration. Thus, there is a tradeoff between ecological restoration and productive goals at the coffee AFS: when we increase the number of coffee plants per area aiming for a more productive AFS, we negatively affect the ecological restoration outcomes, by reducing density of

the natural regeneration tree community. Additionally, our results may suggest a way to combine and maximize both ecological and productive goals in coffee AFS: to start the system with a higher number of coffee plants per area and reduce this number along the time to up to 1,100 plants.ha⁻¹ at the 15 years old. Accordingly to our modeling, this number of plants per hectare should be the upper limit of coffee plants per area that would keep natural regeneration density within adequate levels for the success of forest restoration, at least in São Paulo State (Chaves et al. 2015). A number of 1,100 plants.ha⁻¹ is smaller than the original density of coffee plants in the AFS we evaluated and near than the usual density of coffee plants in shade-grown coffee systems (Dossa et al. 2008). Thus, coffee productivity would not be impacted by the results we found in our modeling.

The coffee AFS at 15 years old is not similar to reference forest for many ecological indicators, but has produced better ecological outcomes than local conventional restoration plantings. Besides, the coffee AFS has in general reached values for ecological indicators that are within the expectations for local mandatory forest restoration (Chaves et al. 2015). This suggests that the studied coffee AFS is a viable alternative for large-scale tropical forest restoration. However, this topic should be the subject of more detailed studies, especially those quantifying also coffee production and the impacts of prioritizing ecological outcomes in coffee productive. As we found, canopy cover, measured by line interception method, was over 80% in the coffee AFS, which is desirable for forest restoration. Although we cannot simply compare this measure to different methods of evaluating canopy close, we considered this value possibly higher than shade values usually prescribed for productive systems with shade-grown coffee (40-60%) (Cerdeira et al. 2017; Vaast Philippe et al. 2005; Lin 2007). However, besides the quantity production it's important to consider the quality of coffee under shade environment (Nesper et al. 2017) and addressing this question for balancing productive and conservation goals should be the objective of further studies.

5. FINAL CONSIDERATIONS

Despite the dynamic of human-modified landscapes in the Pontal do Paranapanema and the high spatial environmental variability in coffee agroforestry systems, we observed that they play an ecological key role, increasing forest structure and diversity in a predominantly fragmented agricultural landscape. We identified that the major drivers of ecological restoration in the studied agroforestry system is the integrated management of coffee plants, either at the beginning, favoring the growth and development of the native trees planted, or after 15 years competing with the natural regeneration (when at high densities). On the other hand, in comparison with conventional restoration planting, even the most productive AFS presented higher ecological responses (table 3, in appendix), standing out as a good alternative for FLR.

As we observed, AFS became a “garden” from settlers farmers, which manage and produce several other products besides the coffee (i.e. timber, fruits, honey) maintaining and protecting these forests patches (de Oliveira & Carvalhaes 2016; de Souza et al. 2016). This impression, make us attribute the forest restoration success also to the contact between producer and forest. However, it is necessary to investigate more deeply the psychological, social and economic factors that support this relationship in AFS (Bhagwat et al. 2008; Raymond et al. 2013; Celentano et al. 2016). Actually, there is few researches investigating how AFS act as facilitators of ecological restoration (Vieira et al. 2009), what makes this study an important tool for decision-making, and a support for public policies that consider AFS as forest restoration activities.

Regarding the Pontal do Paranapanema study-case, it is possible to confirm that coffee AFS with native tree species have a great potential to increase forest structure, positively influencing spontaneously natural regeneration in the understory, a trend widely supported for plantations with only tree species until now (Cusack & Montagnini 2004). In view of the reduced area in AFS plantations, they do not offer extensive restoration opportunities, but clearly these landscapes are benefiting from having trees planted in strategic places to protect and enhance agricultural productivity, biodiversity conservancy, carbon storage and other ES and functions, being a win-win strategy for rural settlers (IUCN 2014).

Finally, we see as necessary the development of more long-term research in productive AFS, including, besides the ecological indicators evaluated here, the quantification of the crop production and of the ecosystem services, as well as ways of valuing both.

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SUPPLEMENTARY FILES

Figure 6. A) Coffee agroforestry system; B) Conventional restoration planting.

Figure 7. Fifteen years old coffee agroforestry system with A) a high, B) a medium, and C) a low density of coffee plants, at Pontal do Paranapanema, São Paulo, Brazil.

APPENDIXES

APPENDIX A.

Table 2. List of identified species, classified by functional traits. Threatened status (EN= Endangered; VU= Vulnerable; NT= Near Threatened; LC= Least Concern; NC= Non-Classified). Successional group (P= Pioneer or NP= Non-pioneer). Origin and Endemism (N=Native; NE= Native Endemic; EC= Exotic Cultivated; EN= Exotic Naturalized; E*=Exotic with invasive potential). Dispersion syndrome (Z= animal-dispersed; A=auto-dispersed; W=Wind-dispersed).

Scientific Name	Family	Threat Status	Origin	Successional Group	Dispersion Syndrome
<i>Acacia mangium</i> Willd.	Fabaceae	NC	EC	NC	Z
<i>Acacia plumosa</i> Martius ex Colla	Fabaceae	NC	NE	P	A
<i>Acrocomia aculeata</i> (Jacq.) Lodd. ex Mart.	Arecaceae	NC	N	NP	Z
<i>Actinostemon conceptionis</i> (Chodat & Hassl.) Hochr.	Euphorbiaceae	NC	N	NP	A
<i>Actinostemon concolor</i> (Spreng.) Mull.Arg.	Euphorbiaceae	NC	N	NP	A
<i>Actinostemon klotzschii</i> (Didr.) Pax	Euphorbiaceae	NC	N	NP	Z
<i>Aegiphila integrifolia</i> (Jacq.) Moldenke	Lamiaceae	NC	N	P	Z
<i>Aegiphila sellowiana</i> Cham.	Lamiaceae	NC	N	P	Z
<i>Albizia niopoides</i> (Spruce ex Benth.) Burkart	Fabaceae	LC	N	P	A
<i>Alchornea sidifolia</i> Mull.Arg.	Euphorbiaceae	NC	N	P	Z
<i>Alchornea</i> sp.	Euphorbiaceae	NC	N	P	Z
<i>Alchornea triplinervia</i> (Spreng.) Mull.Arg.	Euphorbiaceae	NC	N	P	Z
<i>Allophylus edulis</i> (A.St.-Hil. et al.) Hieron. ex Niederl.	Sapindaceae	NC	N	P	Z
<i>Anadenanthera colubrina</i> (Vell.) Brenan	Fabaceae	NC	N	NP	A
<i>Anadenanthera colubrina</i> var. <i>cebil</i> (Griseb.) Altschul	Fabaceae	NC	N	NP	A
<i>Anadenanthera peregrina</i> (L.) Speg.	Fabaceae	NC	N	NP	A
<i>Anadenanthera peregrina</i> var. <i>falcata</i> (Benth.) Altschul	Fabaceae	NC	N	NP	A
<i>Anadenanthera</i> sp.	Fabaceae	NC	N	NP	A
<i>Aniba firmula</i> (Nees & Mart.) Mez	Lauraceae	NC	NE	NP	Z
<i>Annona cacans</i> Warm.	Annonaceae	LC	N	P	Z
<i>Annona muricata</i> L.	Annonaceae	NC	EC	P	Z
<i>Annona squamosa</i> L.	Annonaceae	LC	EC	P	Z
<i>Apocynaceae</i> sp.	Apocynaceae	NC	N	NC	W
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	Fabaceae	VU	N	NP	A
<i>Artocarpus heterophyllus</i> Lam.	Moraceae	NC	EN	P/NP	Z
<i>Aspidosperma parvifolium</i> A.DC.	Apocynaceae	NC	NE	NP	W
<i>Aspidosperma polyneuron</i> Müll.Arg.	Apocynaceae	NT	N	NP	W
<i>Asteraceae</i> Bercht. & J.Presl	Asteraceae	NC	N	NC	W
<i>Astronium graveolens</i> Jacq.	Anacardiaceae	LC	N	NP	W
<i>Baccharis dracunculifolia</i> DC.	Asteraceae	NC	N	P	W
<i>Balfourodendron riedelianum</i> (Engl.) Engl.	Rutaceae	NT	N	NP	W
<i>Bauhinia forficata</i> Link	Fabaceae	NC	N	P	A
<i>Bixa orellana</i> L.	Bixaceae	NC	N	P	Z
<i>Bromelia antiacantha</i> Bertol.	Bromeliaceae	NC	N	NP	Z

<i>Campomanesia aurea</i> O.Berg	Myrtaceae	NC	N	NP	Z
<i>Campomanesia guaviroba</i> (DC.) Kiaersk.	Myrtaceae	NC	N	NP	Z
<i>Campomanesia guazumifolia</i> (Cambess.) O.Berg	Myrtaceae	NC	N	NP	Z
<i>Campomanesia xanthocarpa</i> (Mart.) O.Berg	Myrtaceae	LC	N	NP	Z
<i>Cariniana estrellensis</i> (Raddi) Kuntze	Lecythidaceae	NC	N	NP	W
<i>Cariniana legalis</i> (Mart.) Kuntze	Lecythidaceae	EN	NE	NP	W
<i>Caryocar brasiliense</i> Cambess.	Caryocaraceae	LC	N	NP	Z
<i>Casearia gossypiosperma</i> Briq.	Salicaceae	LC	N	P	Z
<i>Casearia sylvestris</i> Sw.	Salicaceae	NC	N	P	Z
<i>Cecropia</i> Loebl.	Urticaceae	NC	N	P	Z
<i>Cecropia pachystachya</i> Trucul	Urticaceae	NC	N	P	Z
<i>Cedrela fissilis</i> Vell.	Meliaceae	VU	N	NP	W
<i>Ceiba speciosa</i> (A.St.-Hil.) Ravenna	Malvaceae	NC	N	NP	W
<i>Centrolobium tomentosum</i> Guillem. ex Benth.	Fabaceae	LC	NE	NP	W
<i>Cereus jamacaru</i> DC.	Cactaceae	NC	NE	NC	Z
<i>Citharexylum myrianthum</i> Cham.	Verbenaceae	NC	N	P	Z
<i>Citrus aurantiifolia</i> (Christm.) Swingle	Rutaceae	NC	EC	NC	Z
<i>Citrus</i> sp.	Rutaceae	NC	EC	NC	Z
<i>Citrus x aurantium</i> L.	Rutaceae	NC	EN*	NC	Z
<i>Colubrina glandulosa</i> Perkins	Rhamnaceae	LC	N	P/NP	Z
<i>Copaifera langsdorffii</i> Desf.	Fabaceae	LC	N	NP	Z
<i>Cordia americana</i> (L.) Gottschling & J.S.Mill.	Boraginaceae	NC	N	NP	W
<i>Cordia ecalyculata</i> Vell.	Boraginaceae	NC	N	NP	Z
<i>Cordia</i> sp.	Boraginaceae	NC	N	NP	Z
<i>Cordia superba</i> Cham.	Boraginaceae	NC	NE	P	Z
<i>Cordia trichotoma</i> (Vell.) Arráb. ex Steud.	Boraginaceae	NC	N	NP	W
<i>Coussarea hydrangeifolia</i> (Benth.) Mull.Arg.	Rubiaceae	LC	N	NP	Z
<i>Coutarea hexandra</i> (Jacq.) K.Schum.	Rubiaceae	NC	N	NP	W
<i>Croton floribundus</i> Spreng.	Euphorbiaceae	NC	N	P	A
<i>Croton urucurana</i> Baill.	Euphorbiaceae	NC	N	P	A
<i>Cupania tenuivalvis</i> Radlk.	Sapindaceae	NC	NE	NP	Z
<i>Cupania vernalis</i> Cambess.	Sapindaceae	NC	N	NP	Z
<i>Dahlstedtia muehlbergiana</i> (Hassl.) M.J.Silva & A.M.G. Azevedo	Fabaceae	NC	N	NP	A
<i>Dalbergia frutescens</i> (Vell.) Britton	Fabaceae	NC	N	NP	W
<i>Diatenopteryx sorbifolia</i> Radlk.	Sapindaceae	NC	N	P	W
<i>Dictyoloma vandellianum</i> A.Juss.	Rutaceae	NC	N	P	W
<i>Dilodendron bipinnatum</i> Radlk.	Sapindaceae	LC	N	NP	W
<i>Diospyros inconstans</i> Jacq.	Ebenaceae	LC	N	NP	Z
<i>Dipteryx alata</i> Vogel	Fabaceae	LC	N	P	Z
<i>Duguetia lanceolata</i> A.St.-Hil.	Annonaceae	LC	NE	P	Z
<i>Enterolobium contortisiliquum</i> (Vell.) Morong	Fabaceae	NC	N	P	A
<i>Eremanthus erythropappus</i> (DC.) MacLeish	Asteraceae	NC	NE	P	W
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Rosaceae	NC	EN*	NP	Z
<i>Erythrina verna</i> Vell.	Fabaceae	NC	NE	NP	A

<i>Erythroxylum pelleterianum</i> A.St.-Hil.	Erythroxylaceae	LC	N	NP	Z
<i>Esenbeckia febrifuga</i> (A.St.-Hil.) A. Juss. ex Mart.	Rutaceae	NC	N	NP	A
<i>Eugenia florida</i> DC.	Myrtaceae	LC	NE	NP	Z
<i>Eugenia</i> sp.	Myrtaceae	NC	N	NP	Z
<i>Eugenia myrcianthes</i> Nied.	Myrtaceae	NC	N	NP	Z
<i>Eugenia neoverrucosa</i> Sobral	Myrtaceae	NC	NE	NP	Z
<i>Eugenia paracatuana</i> O.Berg	Myrtaceae	NC	N	NP	Z
<i>Eugenia pyriformis</i> Cambess.	Myrtaceae	NC	N	NP	Z
<i>Eugenia rostrata</i> O.Berg	Myrtaceae	NC	NE	NP	Z
<i>Eugenia uniflora</i> L.	Myrtaceae	NC	N	NP	Z
<i>Ficus adhatodifolia</i> Schott in Spreng.	Moraceae	NC	N	NP	Z
<i>Ficus citrifolia</i> Mill.	Moraceae	NC	N	NP	Z
<i>Ficus enormis</i> Mart. ex Miq.	Moraceae	NC	NE	NP	Z
<i>Ficus gomelleira</i> Kunth	Moraceae	NC	N	NP	Z
<i>Ficus guaranitica</i> Chodat	Moraceae	NC	N	NP	Z
<i>Ficus obtusifolia</i> Kunth	Moraceae	NC	N	NP	Z
<i>Gallesia integrifolia</i> (Spreng.) Harms	Phytolaccaceae	NC	NE	NP	W
<i>Garcinia gardneriana</i> (Planch. & Triana) Zappi	Clusiaceae	NC	N	NP	Z
<i>Genipa americana</i> L.	Rubiaceae	LC	N	NP	Z
<i>Gliricidia sepium</i> (Jacq.) Kunth ex Walp.	Fabaceae	NC	EC	P	Z
<i>Grevillea robusta</i>	Proteaceae	NC	EC	P	W
<i>Guapira opposita</i> (Vell.) Reitz	Nyctaginaceae	NC	N	NP	Z
<i>Guarea guidonia</i> (L.) Sleumer	Meliaceae	NC	N	NP	Z
<i>Guazuma</i> Adans.	Malvaceae	NC	N	P	A
<i>Guazuma ulmifolia</i> Lam.	Malvaceae	NC	N	P	Z
<i>Handroanthus albus</i> (Cham.) Mattos	Bignoniaceae	LC	N	NP	W
<i>Handroanthus chrysotrichus</i> (Mart. ex DC.) Mattos	Bignoniaceae	NC	N	NP	W
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	Bignoniaceae	LC	N	NP	W
<i>Handroanthus impetiginosus</i> (Mart. ex DC.) Mattos	Bignoniaceae	NT	N	NP	W
<i>Handroanthus</i> Mattos	Bignoniaceae	NC	N	NP	W
<i>Handroanthus ochraceus</i> (Cham.) Mattos	Bignoniaceae	NC	N	NP	W
<i>Handroanthus umbellatus</i> (Sond.) Mattos	Bignoniaceae	NC	NE	NP	W
<i>Helietta apiculata</i> Benth.	Rutaceae	NC	N	NP	W
<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Mull.Arg.	Euphorbiaceae	NC	NC	P	Z
<i>Holocalyx balansae</i> Micheli	Fabaceae	NC	N	NP	A
<i>Hymenaea courbaril</i> L.	Fabaceae	LC	N	NP	Z
<i>Hypericum</i> sp.	Hypericaceae	NC	N	NC	A
<i>Inga laurina</i> (Sw.) Willd.	Fabaceae	LC	N	NP	Z
<i>Inga marginata</i> Willd.	Fabaceae	NC	N	NP	Z
<i>Inga sessilis</i> (Vell.) Mart.	Fabaceae	NC	NE	P	Z
<i>Inga vera</i> Willd.	Fabaceae	NC	N	P	Z
<i>Jacaranda caroba</i> (Vell.) DC.	Bignoniaceae	NC	NE	P	A
<i>Jacaranda cuspidifolia</i> Mart.	Bignoniaceae	NC	N	NP	W
<i>Jacaratia spinosa</i> (Aubl.) A.DC.	Caricaceae	LC	N	NP	Z

<i>Jatropha mollissima</i> (Pohl) Baill.	Euphorbiaceae	NC	N	NP	Z
<i>Leucaena leucocephala</i> (Lam.) de Wit	Fabaceae	NC	EN*	P	A
<i>Licania tomentosa</i> (Benth.) Fritsch	Chrysobalanaceae	NC	NE	NP	Z
<i>Lithraea molleoides</i> (Vell.) Engl.	Anacardiaceae	NC	N	NC	Z
<i>Luehea divaricata</i> Mart. & Zucc.	Malvaceae	NC	N	P/NP	W
<i>Luehea grandiflora</i> Mart. & Zucc.	Malvaceae	NC	N	NP	W
<i>Lychnophora ericoides</i> Mart.	Asteraceae	NT	NE	NC	W
<i>Mabea fistulifera</i> Mart.	Euphorbiaceae	NC	N	P	A
<i>Machaerium brasiliense</i> Vogel	Fabaceae	NC	N	NP	W
<i>Machaerium isadelphum</i> (E.Mey.) Amshoff	Fabaceae	NC	N	P/NP	W
<i>Machaerium nyctitans</i> (Vell.) Benth.	Fabaceae	LC	N	NP	W
<i>Machaerium</i> Pers.	Fabaceae	NC	N	NP	W
<i>Maclura tinctoria</i> (L.) D.Don ex Steud.	Moraceae	NC	N	NP	Z
<i>Magnolia ovata</i> (A.St.-Hil.) Spreng.	Magnoliaceae	LC	NE	NP	Z
<i>Malpighia emarginata</i> DC.	Malpighiaceae	NC	EC	NC	Z
<i>Mangifera indica</i>	Anacardiaceae	NC	EN*	P	Z
<i>Margaritopsis hassleriana</i> (Chodat) C.M.Taylor	Rubiaceae	NC	N	NC	Z
<i>Matayba elaeagnoides</i> Radlk.	Sapindaceae	NC	N	NP	Z
<i>Maytenus gonoclada</i> Mart.	Celastraceae	NC	N	NP	Z
<i>Melia azedarach</i> sp.	Meliaceae	NC	EN*	NP	Z
<i>Metrodorea nigra</i> A.St.-Hil.	Rutaceae	NC	N	NP	A
<i>Mimosa bimucronata</i> (DC.) Kuntze	Fabaceae	NC	NE	P	A
<i>Moquiniastrum polymorphum</i> (Less.) G. Sancho	Asteraceae	NC	N	P	W
<i>Musa</i> sp.	Musaceae	NC	EN	NC	A
<i>Myracrodruon urundeuva</i> Allemão	Anacardiaceae	NC	N	NP	A
<i>Myrcia</i> sp.	Myrtaceae	NC	N	NP	Z
<i>Myrcia guianensis</i> (Aubl.) DC.	Myrtaceae	LC	N	NP	Z
<i>Myrcia selloi</i> (Spreng.) N.Silveira	Myrtaceae	NC	N	NP	Z
<i>Myrcia splendens</i> (Sw.) DC.	Myrtaceae	NC	NE	NP	Z
<i>Myrciaria delicatula</i> (DC.) O.Berg	Myrtaceae	NC	N	NP	Z
<i>Myrocarpus frondosus</i> Allemão	Fabaceae	LC	N	NP	W
<i>Myroxylon peruiferum</i> L.f.	Fabaceae	NC	N	NP	W
<i>Myrsine umbellata</i> Mart.	Primulaceae	NC	N	NP	Z
<i>Ocotea velutina</i> (Nees) Rohwer	Lauraceae	NC	NE	NP	Z
<i>Ouratea castaneifolia</i> (DC.) Engl.	Ochnaceae	NC	N	NC	Z
<i>Parapiptadenia rigida</i> (Benth.) Brenan	Fabaceae	NC	N	NP	A
<i>Peltophorum dubium</i> (Spreng.) Taub.	Fabaceae	NC	N	NP	A
<i>Phaius tankervilleae</i> (Banks) Blume (accepted name)	Orchidaceae	NC	EC	NC	NC
<i>Platypodium elegans</i> Vogel	Fabaceae	NC	N	NP	W
<i>Pleradenophora membranifolia</i> (Mull. Arg.) Esser & A. L. Melo	Euphorbiaceae	NC	N	NC	Z
<i>Poecilanthe parviflora</i> Benth.	Fabaceae	LC	N	NP	A
<i>Poincianella pluviosa</i> (DC.) L.P.Queiroz	Fabaceae	NC	N	P/NP	A
<i>Pouteria torta</i> (Mart.) Radlk.	Sapotaceae	LC	N	NP	Z
<i>Protium heptaphyllum</i> (Aubl.) Marchand	Burseraceae	NC	N	NP	Z

<i>Psidium cattleianum</i> Sabine	Myrtaceae	NC	NE	NP	Z
<i>Psidium guajava</i> L.	Myrtaceae	NC	EN*	P/NP	Z
<i>Psychotria subtriflora</i> Mull.Arg.	Rubiaceae	NC	NE	NP	Z
<i>Pterocarpus rohrii</i> Vahl	Fabaceae	NC	N	NP	W
<i>Pterodon emarginatus</i> Vogel	Fabaceae	NC	N	NP	A
<i>Pterogyne nitens</i> Tul.	Fabaceae	LC	N	NP	W
<i>Randia armata</i> (Sw.) DC.	Rubiaceae	NC	N	NP	Z
<i>Rudgea jasminoides</i> (Cham.) Mull.Arg.	Rubiaceae	NC	N	NP	Z
<i>Ruprechtia laxiflora</i> Meisn.	Polygonaceae	NC	N	NP	W
<i>Sapindus saponaria</i> L.	Sapindaceae	NC	N	NP	Z
<i>Sapium glandulosum</i> (L.) Morong	Euphorbiaceae	NC	N	NP	Z
<i>Sapium haematospermum</i> Mull.Arg.	Euphorbiaceae	NC	N	NP	Z
<i>Sapium obovatum</i>	Euphorbiaceae	NC	N	NP	Z
<i>Sapotaceae</i> Juss.	Sapotaceae	NC	N	NP	Z
<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	Araliaceae	NC	N	P	Z
<i>Schinus molle</i> L.	Anacardiaceae	NC	N	NP	Z
<i>Schinus terebinthifolia</i> Raddi	Anacardiaceae	NC	N	P	Z
<i>Schizolobium parahyba</i> (Vell.) Blake	Fabaceae	NC	N	P	A
<i>Sebastiania</i> sp.	Euphorbiaceae	NC	N	NC	A
<i>Senegalia polyphylla</i> (DC.) Britton & Rose	Fabaceae	NC	N	P	A
<i>Senna macranthera</i> (DC. ex Collad.) H.S.Irwin & Barneby	Fabaceae	NC	N	P	A
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	Fabaceae	NC	N	P	A
<i>Sida</i> sp.	Malvaceae	NC	N	NC	Z
<i>Siparuna brasiliensis</i> (Spreng.) A.DC.	Siparunaceae	LC	NE	NP	Z
<i>Solanum aculeatissimum</i> Jacq.	Solanaceae	NC	N	P	Z
<i>Solanum granulosoleprosum</i> Dunal	Solanaceae	LC	N	P	Z
<i>Solanum mauritianum</i> Scop.	Solanaceae	NC	N	NP	Z
<i>Solanum paniculatum</i> L.	Solanaceae	NC	N	P	Z
<i>Solanum</i> sp.	Solanaceae	NC	N	P	Z
<i>Solanum swartzianum</i> Roem. & Schult.	Solanaceae	NC	N	P	Z
<i>Strychnos</i> sp.	Loganiaceae	NC	NE	NC	Z
<i>Syagrus romanzoffiana</i> (Cham.) Glassman	Arecaceae	LC	N	NP	Z
<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	NC	EN*	NP	Z
<i>Tabebuia roseoalba</i> (Ridl.) Sandwith	Bignoniaceae	NC	N	NP	W
<i>Tabernaemontana catharinensis</i> A.DC.	Apocynaceae	NC	N	P	Z
<i>Tabernaemontana hystrix</i>	Apocynaceae	NC	N	P	Z
<i>Tabernaemontana laeta</i> Mart.	Apocynaceae	NC	NE	P	Z
<i>Tapirira guianensis</i> Aubl.	Anacardiaceae	NC	N	NP	Z
<i>Terminalia glabrescens</i> Mart.	Combretaceae	NC	N	P	W
<i>Trema micrantha</i> (L.) Blume	Cannabaceae	NC	N	P	Z
<i>Trichilia catigua</i> A.Juss.	Meliaceae	NC	NE	NP	Z
<i>Trichilia elegans</i> A.Juss.	Meliaceae	NC	NE	NP	Z
<i>Trichilia pallida</i> Sw.	Meliaceae	NC	N	NP	Z
<i>Triplaris americana</i> L.	Polygonaceae	NC	N	P	W
<i>Vernonanthura polyanthes</i> (Sprengel) Vega & Dematteis	Asteraceae	NC	N	P	W

<i>Xylopia aromatica</i> (Lam.) Mart.	Annonaceae	LC	N	NP	Z
<i>Zanthoxylum caribaeum</i> Lam.	Rutaceae	NC	N	NP	Z
<i>Zanthoxylum rhoifolium</i> Lam.	Rutaceae	NC	N	NP	Z
<i>Zeyheria tuberculosa</i> (Vell.) Bureau ex Verl.	Bignoniaceae	VU	N	P/NP	W

APPENDIX B.

Table 3. Classification (Class.) of the sampled areas in minimum, critical or adequate category, according to the reference values used to attest forest restoration in São Paulo State, Brazil. Note: Areas of 12 years old were compared with thresholds for 10 year, while areas of 15 years old were compared with thresholds for the same age.

Area	Density of coffee (ind.ha ⁻¹)	Density of natural regeneration (ind.ha ⁻¹)	Class.	Number of species in the natural regeneration	Class.	Canopy cover (%)	Class.
Area 1	1150	1900	minimum	16	minimum	100	adequate
Area 2	1625	350	critical	3	critical	60	critical
Area 3	2050	1650	minimum	13	minimum	96	adequate
Area 4	1725	1550	minimum	10	minimum	88	adequate
Area 5	75	4550	adequate	12	minimum	98	adequate
Area 6	1125	1800	minimum	7	critical	86	adequate
Area 7	2625	2950	adequate	15	minimum	92	adequate
Area 8	2200	1250	minimum	7	critical	84	adequate
Area 9	4800	850	critical	9	critical	93	adequate
Area 10	1550	2500	adequate	13	minimum	75	minimum
Area 11	2800	500	critical	8	critical	90	adequate
Mean AFS 12y	1975	1805	Minimum	10	Minimum	87	Adequate
Area 12	25	3650	adequate	11	minimum	96	adequate
Area 13	0	4200	adequate	12	minimum	90,6	adequate
Area 14	75	9100	adequate	15	minimum	91	adequate
Area 15	900	2400	adequate	10	minimum	70	minimum
Area 16	1038	3325	adequate	16	minimum	94	adequate
Area 17	2150	2350	adequate	8	critical	86	adequate
Area 18	1663	2325	adequate	21	adequate	79	minimum
Area 19	3125	2300	adequate	18	minimum	66	minimum
Area 20	650	1650	minimum	9	critical	82	adequate
Mean AFS 15y	1070	3478	Adequate	13	Minimum	84	Adequate
Area 1	0	840	critical	16	minimum	64	critical
Mean CRP 15y	0	840	Critical	16	Minimum	64	Critical
Area 1	0	400	critical	12	minimum	70	minimum
Area 2	0	400	critical	5	critical	76	minimum
Area 3	0	817	critical	17	minimum	31	critical
Mean CRP 12y	0	539	Critical	11	Minimum	59	Critical
Area 1	0	10100	adequate	32	adequate	92	adequate
Area 2	0	16016	adequate	52	adequate	99,8	adequate
Area 3	0	16900	adequate	35	adequate	88,4	adequate
Area 4	0	10050	adequate	30	adequate	80	adequate
Mean Ref	0	13267	Adequate	37	Adequate	90	Adequate

APPENDIX C.

Table 4. . List of species abundancy per area studied.

Reference Ecosystem	Trees (DBH > 5cm)	Natural regeneration (H > 50cm and DBH < 5cm)	Total
<i>Acacia plumosa</i> Martius ex Colla		1	1
<i>Actinostemon klotzschii</i> (Didr.) Pax	3	618	621
<i>Actinostemon conceptionis</i> (Chodat & Hassl.) Hochr.		1	1
<i>Actinostemon concolor</i> (Spreng.) Müll.Arg.		1	1
<i>Albizia niopoides</i> (Benth.) Burkart	3		3
<i>Alchornea</i> sp.	1		1
<i>Alchornea triplinervia</i> (Spreng.) Müll.Arg.		2	2
<i>Allophylus edulis</i> (A.St.-Hil. et al.) Hieron. ex Niederl.		1	1
<i>Anadenanthera colubrina</i> (Vell.) Brenan	1		1
<i>Anadenanthera colubrina</i> var. <i>cebil</i> (Griseb.) Altschul	5	4	9
<i>Anadenanthera peregrina</i> (L.) Speg.	1	2	3
<i>Anadenanthera peregrina</i> var. <i>falcata</i> (Benth.) Altschul		1	1
<i>Aniba firmula</i> (Nees & Mart.) Mez	1	3	4
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	15	2	17
<i>Aspidosperma parvifolium</i> A.DC.	14	35	49
<i>Aspidosperma polyneuron</i> Müll.Arg.	11	4	15
<i>Aspidosperma</i> sp.	1		1
Asteraceae Bercht. & J.Presl		1	1
<i>Astronium graveolens</i> Jacq.	27	23	50
<i>Balfourodendron riedelianum</i> (Engl.) Engl.	2	6	8
<i>Bauhinia forficata</i> Link		1	1
<i>Bromelia antiacantha</i> Bertol.		39	39
Bush non classified 1		3	3
Bush non classified 2		2	2
<i>Campomanesia xanthocarpa</i> (Mart.) O.Berg	1		1
<i>Campomanesia guaviroba</i> (DC.) Kiaersk.	16	8	24
<i>Campomanesia guazumifolia</i> (Cambess.) O.Berg	2		2
<i>Casearia gossypiosperma</i> Briq.	16	6	22
<i>Casearia sylvestris</i> Sw.	6	4	10
<i>Cereus jamacaru</i> DC.		1	1
<i>Chrysophyllum marginatum</i> (Hook. & Arn.) Radlk.	1	1	2
<i>Copaifera langsdorffii</i> Desf.	18	14	32
<i>Cordia americana</i> (L.) Gottschling & J.S.Mill.	1		1
<i>Cordia ecalyculata</i> Vell.	2		2
<i>Coussarea hydrangeifolia</i> (Benth.) Müll.Arg.	1		1
<i>Coutarea hexandra</i> (Jacq.) K.Schum.		1	1
<i>Croton floribundus</i> Spreng.	35	4	39
<i>Cupania tenuivalvis</i> Radlk.	39	315	354
<i>Cupania vernalis</i> Cambess.	1	8	9
<i>Dahlstedtia muehlbergiana</i> (Hassl.) M.J.Silva & A.M.G. Azevedo	1		1
<i>Dalbergia frutescens</i> (Vell.) Britton	2	1	3

<i>Diatenopteryx sorbifolia</i> Radlk.		1	1
<i>Diospyros inconstans</i> Jacq.		1	1
<i>Duguetia lanceolata</i> A.St.-Hil.	1	5	6
<i>Enterolobium contortisiliquum</i> (Vell.) Morong		5	5
<i>Eremanthus erythropappus</i> (DC.) Macleish	1	1	2
<i>Erythroxylum pelleterianum</i> A.St.-Hil.		1	1
<i>Esenbeckia febrifuga</i> (A.St.-Hil.) A.Juss. ex Mart.		5	5
<i>Eugenia</i> cf. <i>rostrata</i> O.Berg		1	1
<i>Eugenia florida</i> DC.		1	1
<i>Eugenia paracatuana</i> O.Berg	1	2	3
<i>Eugenia pyriformis</i> Cambess.	6	26	32
<i>Eugenia</i> sp.	2	27	29
<i>Eugenia</i> sp2.	7		7
<i>Eugenia</i> sp3.	1	66	67
<i>Eugenia uniflora</i> L.	100	628	728
<i>Eugenia neoverrucosa</i> Sobral	8	3	11
<i>Ficus obtusifolia</i> Kunth	2		2
<i>Gallesia integrifolia</i> (Spreng.) Harms	1		1
<i>Garcinia gardneriana</i> (Planch. & Triana) Zappi		1	1
<i>Guapira opposita</i> (Vell.) Reitz	2	2	4
<i>Handroanthus chrysotrichus</i> (Mart. ex DC.) Mattos		4	4
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	1	1	2
<i>Handroanthus impetiginosus</i> (Mart. ex DC.) Mattos	1	5	6
<i>Helietta apiculata</i> Benth.	14	7	21
<i>Holocalyx balansae</i> Micheli		2	2
<i>Hymenaea courbaril</i> L.	4	6	10
<i>Inga laurina</i> (Sw.) Willd.		1	1
<i>Inga sessilis</i> (Vell.) Mart.	3	2	5
<i>Inga vera</i> Willd.	4	1	5
<i>Jacaranda caroba</i> (Vell.) DC.		1	1
<i>Jacaranda cuspidifolia</i> Mart.	2		2
<i>Luehea divaricata</i> Mart.	1		1
<i>Luehea grandiflora</i> Mart. & Zucc.	6	1	7
<i>Machaerium nyctitans</i> (Vell.) Benth.	3	3	6
<i>Machaerium</i> sp.		1	1
<i>Machaerium brasiliense</i> Vogel	3	1	4
<i>Maclura tinctoria</i> (L.) D.Don ex Steud.v	9	1	10
<i>Margaritopsis</i> cf. <i>hassleriana</i> (Chodat) C.M.Taylor		6	6
<i>Matayba elaeagnoides</i> Radlk.	7	2	9
<i>Maytenus gonoclada</i> Mart.	9	3	12
<i>Metrodorea nigra</i> A.St.-Hil.		1	1
<i>Moquiniastrum polymorphum</i> (Less.) G. Sancho	1		1
<i>Myracrodruon urundeuva</i> Allemão	1		1
<i>Myracrodruon urundeuva</i> Allemão	2		2
<i>Myrcia guianensis</i> (Aubl.) DC.		1	1
<i>Myrcia</i> sp.	2	15	17

<i>Myrcia splendens</i> (Sw.) DC.	2	7	9
<i>Myrcia tomentosa</i> (Aubl.) DC.	3	17	20
<i>Myrciaria</i> cf. <i>delicatula</i> (DC.) O.Berg		5	5
<i>Myrocarpus frondosus</i> Allemao	1	1	2
<i>Myroxylon peruiferum</i> L.f.	2	5	7
<i>Myrsine umbellata</i> Mart.		5	5
Non classified 1	1		1
Non classified 2	1		1
Non classified 3		1	1
Non classified 4	1		1
Non classified 5	1		1
Non classified 6	1		1
Non classified 7	1		1
Non classified 8	1		1
<i>Ocotea velutina</i> (Nees) Mart. ex B.D.Jacks.		1	1
<i>Ouratea castaneifolia</i> (DC.) Engl.	3	1	4
<i>Parapiptadenia rigida</i> (Benth.) Brenan	3	13	16
<i>Peltophorum dubium</i> (Spreng.) Taub.	12	7	19
<i>Pleradenophora membranifolia</i> (Mull. Arg.) Esser & A. L. Melo	1		1
<i>Protium heptaphyllum</i> (Aubl.) Marchand	14	3	17
<i>Psidium cattleianum</i> Sabine	7	3	10
<i>Psychotria subtriflora</i> Müll.Arg.		1	1
<i>Pterodon emarginatus</i> Vogel	2	1	3
<i>Pterogyne nitens</i> Tul.	1		1
<i>Rudgea jasminoides</i> (Cham.) Müll.Arg.	5	5	10
<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	4		4
<i>Senegalia polyphylla</i> (DC.) Britton & Rose	2	5	7
<i>Siparuna brasiliensis</i> (Spreng.) A.DC.	4	17	21
<i>Solanum mauritianum</i> Scop.		1	1
<i>Solanum swartzianum</i> Roem. & Schult.		3	3
<i>Strychnos</i> sp.		1	1
<i>Syagrus romanzoffiana</i> (Cham.) Glassman	20	16	36
<i>Tabernaemontana hystrix</i> Steud.	5		5
<i>Tabernaemontana laeta</i> Mart.	10	6	16
<i>Tabernaemontana catharinensis</i> A.DC.	4	9	13
<i>Tapirira guianensis</i> Aubl	4	9	13
<i>Terminalia glabrescens</i> Mart.	1	4	5
<i>Trichilia catigua</i> A.Juss.	2		2
<i>Trichilia elegans</i> A.Juss.		2	2
<i>Trichilia pallida</i> Sw.	9	2	11
<i>Zanthoxylum rhoifolium</i> Lam.		1	1
<i>Zeyheria tuberculosa</i> (Vell.) Bureau ex Verl.	3		3
	563	2106	2669
Conventional Restoration Planting	Trees (DBH > 5cm)	Natural regeneration (H > 50cm and DBH < 5cm)	Total

<i>Aegiphila sellowiana</i> Cham.	12	14	26
<i>Albizia niopoides</i> (Benth.) Burkart	3	16	19
<i>Allophylus edulis</i> (A.St.-Hil. et al.) Hieron. ex Niederl.	6	39	45
<i>Anadenanthera colubrina</i> (Vell.) Brenan	8	2	10
<i>Anadenanthera colubrina</i> var. <i>cebil</i> (Griseb.) Altschul	1		1
<i>Anadenanthera peregrina</i> (L.) Speg.	2		2
<i>Anadenanthera peregrina</i> var. <i>falcata</i> (Benth.) Altschul	11		11
<i>Anadenanthera</i> sp.		1	1
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	1	2	3
<i>Astronium graveolens</i> Jacq.	2	1	3
<i>Baccharis dracunculifolia</i> DC.	12	60	72
<i>Balfourodendron riedelianum</i> (Engl.) Engl.	1		1
<i>Bauhinia forficata</i> Link	1		1
<i>Casearia gossypiosperma</i> Briq.	2		2
<i>Casearia sylvestris</i> Sw.		4	4
<i>Cecropia pachystachya</i> Trécul	8	1	9
<i>Cecropia</i> sp.	4		4
<i>Cedrela fissilis</i> Vell.	2		2
<i>Ceiba speciosa</i> (A.St.-Hil.) Ravenna	1		1
<i>Centrolobium tomentosum</i> Benth.	1		1
<i>Citharexylum myrianthum</i> Cham.	5	1	6
<i>Croton floribundus</i> Spreng.	13	1	14
<i>Croton urucurana</i> Baill.	1		1
<i>Dahlstedtia muehlbergiana</i> (Hassl.) M.J.Silva & A.M.G. Azevedo		5	5
<i>Dictyoloma vandellianum</i> A.Juss.		7	7
<i>Enterolobium contortisiliquum</i> (Vell.) Morong	1		1
<i>Eremanthus erythropappus</i> (DC.) Macleish	1	1	2
<i>Erythrina verna</i> Vell.	2		2
<i>Eugenia uniflora</i> L.		1	1
<i>Ficus adhatodifolia</i> Schott	1		1
<i>Ficus gomelleira</i> Kunth & C.D.Bouché	1		1
<i>Guazuma ulmifolia</i> Lam.	46	1	47
<i>Handroanthus chrysotrichus</i> (Mart. ex DC.) Mattos	6		6
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	2	3	5
<i>Handroanthus impetiginosus</i> (Mart. ex DC.) Mattos		1	1
<i>Handroanthus</i> sp.	1		1
<i>Handroanthus umbellatus</i> (Sond.) Mattos	3		3
<i>Hymenaea courbaril</i> L.	4		4
<i>Inga laurina</i> (Sw.) Willd.	16	5	21
<i>Inga sessilis</i> (Vell.) Mart.	1		1
<i>Inga vera</i> Willd.	18	8	26
<i>Lithraea molleoides</i> (Vell.) Engl.	1		1
<i>Luehea divaricata</i> Mart.	7		7
<i>Lychnophora ericoides</i> Mart.		1	1
<i>Mabea fistulifera</i> Mart.	3	6	9
<i>Machaerium nyctitans</i> (Vell.) Benth.	1		1

<i>Machaerium nyctitans</i> (Vell.) Benth.	3	5	8
<i>Maclura tinctoria</i> (L.) D.Don ex Steudv	2		2
<i>Mimosa bimucronata</i> (DC.) Kuntze	6	3	9
<i>Myracrodruon urundeuva</i> Allemão	10	1	11
<i>Myrcia selloi</i> (Spreng.) N.Silveira	1		1
<i>Myrsine umbellata</i> Mart.		1	1
Non classified 1		1	1
<i>Peltophorum dubium</i> (Spreng.) Taub.	35	5	40
<i>Poecilanthe parviflora</i> Benth.	3	2	5
<i>Pouteria torta</i> (Mart.) Radlk.		1	1
<i>Psidium guajava</i> L.		1	1
<i>Pterodon emarginatus</i> Vogel	1		1
<i>Pterogyne nitens</i> Tul.	3		3
<i>Sapindus saponaria</i> L.	1		1
<i>Sapium obovatum</i> Klotzsch ex Müll.Arg.		1	1
<i>Schinus terebinthifolia</i> Raddi	14	8	22
<i>Senegalia polyphylla</i> (DC.) Britton & Rose	8	5	13
<i>Solanum granulosoleprosum</i> Dunal		1	1
<i>Solanum mauritianum</i> Scop.		7	7
<i>Tabernaemontana hystrix</i> Steud.	4	3	7
<i>Tapirira guianensis</i> Aubl	4		4
<i>Triplaris americana</i> L.	1		1
<i>Zeyheria tuberculosa</i> (Vell.) Bureau ex Verl.	5		5
	313	226	539

Coffee Agroforestry System	Trees (DBH > 5cm)	Natural regeneration (H > 50cm and DBH < 5cm)	Total
<i>Acacia mangium</i> Willd.	17		17
<i>Acrocomia aculeata</i> (Jacq.) Lodd. ex Mart.		14	14
<i>Aegiphila sellowiana</i> Cham.	4	35	39
<i>Albizia niopoides</i> (Benth.) Burkart	2	1	3
<i>Allophylus edulis</i> (A.St.-Hil. et al.) Hieron. ex Niederl.	3	57	60
<i>Anadenanthera colubrina</i> (Vell.) Brenan	4	2	6
<i>Anadenanthera colubrina</i> var. <i>cebil</i> (Griseb.) Altschul	3	6	9
<i>Anadenanthera peregrina</i> var. <i>falcata</i> (Benth.) Altschul	3	4	7
<i>Anadenanthera</i> sp.		16	16
<i>Annona muricata</i> L.	4	1	5
<i>Annona squamosa</i> L.	1		1
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	4	17	21
<i>Artocarpus heterophyllus</i> Lam.	2	1	3
<i>Aspidosperma polyneuron</i> Müll.Arg.	2		2
<i>Astronium graveolens</i> Jacq.	5		5
<i>Baccharis dracunculifolia</i> DC.		4	4
<i>Bauhinia forficata</i> Link	1	1	2
<i>Bixa orellana</i> L.	2		2
<i>Campomanesia xanthocarpa</i> (Mart.) O.Berg	2		2

<i>Cariniana estrellensis</i> (Raddi) Kuntze		1	1
<i>Caryocar brasiliense</i> Cambess.	1		1
<i>Casearia sylvestris</i> Sw.		3	3
<i>Cecropia pachystachya</i> Trécul	13		13
<i>Cedrela fissilis</i> Vell.	7		7
<i>Ceiba speciosa</i> (A.St.-Hil.) Ravenna	3		3
<i>Cereus jamacaru</i> DC.		13	13
<i>Citharexylum myrianthum</i> Cham.	1		1
<i>Citrus aurantiifolia</i> (Christm.) Swingle	2		2
<i>Citrus</i> sp.	2		2
<i>Citrus x aurantium</i> L.		5	5
<i>Colubrina glandulosa</i> Perkins		1	1
<i>Copaifera langsdorffii</i> Desf.	2	5	7
<i>Cordia americana</i> (L.) Gottschling & J.S.Mill.	2	3	5
<i>Cordia</i> sp.		1	1
<i>Cordia superba</i> Cham.	2		2
<i>Cordia trichotoma</i> (Vell.) Arráb. ex Steud.	10	26	36
<i>Croton floribundus</i> Spreng.	11	48	59
<i>Croton urucurana</i> Baill.	15	1	16
<i>Cupania vernalis</i> Cambess.		4	4
<i>Dahlstedtia muehlbergiana</i> (Hassl.) M.J.Silva & A.M.G. Azevedo	5	22	27
<i>Dictyoloma vandellianum</i> A.Juss.	2	14	16
<i>Dipteryx alata</i> Vogel		1	1
<i>Enterolobium contortisiliquum</i> (Vell.) Morong	4	1	5
<i>Eugenia myrcianthes</i> Nied.	1		1
<i>Eugenia pyriformis</i> Cambess.	1	4	5
<i>Eugenia uniflora</i> L.	1	20	21
<i>Ficus adhatodifolia</i> Schott	1		1
<i>Ficus citrifolia</i> Mill.	2		2
<i>Ficus gomelleira</i> Kunth & C.D.Bouché	7	4	11
<i>Ficus guaranitica</i> Chodat	1		1
<i>Ficus obtusifolia</i> Kunth	1		1
<i>Gallesia integrifolia</i> (Spreng.) Harms	6		6
<i>Genipa americana</i> L.	1	1	2
<i>Gliricidia sepium</i> (Jacq.) Walp.	22	1	23
<i>Grevillea robusta</i> A.Cunn. ex R.Br		1	1
<i>Guarea guidonia</i> (L.) Sleumer	1	11	12
<i>Guazuma crinita</i> Mart.	5		5
<i>Guazuma ulmifolia</i> Lam.	15	4	19
<i>Handroanthus chrysotrichus</i> (Mart. ex DC.) Mattos	1		1
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	4	1	5
<i>Handroanthus impetiginosus</i> (Mart. ex DC.) Mattos	1		1
<i>Handroanthus ochraceus</i> (Cham.) Mattos	1		1
<i>Handroanthus umbellatus</i> (Sond.) Mattos	2		2
<i>Helietta apiculata</i> Benth.	1	10	11
<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	1		1

<i>Hymenaea courbaril</i> L.	3	2	5
<i>Hypericum perforatum</i> L.		6	6
<i>Inga laurina</i> (Sw.) Willd.	16	33	49
<i>Inga sessilis</i> (Vell.) Mart.		1	1
<i>Inga vera</i> Willd.	53	64	117
<i>Jacaranda caroba</i> (Vell.) DC.	2	5	7
<i>Jatropha mollissima</i> (Pohl) Baill.		1	1
<i>Leucaena leucocephala</i> (Lam.) de Wit	4	10	14
<i>Licania octandra</i> (Hoffmanns. ex Roem. & Schult.) Kuntze	1	2	3
<i>Luehea divaricata</i> Mart.	8	78	86
<i>Mabea fistulifera</i> Mart.	16	47	63
<i>Magnolia ovata</i> (A.St.-Hil.) Spreng.		2	2
<i>Malpighia emarginata</i> DC.	2		2
<i>Mangifera indica</i> L.	4	10	14
<i>Melia azedarach</i> L.	1	3	4
<i>Moquiniastrum polymorphum</i> (Less.) G. Sancho		2	2
<i>Musa</i> sp.		5	5
<i>Myracrodruon urundeuva</i> Allemao	10	30	40
<i>Myrcia selloi</i> (Spreng.) N.Silveira		13	13
<i>Myrcia splendens</i> (Sw.) DC.		2	2
<i>Myrocarpus frondosus</i> Allemao		1	1
Non classified 1		2	2
Non classified 2		1	1
<i>Peltophorum dubium</i> (Spreng.) Taub.	36	89	125
<i>Platypodium elegans</i> Vogel	1		1
<i>Poecilanthe parviflora</i> Benth.	1		1
<i>Poincianella pluviosa</i> (DC.) L.P.Queiroz	1	1	2
<i>Pouteria torta</i> (Mart.) Radlk.		6	6
<i>Psidium guajava</i> L.	14	23	37
<i>Pterocarpus rohrii</i> Vahl	2	1	3
<i>Pterogyne nitens</i> Tul.	4	1	5
<i>Randia armata</i> (Sw.) DC.		2	2
<i>Ruprechtia laxiflora</i> Meisn.	1	1	2
<i>Sapindus saponaria</i> L.	3		3
<i>Sapium glandulosum</i> (L.) Morong	2	5	7
<i>Schinus terebinthifolia</i> Raddi	10	20	30
<i>Schizolobium parahyba</i> (Vell.) Blake	5	2	7
<i>Sebastiania</i> sp.		3	3
<i>Senegalia polyphylla</i> (DC.) Britton & Rose	5	48	53
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	1	1	2
<i>Sida</i> sp.		1	1
<i>Solanum granulosoleprosum</i> Dunal		5	5
<i>Solanum mauritianum</i> Scop.		5	5
<i>Syagrus romanzoffiana</i> (Cham.) Glassman		14	14
<i>Syzygium cumini</i> (L.) Skeels	10	1	11
<i>Tabebuia roseoalba</i> (Ridl.) Sandwith	2		2

<i>Tabernaemontana hystrix</i> Steud.	8	234	242
<i>Tabernaemontana catharinensis</i> A.DC.		33	33
<i>Tapirira guianensis</i> Aubl		4	4
<i>Trema micrantha</i> (L.) Blume	3		3
<i>Trichilia elegans</i> A.Juss.		15	15
<i>Triplaris americana</i> L.	3		3
<i>Xylopia aromatica</i> (Lam.) Mart		4	4
<i>Zanthoxylum caribaeum</i> Lam.	2	1	3
	451	1205	1656
TOTAL	1327	3537	4864

APPENDIX D.

Ecological Indicators Resolution SMA 32/2014	
Indicator	Driver Description
Density of native plants spontaneously regenerating	Number of individuals per hectare; height H>50cm and DBH<15 cm
Number of spontaneously regenerating native plant species	Number of spontaneously regenerating native plant species
Ground coverage with native vegetation	Percentage of Canopy Cover

Drivers	
Codes	Descriptions
AGB	Above Ground Biomass
% ADS	% Animal Dispersed Species
CC	Canopy Cover
FD	Distance from the nearest old-growth forest
C dens	Coffee density (ind.ha ⁻¹)
T dens	Trees density (ind.ha ⁻¹)
T rich	Trees richness (plot ⁻¹)
S dens	Saplings density (ind.ha ⁻¹)
S rich	Saplings richness (ind.ha ⁻¹)

Saplings density

Model	AGB	%ADS	CC	FD	C dens	T dens	T rich	r ²	df	logLik	AICc	delta	weight
1	NA	NA	NA	NA	-0,0004	0,00192	NA	0,656	4	-162,8	336,186	0	0,249
2	NA	NA	0,01120	NA	-0,0004	0,00172	NA	0,673	5	-162,3	338,791	2,606	0,068
3	NA	NA	NA	NA	-0,00038	NA	0,0511	0,605	4	-164,1	338,928	2,742	0,063
4	NA	NA	NA	NA	-0,00042	NA	NA	0,536	3	-165,7	338,99	2,804	0,061
5	NA	NA	NA	0,000123	-0,00036	0,0019	NA	0,669	5	-162,4	339,017	2,832	0,06
6	NA	0,003	NA	NA	-0,00039	0,00173	NA	0,66	5	-162,6	339,549	3,363	0,046
7	O	NA	NA	NA	-0,00039	0,00199	NA	0,656	5	-162,7	339,769	3,584	0,041
8	NA	NA	NA	NA	-0,0004	0,00186	0,0026	0,656	5	-162,8	339,8	3,615	0,041
9	NA	NA	0,01836	NA	-0,00042	NA	NA	0,583	4	-164,7	340,005	3,82	0,037
10	NA	0,008	NA	NA	-0,0004	NA	NA	0,582	4	-164,7	340,047	3,861	0,036
11	NA	NA	NA	0,000188	-0,00032	NA	0,0581	0,636	5	-163,3	340,944	4,758	0,023
12	NA	NA	0,01362	NA	-0,00038	NA	0,0438	0,63	5	-163,5	341,222	5,037	0,02
13	O	NA	NA	NA	-0,00044	NA	NA	0,553	4	-165,4	341,417	5,232	0,018
14	NA	0,006	NA	NA	-0,00036	NA	0,0428	0,626	5	-163,6	341,48	5,295	0,018
15	NA	NA	NA	0,000128	-0,00039	NA	NA	0,55	4	-165,4	341,533	5,347	0,017
16	NA	0,007	0,01618	NA	-0,0004	NA	NA	0,619	5	-163,8	341,813	5,628	0,015
17	NA	NA	0,01246	0,000138	-0,00036	0,00171	NA	0,69	6	-161,7	341,862	5,677	0,015
18	O	NA	NA	NA	-0,00037	NA	0,0546	0,606	5	-164,1	342,513	6,328	0,011
19	NA	0,003	0,01119	NA	-0,00039	0,00153	NA	0,677	6	-162,1	342,691	6,506	0,01
20	NA	NA	0,01861	0,000128	-0,00039	NA	NA	0,599	5	-164,3	342,865	6,679	0,009
21	O	NA	0,01150	NA	-0,0004	0,00181	NA	0,674	6	-162,2	342,887	6,702	0,009
22	NA	NA	0,01125	NA	-0,0004	0,00175	0,0015	0,673	6	-162,3	342,966	6,78	0,008
23	NA	NA	NA	0,000136	-0,00035	0,00161	0,0136	0,671	6	-162,3	343,084	6,899	0,008
24	NA	0,001	NA	0,000112	-0,00036	0,0018	NA	0,67	6	-162,3	343,132	6,946	0,008
25	O	NA	NA	0,000132	-0,00036	0,00183	NA	0,669	6	-162,4	343,167	6,982	0,008
26	O	0,007	NA	NA	-0,00041	NA	NA	0,592	5	-164,5	343,195	7,01	0,007
27	O	NA	0,01676	NA	-0,00044	NA	NA	0,591	5	-164,5	343,236	7,05	0,007
28	O	NA	NA	0,000215	-0,00039	NA	NA	0,587	5	-164,6	343,43	7,244	0,007
29	NA	0,007	NA	0,000076	-0,00038	NA	NA	0,587	5	-164,6	343,443	7,257	0,007
30	NA	NA	0,01405	0,000191	-0,00032	NA	0,0525	0,663	6	-162,5	343,536	7,35	0,006
31	O	0,003	NA	NA	-0,00039	0,0018	NA	0,661	6	-162,6	343,686	7,5	0,006
32	NA	0,003	NA	NA	-0,00039	0,00166	0,0029	0,66	6	-162,6	343,719	7,534	0,006
33	O	NA	NA	NA	-0,00039	0,00187	0,0064	0,657	6	-162,7	343,923	7,738	0,005
34	NA	0,005	0,01260	NA	-0,00037	NA	0,0359	0,647	6	-163,0	344,477	8,292	0,004
35	NA	0,004	NA	0,000153	-0,00032	NA	0,0512	0,643	6	-163,1	344,688	8,502	0,004
36	NA	NA	NA	0,000400	NA	NA	0,0919	0,468	4	-167,1	344,903	8,718	0,003
37	O	NA	NA	0,000201	-0,00032	NA	0,0534	0,637	6	-163,3	345,053	8,868	0,003
38	O	NA	0,01386	NA	-0,00037	NA	0,0488	0,632	6	-163,4	345,325	9,139	0,003
39	O	NA	0,01667	0,000219	-0,00039	NA	NA	0,627	6	-163,6	345,576	9,39	0,002

40	NA	-	0,006	0,01680	0,000092	-0,00037	NA	NA	0,627	6	-163,6	345,598	9,412	0,002
41	0	-	0,006	NA	NA	-0,00036	NA	0,0462	0,626	6	-163,6	345,625	9,44	0,002
42	0	-	0,007	0,01515	NA	-0,00041	NA	NA	0,624	6	-163,6	345,741	9,555	0,002
43	NA	-	NA	NA	0,000331	NA	0,00258	NA	0,435	4	-167,7	346,082	9,897	0,002
44	0	-	0,006	NA	0,000150	-0,00038	NA	NA	0,607	6	-164,1	346,632	10,446	0,001
45	NA	-	NA	0,01228	0,000149	-0,00035	0,00147	0,0112	0,691	7	-161,7	346,66	10,475	0,001
46	NA	-	0,001	0,01240	0,000129	-0,00036	0,00162	NA	0,691	7	-161,7	346,68	10,495	0,001
47	0	-	NA	0,01246	0,000149	-0,00036	0,00164	NA	0,691	7	-161,7	346,702	10,517	0,001
48	NA	-	NA	NA	NA	NA	0,00287	NA	0,312	3	-169,7	346,865	10,68	0,001
49	NA	-	NA	0,01382	0,000389	NA	NA	0,089	0,498	5	-166,5	347,332	11,146	0,001
50	0	-	0,003	0,01145	NA	-0,00039	0,00162	NA	0,678	7	-162,1	347,484	11,298	0,001
51	NA	-	0,003	0,01126	NA	-0,0004	0,00157	-0,002	0,677	7	-162,1	347,56	11,375	0,001
52	0	-	NA	0,01144	NA	-0,00039	0,00176	0,003	0,674	7	-162,2	347,754	11,568	0,001
53	NA	-	NA	NA	NA	NA	NA	0,09	0,281	3	-170,1	347,755	11,569	0,001
54	NA	-	NA	NA	0,000365	NA	0,0011	0,064	0,486	5	-166,8	347,813	11,627	0,001
55	NA	-	0,005	NA	0,000348	NA	NA	0,083	0,484	5	-166,8	347,901	11,716	0,001
56	NA	-	0,001	NA	0,000125	-0,00035	0,00153	0,013	0,672	7	-162,3	347,905	11,719	0,001
57	0	-	NA	NA	0,000139	-0,00035	0,0016	0,013	0,671	7	-162,3	347,952	11,766	0,001
58	0	-	0,001	NA	0,000120	-0,00036	0,00176	NA	0,67	7	-162,3	347,988	11,802	0,001
59	NA	-	0,003	0,01345	0,000164	-0,00032	NA	0,046	0,668	7	-162,4	348,105	11,919	0,001
60	0	-	NA	0,01405	0,000207	-0,00032	NA	0,048	0,665	7	-162,5	348,329	12,144	0,001
61	NA	-	-0,01	NA	NA	NA	NA	0,077	0,365	4	-168,9	348,416	12,231	0,001
62	0	-	NA	NA	0,000378	NA	NA	0,098	0,47	5	-167,1	348,424	12,239	0,001
63	0	-	0,003	NA	NA	-0,00038	0,00167	0,007	0,661	7	-162,6	348,533	12,347	0,001
64	NA	-	NA	0,01159	0,000330	NA	0,00243	NA	0,456	5	-167,3	348,94	12,754	0
65	NA	-	NA	NA	NA	NA	0,00185	0,0451	0,341	4	-169,3	349,175	12,99	0
66	0	-	0,005	0,01272	NA	-0,00036	NA	0,0401	0,648	7	-163,0	349,301	13,115	0
67	NA	-	0,006	NA	NA	NA	0,00238	NA	0,336	4	-169,3	349,313	13,128	0
68	0	-	NA	NA	NA	NA	NA	0,1127	0,334	4	-169,4	349,372	13,187	0
69	0	-	0,003	NA	0,000163	-0,00032	NA	0,0483	0,644	7	-163,1	349,53	13,345	0
70	NA	-	NA	0,01024	NA	NA	0,00264	NA	0,328	4	-169,4	349,562	13,376	0
71	0	-	0,005	0,01578	0,000166	-0,00038	NA	NA	0,642	7	-163,1	349,607	13,422	0
72	NA	-	0,002	NA	0,000316	NA	0,00241	NA	0,438	5	-167,7	349,613	13,428	0
73	0	-	NA	NA	NA	NA	0,00309	NA	0,325	4	-169,5	349,637	13,452	0
74	0	-	NA	NA	0,000335	NA	0,00255	NA	0,435	5	-167,7	349,698	13,512	0
75	NA	-	NA	0,01467	NA	NA	NA	0,0831	0,316	4	-169,6	349,908	13,722	0
76	NA	-	NA	NA	0,000400	NA	NA	NA	0,185	3	-171,4	350,247	14,062	0
77	NA	-	0,015	NA	NA	NA	NA	NA	0,177	3	-171,5	350,455	14,269	0
78	0	-	-0,01	NA	NA	NA	NA	0,0987	0,41	5	-168,1	350,57	14,385	0
79	NA	-	-	NA	0,000319	NA	NA	NA	0,282	4	-170,1	350,887	14,702	0

		0,011											
		-											
80	NA	0,004	0,01295	0,000348	NA	NA	0,0805	0,51	6	-166,3	351,019	14,833	0
81	NA	NA	0,01221	0,000366	NA	0,00087	0,0664	0,509	6	-166,3	351,064	14,878	0
82	NA	-0,01	0,01144	NA	NA	NA	0,0711	0,386	5	-168,5	351,38	15,195	0
83	0	NA	0,01374	0,000368	NA	NA	0,0941	0,5	6	-166,5	351,431	15,245	0
84	0	NA	NA	NA	NA	0,00168	0,0695	0,381	5	-168,6	351,527	15,341	0
85	NA	NA	NA	NA	NA	NA	NA	0	2	-173,4	351,55	15,364	0
		-											
86	NA	0,008	NA	NA	NA	0,00098	0,0556	0,377	5	-168,7	351,665	15,479	0
87	0	NA	NA	0,000500	NA	NA	NA	0,251	4	-170,5	351,74	15,555	0
88	0	NA	0,01581	NA	NA	NA	0,1068	0,374	5	-168,7	351,776	15,59	0
		-											
89	NA	0,003	NA	0,000342	NA	0,00079	0,0659	0,491	6	-166,7	351,784	15,598	0
90	0	NA	NA	0,000339	NA	0,00115	0,0698	0,49	6	-166,7	351,829	15,643	0
		-											
91	0	0,005	NA	0,000313	NA	NA	0,0909	0,489	6	-166,7	351,88	15,694	0
		-											
92	NA	0,014	0,01949	NA	NA	NA	NA	0,24	4	-170,7	352,026	15,84	0
93	NA	NA	0,01849	0,000355	NA	NA	NA	0,237	4	-170,7	352,089	15,904	0
94	NA	NA	0,01022	NA	NA	0,0016	0,0457	0,357	5	-169,0	352,307	16,122	0
		-											
95	NA	0,007	0,01100	NA	NA	0,00212	NA	0,355	5	-169,0	352,364	16,179	0
		-											
96	NA	0,001	0,01222	0,000140	-0,00035	0,00141	0,0103	0,692	8	-161,6	352,376	16,191	0
97	0	NA	0,01230	0,000154	-0,00035	0,00146	0,0099	0,692	8	-161,7	352,407	16,221	0
		-											
98	0	0,001	0,01241	0,000139	-0,00036	0,00157	NA	0,691	8	-161,7	352,417	16,231	0
		-											
99	0	0,006	NA	NA	NA	0,00264	NA	0,351	5	-169,1	352,479	16,293	0
100	NA	NA	0,02292	NA	NA	NA	NA	0,087	3	-172,5	352,513	16,327	0
101	0	NA	0,01118	NA	NA	0,00287	NA	0,344	5	-169,2	352,699	16,513	0
		-											
102	NA	0,011	0,01824	0,000292	NA	NA	NA	0,335	5	-169,3	352,97	16,784	0
		-											
103	NA	0,003	0,01198	0,000313	NA	0,00221	NA	0,46	6	-167,3	352,973	16,788	0
104	0	NA	0,01167	0,000339	NA	0,00237	NA	0,457	6	-167,3	353,102	16,916	0
		-											
105	0	0,003	0,01139	NA	-0,00039	0,00158	0,0025	0,679	8	-162,1	353,238	17,052	0
		-											
106	0	0,015	NA	NA	NA	NA	NA	0,178	4	-171,5	353,594	17,409	0
		-											
107	0	0,001	NA	0,000128	-0,00035	0,00153	0,0125	0,672	8	-162,3	353,661	17,475	0
		-											
108	0	0,009	NA	0,000391	NA	NA	NA	0,31	5	-169,7	353,722	17,537	0
		-											
109	0	0,002	NA	0,000317	NA	0,00241	NA	0,438	6	-167,7	353,789	17,604	0
		-											
110	0	0,003	0,01350	0,000178	-0,00032	NA	0,0427	0,669	8	-162,4	353,814	17,628	0
		-											
111	0	0,009	0,01224	NA	NA	NA	0,0934	0,432	6	-167,8	353,976	17,791	0
112	0	NA	0,01723	0,000475	NA	NA	NA	0,3	5	-169,9	354,01	17,825	0
113	0	NA	NA	NA	NA	NA	NA	0,005	3	-173,4	354,247	18,062	0
		-											
114	0	0,008	NA	NA	NA	0,00091	0,0782	0,421	6	-168,0	354,384	18,198	0
115	0	NA	0,01195	NA	NA	0,00139	0,0721	0,402	6	-168,3	355,022	18,836	0
		-											
116	NA	0,008	0,01025	NA	NA	0,00078	0,0544	0,393	6	-168,4	355,319	19,134	0
		-											
117	0	0,014	0,01956	NA	NA	NA	NA	0,24	5	-170,7	355,644	19,458	0

118	0	NA	0,02255	NA	NA	NA	NA	0,088	4	-172,5	355,662	19,477	0
119	NA	0,003	0,01219	0,000344	NA	0,00059	0,0674	0,515	7	-166,2	355,721	19,536	0
120	0	0,005	0,01270	0,000317	NA	NA	0,0869	0,514	7	-166,2	355,744	19,559	0
121	0	NA	0,01200	0,000341	NA	0,00092	0,0716	0,512	7	-166,2	355,813	19,628	0
122	0	0,007	0,01184	NA	NA	0,00239	NA	0,372	6	-168,8	355,995	19,81	0
123	0	0,009	0,01737	0,000372	NA	NA	NA	0,359	6	-169,0	356,401	20,215	0
124	0	0,004	NA	0,000306	NA	0,00082	0,0732	0,497	7	-166,5	356,426	20,241	0
125	0	0,003	0,01201	0,000318	NA	0,00219	NA	0,46	7	-167,3	357,842	21,656	0
126	0	0,008	0,01117	NA	NA	0,00072	0,0774	0,439	7	-167,6	358,616	22,43	0
127	0	0,001	0,01224	0,000144	-0,00035	0,0014	0,0093	0,692	9	-161,6	359,279	23,093	0
128	0	0,003	0,01188	0,000311	NA	0,00063	0,0734	0,519	8	-166,1	361,305	25,119	0

Saplings richness

Model	AGB	%ADS	CC	FD	C dens	T dens	T rich	r ²	df	logLik	AICc	delta	weight
1	NA	NA	NA	NA	NA	NA	0,035	0,230	2	-61,335	127,242	0	0,089
2	NA	-0,00465	NA	NA	NA	NA	0,027	0,298	3	-60,226	127,652	0,410	0,073
3	NA	-0,00649	NA	NA	NA	NA	NA	0,196	2	-61,850	128,270	1,029	0,053
4	NA	NA	-0,00500	NA	NA	NA	0,042	0,263	3	-60,807	128,815	1,573	0,041
5	NA	NA	NA	NA	NA	-0,016	0,057	0,262	3	-60,822	128,844	1,603	0,040
6	NA	-0,00559	NA	-0,00010	NA	NA	0,027	0,342	4	-59,442	128,989	1,747	0,037
7	NA	NA	NA	-0,00007	NA	NA	0,037	0,253	3	-60,974	129,149	1,907	0,034
8	NA	-0,00742	NA	-0,00010	NA	NA	NA	0,247	3	-61,068	129,336	2,095	0,031
9	NA	-0,00455	NA	NA	NA	-0,016	0,047	0,325	4	-59,758	129,622	2,380	0,027
10	-1,04E-05	NA	NA	NA	NA	NA	0,036	0,231	3	-61,324	129,849	2,607	0,024
11	NA	NA	NA	NA	-0,00017	NA	0,035	0,230	3	-61,327	129,854	2,612	0,024
12	5,88E-05	-0,00661	NA	NA	NA	NA	NA	0,224	3	-61,431	130,063	2,821	0,022
13	NA	-0,00411	-0,00333	NA	NA	NA	0,032	0,311	4	-59,997	130,099	2,858	0,021
14	NA	-0,00582	NA	NA	NA	0,008	NA	0,222	3	-61,464	130,128	2,886	0,021
15	NA	-0,00717	NA	-0,00015	-0,00182	NA	NA	0,299	4	-60,201	130,507	3,266	0,017
16	NA	-0,00617	NA	NA	-0,00077	NA	NA	0,209	3	-61,661	130,522	3,281	0,017
17	9,84E-06	-0,00474	NA	NA	NA	NA	0,026	0,298	4	-60,217	130,539	3,297	0,017
18	NA	-0,00464	NA	NA	-0,00006	NA	0,027	0,298	4	-60,225	130,555	3,314	0,017
19	NA	-0,00654	0,00084	NA	NA	NA	NA	0,197	3	-61,830	130,860	3,619	0,015
20	NA	NA	NA	NA	NA	NA	NA	0,000	1	-64,469	131,119	3,877	0,013
21	NA	NA	-0,00385	NA	NA	-0,013	0,057	0,280	4	-60,531	131,168	3,926	0,012
22	NA	NA	NA	-0,00006	NA	-0,015	0,056	0,279	4	-60,551	131,206	3,965	0,012
23	NA	-0,00674	NA	-0,00011	NA	0,009	NA	0,278	4	-60,553	131,212	3,970	0,012
24	NA	NA	NA	NA	NA	0,013	NA	0,089	2	-63,349	131,269	4,027	0,012
25	NA	NA	-0,00432	-0,00005	NA	NA	0,042	0,276	4	-60,591	131,288	4,046	0,012
26	NA	-0,00538	NA	-0,00009	NA	-0,013	0,044	0,359	5	-59,129	131,591	4,349	0,010
27	NA	NA	-0,00509	NA	-0,00028	NA	0,041	0,264	4	-60,785	131,676	4,434	0,010
28	NA	-0,00573	NA	-0,00013	-0,00104	NA	0,023	0,356	5	-59,189	131,712	4,470	0,010
29	NA	NA	NA	-0,00009	-0,00087	NA	0,033	0,263	4	-60,803	131,712	4,470	0,010
30	1,14E-06	NA	-0,00501	NA	NA	NA	0,042	0,263	4	-60,807	131,720	4,478	0,009
31	-4,88E-06	NA	NA	NA	NA	-0,016	0,057	0,262	4	-60,820	131,745	4,503	0,009
32	NA	NA	NA	NA	-0,00003	-0,016	0,057	0,262	4	-60,822	131,749	4,508	0,009
33	-3,47E-05	NA	NA	-0,00008	NA	NA	0,040	0,259	4	-60,867	131,838	4,597	0,009
34	4,09E-05	-0,00739	NA	-0,00009	NA	NA	NA	0,259	4	-60,869	131,844	4,602	0,009
35	NA	-0,00772	0,00245	-0,00011	NA	NA	NA	0,256	4	-60,913	131,931	4,689	0,009

36	NA	-0,00523	-0,00160	-0,00009	NA	NA	0,030	0,345	5	-59,393	132,119	4,878	0,008
37	-1,89E-05	-0,00548	NA	-0,00011	NA	NA	0,029	0,344	5	-59,410	132,153	4,912	0,008
38	NA	NA	NA	NA	-0,00132	NA	NA	0,044	2	-63,927	132,426	5,185	0,007
39	5,95E-05	-0,00627	NA	NA	-0,00077	NA	NA	0,236	4	-61,242	132,589	5,347	0,006
40	4,35E-05	-0,00611	NA	NA	NA	0,006	NA	0,234	4	-61,270	132,644	5,403	0,006
41	NA	-0,00422	-0,00197	NA	NA	-0,013	0,048	0,329	5	-59,687	132,708	5,466	0,006
42	-8,77E-06	NA	NA	NA	-0,00013	NA	0,036	0,231	4	-61,320	132,745	5,503	0,006
43	5,53E-05	NA	NA	NA	NA	NA	NA	0,031	2	-64,096	132,763	5,521	0,006
44	1,42E-05	-0,00466	NA	NA	NA	-0,016	0,046	0,326	5	-59,739	132,812	5,570	0,005
45	NA	-0,00455	NA	NA	0,00000	-0,016	0,047	0,325	5	-59,758	132,850	5,608	0,005
46	NA	-0,00566	NA	NA	-0,00052	0,007	NA	0,227	4	-61,380	132,866	5,624	0,005
47	NA	-0,00556	-0,00177	NA	NA	0,010	NA	0,225	4	-61,405	132,916	5,674	0,005
48	6,16E-05	-0,00659	-0,00057	NA	NA	NA	NA	0,224	4	-61,424	132,953	5,711	0,005
49	NA	NA	NA	-0,00004	NA	NA	NA	0,014	2	-64,304	133,179	5,937	0,005
50	NA	NA	NA	-0,00007	NA	0,015	NA	0,116	3	-62,992	133,183	5,942	0,005
51	NA	-0,00666	NA	-0,00015	-0,00156	0,007	NA	0,314	5	-59,940	133,214	5,972	0,004
52	1,78E-05	-0,00425	-0,00353	NA	NA	NA	0,031	0,313	5	-59,967	133,268	6,026	0,004
53	NA	NA	-0,00404	NA	NA	0,017	NA	0,113	3	-63,035	133,271	6,029	0,004
54	NA	-0,00408	-0,00342	NA	-0,00017	NA	0,032	0,312	5	-59,988	133,310	6,068	0,004
55	NA	-0,00618	0,00009	NA	-0,00076	NA	NA	0,209	4	-61,661	133,427	6,186	0,004
56	NA	NA	NA	NA	-0,00087	0,012	NA	0,106	3	-63,123	133,446	6,205	0,004
57	NA	NA	0,00012	NA	NA	NA	NA	0,000	2	-64,468	133,508	6,266	0,004
58	2,96E-05	-0,00713	NA	-0,00014	-0,00172	NA	NA	0,305	5	-60,103	133,539	6,297	0,004
59	NA	NA	NA	-0,00010	-0,00213	NA	NA	0,100	3	-63,199	133,598	6,356	0,004
60	NA	-0,00734	0,00143	-0,00016	-0,00173	NA	NA	0,302	5	-60,151	133,636	6,394	0,004
61	1,09E-05	-0,00473	NA	NA	-0,00009	NA	0,026	0,298	5	-60,214	133,762	6,520	0,003
62	2,30E-05	NA	NA	NA	NA	0,012	NA	0,093	3	-63,294	133,787	6,546	0,003
63	NA	NA	-0,00329	-0,00005	NA	-0,012	0,056	0,291	5	-60,342	134,018	6,776	0,003
64	NA	NA	-0,00427	-0,00008	-0,00084	NA	0,038	0,286	5	-60,430	134,193	6,952	0,003
65	NA	NA	NA	-0,00008	-0,00064	-0,014	0,052	0,284	5	-60,462	134,257	7,015	0,003
66	5,83E-05	NA	NA	NA	-0,00134	NA	NA	0,075	3	-63,528	134,257	7,015	0,003
67	-2,54E-05	NA	NA	-0,00007	NA	-0,014	0,058	0,282	5	-60,494	134,321	7,080	0,003
68	NA	NA	-0,00392	NA	-0,00015	-0,012	0,056	0,280	5	-60,525	134,383	7,142	0,003
69	3,11E-06	NA	-0,00389	NA	NA	-0,013	0,057	0,280	5	-60,530	134,394	7,153	0,002
70	1,38E-05	-0,00679	NA	-0,00010	NA	0,009	NA	0,279	5	-60,536	134,405	7,163	0,002
71	NA	-0,00675	0,00003	-0,00011	NA	0,009	NA	0,278	5	-60,553	134,440	7,199	0,002
72	-2,05E-05	NA	-0,00397	-0,00006	NA	NA	0,043	0,278	5	-60,556	134,445	7,204	0,002
73	NA	NA	NA	-0,00011	-0,00168	0,012	NA	0,165	4	-62,303	134,712	7,470	0,002
74	-3,14E-05	NA	NA	-0,00010	-0,00082	NA	0,037	0,269	5	-60,716	134,766	7,525	0,002
75	NA	-0,00558	NA	-0,00012	-0,00091	-0,012	0,039	0,369	6	-58,940	134,822	7,580	0,002
76	4,81E-06	NA	-0,00515	NA	-0,00030	NA	0,040	0,264	5	-60,783	134,899	7,658	0,002
77	-4,75E-06	NA	NA	NA	-0,00001	-0,016	0,057	0,262	5	-60,820	134,973	7,731	0,002
78	3,10E-05	-0,00757	0,00155	-0,00010	NA	NA	NA	0,262	5	-60,820	134,974	7,732	0,002
79	NA	NA	-0,00103	NA	-0,00139	NA	NA	0,046	3	-63,902	135,004	7,762	0,002
80	-1,12E-05	-0,00532	NA	-0,00010	NA	-0,013	0,045	0,360	6	-59,118	135,176	7,935	0,002
81	NA	-0,00530	-0,00039	-0,00009	NA	-0,013	0,044	0,359	6	-59,126	135,193	7,951	0,002
82	NA	-0,00540	-0,00154	-0,00012	-0,00103	NA	0,025	0,358	6	-59,144	135,229	7,987	0,002
83	4,89E-05	NA	NA	-0,00003	NA	NA	NA	0,036	3	-64,024	135,248	8,006	0,002
84	-1,61E-05	-0,00564	NA	-0,00014	-0,00102	NA	0,025	0,357	6	-59,166	135,274	8,032	0,002
85	5,97E-05	NA	-0,00109	NA	NA	NA	NA	0,033	3	-64,068	135,336	8,095	0,002
86	NA	NA	-0,00451	NA	-0,00100	0,016	NA	0,134	4	-62,741	135,587	8,345	0,001
87	4,79E-05	-0,00593	NA	NA	-0,00063	0,005	NA	0,242	5	-61,150	135,632	8,391	0,001
88	NA	NA	-0,00342	-0,00006	NA	0,018	NA	0,132	4	-62,768	135,642	8,401	0,001
89	4,84E-05	-0,00583	-0,00234	NA	NA	0,008	NA	0,240	5	-61,171	135,676	8,434	0,001

90	-1,37E-05	-0,00520	-0,00135	-0,00010	NA	NA	0,031	0,346	6	-59,377	135,696	8,455	0,001
91	6,66E-05	-0,00618	-0,00149	NA	-0,00088	NA	NA	0,239	5	-61,194	135,722	8,480	0,001
92	NA	NA	0,00064	-0,00005	NA	NA	NA	0,015	3	-64,293	135,787	8,545	0,001
93	NA	-0,00532	-0,00221	NA	-0,00062	0,010	NA	0,233	5	-61,292	135,918	8,677	0,001
94	3,05E-05	NA	-0,00436	NA	NA	0,016	NA	0,120	4	-62,939	135,983	8,741	0,001
95	1,87E-06	NA	NA	-0,00007	NA	0,015	NA	0,116	4	-62,991	136,088	8,846	0,001
96	3,19E-05	NA	NA	NA	-0,00096	0,010	NA	0,114	4	-63,021	136,146	8,905	0,001
97	3,96E-05	NA	NA	-0,00009	-0,00202	NA	NA	0,113	4	-63,025	136,155	8,913	0,001
98	1,86E-05	-0,00434	-0,00216	NA	NA	-0,014	0,046	0,330	6	-59,655	136,251	9,010	0,001
99	NA	-0,00421	-0,00201	NA	-0,00007	-0,013	0,047	0,329	6	-59,686	136,312	9,071	0,001
100	1,45E-05	-0,00467	NA	NA	-0,00004	-0,016	0,046	0,326	6	-59,739	136,419	9,177	0,001
101	NA	NA	-0,00039	-0,00010	-0,00215	NA	NA	0,101	4	-63,195	136,496	9,254	0,001
102	1,16E-05	-0,00670	NA	-0,00015	-0,00155	0,006	NA	0,315	6	-59,928	136,797	9,555	0,001
103	NA	-0,00660	-0,00032	-0,00015	-0,00156	0,007	NA	0,314	6	-59,938	136,818	9,576	0,001
104	2,08E-05	-0,00422	-0,00368	NA	-0,00025	NA	0,030	0,314	6	-59,950	136,841	9,599	0,001
105	6,76E-05	NA	-0,00240	NA	-0,00149	NA	NA	0,085	4	-63,405	136,914	9,673	0,001
106	2,52E-05	-0,00723	0,00077	-0,00015	-0,00169	NA	NA	0,306	6	-60,091	137,122	9,881	0,001
107	NA	NA	-0,00338	-0,00007	-0,00068	-0,011	0,052	0,297	6	-60,243	137,426	10,185	0,001
108	NA	NA	-0,00368	-0,00010	-0,00172	0,016	NA	0,183	5	-62,047	137,428	10,186	0,001
109	-1,61E-05	NA	-0,00305	-0,00006	NA	-0,012	0,057	0,292	6	-60,321	137,582	10,341	0,001
110	-1,79E-05	NA	-0,00399	-0,00008	-0,00083	NA	0,040	0,287	6	-60,403	137,747	10,506	0,000
111	-2,42E-05	NA	NA	-0,00009	-0,00062	-0,013	0,054	0,287	6	-60,410	137,762	10,520	0,000
112	2,71E-06	NA	NA	-0,00011	-0,00168	0,012	NA	0,165	5	-62,303	137,939	10,697	0,000
113	4,98E-06	NA	-0,00399	NA	-0,00017	-0,012	0,055	0,280	6	-60,523	137,987	10,745	0,000
114	1,46E-05	-0,00675	-0,00023	-0,00010	NA	0,009	NA	0,279	6	-60,535	138,011	10,769	0,000
115	5,21E-05	NA	-0,00062	-0,00003	NA	NA	NA	0,037	4	-64,016	138,137	10,896	0,000
116	4,15E-05	NA	-0,00499	NA	-0,00112	0,014	NA	0,146	5	-62,569	138,472	11,230	0,000
117	1,18E-05	NA	-0,00359	-0,00005	NA	0,017	NA	0,133	5	-62,756	138,846	11,604	0,000
118	-1,01E-05	-0,00552	NA	-0,00012	-0,00091	-0,011	0,039	0,370	7	-58,931	138,863	11,621	0,000
119	NA	-0,00548	-0,00046	-0,00012	-0,00091	-0,011	0,039	0,369	7	-58,937	138,873	11,632	0,000
120	5,46E-05	-0,00555	-0,00294	NA	-0,00076	0,007	NA	0,251	6	-61,001	138,943	11,701	0,000
121	-1,04E-05	-0,00528	-0,00022	-0,00009	NA	-0,012	0,045	0,360	7	-59,117	139,234	11,992	0,000
122	-1,12E-05	-0,00538	-0,00135	-0,00013	-0,00102	NA	0,026	0,359	7	-59,133	139,267	12,025	0,000
123	4,56E-05	NA	-0,00136	-0,00008	-0,00206	NA	NA	0,116	5	-62,986	139,305	12,064	0,000
124	2,01E-05	-0,00433	-0,00227	NA	-0,00014	-0,013	0,045	0,331	7	-59,649	140,299	13,057	0,000
125	1,33E-05	-0,00660	-0,00054	-0,00015	-0,00156	0,007	NA	0,315	7	-59,923	140,846	13,604	0,000
126	1,21E-05	NA	-0,00384	-0,00010	-0,00171	0,015	NA	0,184	6	-62,034	141,010	13,768	0,000
127	-1,49E-05	NA	-0,00316	-0,00007	-0,00067	-0,010	0,053	0,298	7	-60,224	141,448	14,206	0,000
128	-9,14E-06	-0,00546	-0,00031	-0,00012	-0,00091	-0,011	0,039	0,370	8	-58,930	143,459	16,218	0,000

Canopy cover

Model	AGB	%ADS	FD	C dens	S dens	T dens	S rich	T rich	r ²	df	logLik	AICc	delta	w
1	NA	NA	NA	NA	NA	0,01196	NA	NA	0,201	3	-97,548	202,295	0,000	0,105
2	NA	0,00201	NA	NA	NA	0,0142	NA	NA	0,254	4	-96,725	203,556	1,261	0,056
3	NA	NA	NA	NA	NA	NA	NA	0,0148	0,123	3	-98,665	204,529	2,234	0,034
4	NA	NA	NA	NA	NA	0,01328	-0,00820	NA	0,223	4	-97,214	204,533	2,238	0,034
5	3E-05	NA	NA	NA	NA	0,01065	NA	NA	0,217	4	-97,300	204,706	2,411	0,031
6	NA	NA	NA	-0,00044	NA	0,01124	NA	NA	0,214	4	-97,342	204,789	2,494	0,030
7	NA	NA	3E-05	NA	NA	0,01144	NA	NA	0,213	4	-97,360	204,825	2,530	0,030
8	NA	NA	NA	NA	-0,00056	0,01301	NA	NA	0,213	4	-97,360	204,825	2,530	0,030
9	NA	NA	NA	NA	NA	NA	NA	NA	0,000	2	-100,239	205,048	2,753	0,027
10	NA	NA	NA	NA	NA	0,01287	NA	-0,0018	0,201	4	-97,539	205,183	2,887	0,025
11	NA	0,00247	4E-05	NA	NA	0,0138	NA	NA	0,287	5	-96,174	205,681	3,386	0,019
12	5E-05	NA	NA	NA	NA	NA	NA	NA	0,077	3	-99,271	205,742	3,446	0,019

13	NA	0,00222	NA	-0,00058	NA	0,0135	NA	NA	0,277	5	-96,342	206,017	3,722	0,016
14	NA	0,00193	NA	NA	NA	NA	NA	0,0186	0,169	4	-98,016	206,136	3,841	0,015
15	NA	NA	NA	NA	NA	NA	-0,01274	0,0200	0,166	4	-98,066	206,237	3,942	0,015
16	2E-05	0,00192	NA	NA	NA	0,0130	NA	NA	0,265	5	-96,543	206,419	4,124	0,013
17	NA	NA	NA	-0,00079	NA	NA	NA	NA	0,045	3	-99,685	206,570	4,275	0,012
18	NA	0,00178	NA	NA	NA	0,0146	-0,0044	NA	0,259	5	-96,633	206,600	4,305	0,012
19	NA	0,00189	NA	NA	-0,0002	0,0145	NA	NA	0,256	5	-96,698	206,729	4,434	0,011
20	NA	0,00205	NA	NA	NA	0,0134	NA	0,0017	0,254	5	-96,717	206,767	4,472	0,011
21	3E-05	NA	NA	NA	NA	NA	NA	0,0120	0,146	4	-98,339	206,784	4,489	0,011
22	NA	NA	3E-05	NA	NA	NA	NA	0,0142	0,146	4	-98,343	206,791	4,496	0,011
23	NA	NA	4E-05	NA	NA	NA	NA	NA	0,034	3	-99,821	206,843	4,548	0,011
24	7E-05	NA	6E-05	NA	NA	NA	NA	NA	0,144	4	-98,369	206,843	4,548	0,011
25	NA	NA	NA	NA	-0,00068	NA	NA	0,0175	0,139	4	-98,440	206,986	4,691	0,010
26	NA	NA	NA	-0,00077	-0,00102	0,01259	NA	NA	0,247	5	-96,830	206,994	4,699	0,010
27	3E-05	NA	NA	NA	NA	0,01192	-0,00914	NA	0,244	5	-96,882	207,097	4,802	0,010
28	NA	NA	NA	-0,00056	NA	0,01260	-0,00969	NA	0,244	5	-96,882	207,097	4,802	0,010
29	4E-05	NA	4E-05	NA	NA	0,00930	NA	NA	0,243	5	-96,895	207,123	4,827	0,009
30	NA	NA	NA	-0,00041	NA	NA	NA	0,0133	0,134	4	-98,514	207,134	4,839	0,009
31	6E-05	NA	NA	-0,00087	NA	NA	NA	NA	0,133	4	-98,526	207,158	4,863	0,009
32	3E-05	NA	NA	-0,00053	NA	0,00953	NA	NA	0,237	5	-96,998	207,329	5,034	0,008
33	NA	NA	4E-05	NA	-0,00077	0,01268	NA	NA	0,235	5	-97,027	207,388	5,093	0,008
34	NA	NA	2E-05	NA	NA	0,01273	-0,00735	NA	0,230	5	-97,096	207,525	5,230	0,008
35	NA	0,00048	NA	NA	NA	NA	NA	NA	0,003	3	-100,198	207,597	5,302	0,007
36	NA	NA	NA	NA	0,00022	NA	NA	NA	0,002	3	-100,213	207,626	5,330	0,007
37	2E-05	NA	NA	NA	-0,00049	0,01169	NA	NA	0,226	5	-97,160	207,653	5,358	0,007
38	NA	NA	NA	NA	NA	NA	0,00026	NA	0,000	3	-100,238	207,676	5,381	0,007
39	NA	NA	NA	NA	NA	0,01143	-0,00962	0,0040	0,225	5	-97,177	207,687	5,392	0,007
40	NA	NA	NA	NA	-0,00027	0,01356	-0,00681	NA	0,225	5	-97,180	207,694	5,399	0,007
41	NA	0,00259	6E-05	NA	NA	NA	NA	0,0190	0,222	5	-97,221	207,775	5,480	0,007
42	3E-05	NA	NA	NA	NA	0,01244	NA	-0,0036	0,220	5	-97,263	207,858	5,563	0,007
43	NA	NA	2E-05	-0,00031	NA	0,01111	NA	NA	0,219	5	-97,277	207,887	5,592	0,006
44	NA	NA	NA	-0,00049	NA	0,01334	NA	-0,0042	0,218	5	-97,293	207,919	5,624	0,006
45	NA	NA	3E-05	NA	NA	0,01206	NA	-0,0012	0,214	5	-97,356	208,045	5,750	0,006
46	NA	NA	NA	NA	-0,00059	0,01254	NA	0,0010	0,213	5	-97,357	208,048	5,752	0,006
47	4E-05	0,00245	6E-05	NA	NA	0,0117	NA	NA	0,316	6	-95,673	208,287	5,992	0,005
48	5E-05	0,00061	NA	NA	NA	NA	NA	NA	0,083	4	-99,202	208,509	6,214	0,005
49	6E-05	NA	NA	NA	NA	NA	-0,00333	NA	0,081	4	-99,223	208,551	6,256	0,005
50	5E-05	NA	NA	NA	0,00021	NA	NA	NA	0,079	4	-99,247	208,599	6,304	0,004
51	NA	0,00155	NA	NA	NA	NA	-0,0100	0,0219	0,194	5	-97,655	208,642	6,347	0,004
52	3E-05	NA	NA	NA	NA	NA	-0,01295	0,0172	0,191	5	-97,702	208,737	6,442	0,004
53	5E-05	NA	5E-05	NA	NA	NA	NA	0,0099	0,190	5	-97,716	208,765	6,470	0,004
54	NA	0,00205	NA	-0,00050	NA	NA	NA	0,0170	0,186	5	-97,774	208,882	6,587	0,004
55	3E-05	0,00178	NA	NA	NA	NA	NA	0,0160	0,185	5	-97,782	208,897	6,602	0,004
56	NA	NA	NA	-0,00048	NA	NA	-0,01343	0,0185	0,181	5	-97,844	209,021	6,726	0,004
57	3E-05	0,00213	NA	-0,00066	NA	0,0119	NA	NA	0,294	6	-96,054	209,050	6,755	0,004
58	NA	0,00249	3E-05	-0,00034	NA	0,0135	NA	NA	0,294	6	-96,063	209,067	6,772	0,004
59	NA	NA	3E-05	NA	NA	NA	-0,01138	0,0189	0,179	5	-97,867	209,068	6,773	0,004
60	NA	NA	5E-05	NA	-0,00101	NA	NA	0,0180	0,179	5	-97,873	209,079	6,784	0,004
61	NA	0,00228	5E-05	NA	-0,0004	0,0143	NA	NA	0,293	6	-96,070	209,081	6,786	0,004
62	NA	0,00093	NA	-0,00088	NA	NA	NA	NA	0,057	4	-99,535	209,174	6,879	0,003
63	NA	0,00193	NA	-0,0008	-0,0007	0,0140	NA	NA	0,291	6	-96,119	209,178	6,883	0,003
64	NA	0,00175	NA	NA	-0,0004	NA	NA	0,0199	0,175	5	-97,936	209,205	6,910	0,003
65	NA	0,00258	5E-05	NA	NA	0,0120	NA	0,0036	0,290	6	-96,134	209,209	6,914	0,003
66	7E-05	0,00151	8E-05	NA	NA	NA	NA	NA	0,174	5	-97,948	209,229	6,934	0,003

67	NA	NA	2E-05	-0,00059	NA	NA	NA	NA	0,054	4	-99,572	209,249	6,953	0,003
68	NA	0,00238	4E-05	NA	NA	0,0140	-0,0014	NA	0,288	6	-96,166	209,272	6,977	0,003
69	NA	0,00193	NA	-0,00063	NA	0,0140	-0,0058	NA	0,287	6	-96,184	209,309	7,014	0,003
70	NA	0,00110	5E-05	NA	NA	NA	NA	NA	0,050	4	-99,626	209,357	7,062	0,003
71	NA	NA	NA	-0,00092	-0,00036	NA	NA	NA	0,049	4	-99,630	209,366	7,071	0,003
72	NA	NA	NA	NA	-0,00030	NA	-0,01141	0,0206	0,168	5	-98,028	209,389	7,094	0,003
73	NA	NA	NA	-0,00072	-0,00108	NA	NA	0,0164	0,168	5	-98,034	209,402	7,107	0,003
74	NA	NA	NA	-0,00083	NA	NA	-0,00275	NA	0,048	4	-99,654	209,413	7,117	0,003
75	4E-05	NA	NA	-0,00058	NA	NA	NA	0,0092	0,167	5	-98,042	209,418	7,123	0,003
76	6E-05	NA	4E-05	-0,00054	NA	NA	NA	NA	0,161	5	-98,137	209,608	7,313	0,003
77	NA	0,00220	NA	-0,00060	NA	0,0139	NA	-0,0010	0,277	6	-96,339	209,618	7,323	0,003
78	4E-05	NA	NA	-0,00069	NA	0,01076	-0,01118	NA	0,275	6	-96,378	209,697	7,402	0,003
79	NA	NA	4E-05	NA	NA	NA	0,00128	NA	0,035	4	-99,814	209,734	7,439	0,003
80	3E-05	NA	NA	NA	-0,00054	NA	NA	0,0145	0,156	5	-98,205	209,743	7,447	0,003
81	2E-05	0,00162	NA	NA	NA	0,0134	-0,0055	NA	0,274	6	-96,401	209,743	7,448	0,003
82	NA	NA	4E-05	NA	-0,00006	NA	NA	NA	0,034	4	-99,820	209,745	7,450	0,003
83	6E-05	0,00110	NA	-0,00098	NA	NA	NA	NA	0,150	5	-98,292	209,918	7,623	0,002
84	6E-05	NA	NA	-0,00100	NA	NA	-0,00727	NA	0,149	5	-98,297	209,928	7,633	0,002
85	NA	NA	3E-05	-0,00016	NA	NA	NA	0,0136	0,147	5	-98,324	209,982	7,687	0,002
86	3E-05	NA	NA	-0,00084	-0,00097	0,01093	NA	NA	0,266	6	-96,527	209,996	7,701	0,002
87	2E-05	0,00184	NA	NA	-0,0002	0,0132	NA	NA	0,266	6	-96,528	209,997	7,702	0,002
88	7E-05	NA	6E-05	NA	NA	NA	-0,00251	NA	0,146	5	-98,339	210,011	7,716	0,002
89	7E-05	NA	6E-05	NA	-0,00021	NA	NA	NA	0,146	5	-98,345	210,022	7,727	0,002
90	2E-05	0,00192	NA	NA	NA	0,0130	NA	0,0000	0,265	6	-96,543	210,027	7,731	0,002
91	4E-05	NA	3E-05	NA	NA	0,01058	-0,00798	NA	0,263	6	-96,570	210,080	7,785	0,002
92	NA	0,00181	NA	NA	NA	0,0124	-0,0061	0,0049	0,263	6	-96,574	210,090	7,795	0,002
93	4E-05	NA	5E-05	NA	-0,00072	0,01054	NA	NA	0,262	6	-96,588	210,117	7,822	0,002
94	4E-05	0,00251	7E-05	NA	NA	NA	NA	0,0148	0,261	6	-96,610	210,160	7,865	0,002
95	6E-05	NA	NA	-0,00104	-0,00045	NA	NA	NA	0,140	5	-98,434	210,201	7,906	0,002
96	NA	0,00176	NA	NA	-0,0001	0,0147	-0,0041	NA	0,260	6	-96,631	210,204	7,909	0,002
97	NA	NA	NA	-0,00076	-0,00073	0,01311	-0,00641	NA	0,258	6	-96,666	210,273	7,977	0,002
98	NA	0,00193	NA	NA	-0,0003	0,0132	NA	0,0028	0,257	6	-96,677	210,295	7,999	0,002
99	NA	0,00075	NA	NA	0,0004	NA	NA	NA	0,009	4	-100,131	210,368	8,072	0,002
100	NA	NA	2E-05	-0,00063	-0,00106	0,01247	NA	NA	0,254	6	-96,727	210,396	8,101	0,002
101	NA	0,00059	NA	NA	NA	NA	0,0018	NA	0,004	4	-100,187	210,480	8,185	0,002
102	NA	NA	NA	NA	0,00029	NA	-0,00146	NA	0,003	4	-100,206	210,518	8,223	0,002
103	4E-05	NA	3E-05	-0,00033	NA	0,00892	NA	NA	0,249	6	-96,800	210,540	8,245	0,002
104	NA	NA	NA	-0,00078	-0,00100	0,01302	NA	-0,0009	0,247	6	-96,828	210,597	8,302	0,002
105	4E-05	NA	NA	-0,00065	NA	0,01292	NA	-0,0074	0,246	6	-96,852	210,645	8,350	0,002
106	4E-05	NA	4E-05	NA	NA	0,01102	NA	-0,0035	0,245	6	-96,858	210,658	8,363	0,002
107	3E-05	NA	NA	NA	NA	0,01095	-0,00989	0,0022	0,245	6	-96,870	210,682	8,387	0,002
108	NA	NA	NA	-0,00054	NA	0,01185	-0,01024	0,0017	0,244	6	-96,876	210,692	8,397	0,002
109	3E-05	NA	NA	NA	-0,00009	0,01205	-0,00863	NA	0,244	6	-96,878	210,696	8,401	0,002
110	NA	NA	4E-06	-0,00052	NA	0,01253	-0,00941	NA	0,244	6	-96,878	210,697	8,402	0,002
111	NA	0,00236	6E-05	NA	-0,0008	NA	NA	0,0213	0,240	6	-96,949	210,839	8,544	0,001
112	NA	NA	3E-05	NA	-0,00056	0,01306	-0,00405	NA	0,238	6	-96,970	210,882	8,587	0,001
113	NA	NA	4E-05	NA	-0,00085	0,01120	NA	0,0031	0,236	6	-97,003	210,947	8,652	0,001
114	NA	NA	2E-05	NA	NA	0,01091	-0,00874	0,0039	0,233	6	-97,059	211,059	8,764	0,001
115	NA	0,00228	5E-05	NA	NA	NA	-0,0063	0,0210	0,231	6	-97,082	211,105	8,810	0,001
116	NA	NA	NA	NA	-0,00031	0,01147	-0,00820	0,0046	0,228	6	-97,131	211,203	8,908	0,001
117	2E-05	NA	NA	NA	-0,00045	0,01224	NA	-0,0013	0,227	6	-97,156	211,253	8,958	0,001
118	NA	0,00258	5E-05	-0,00010	NA	NA	NA	0,0186	0,223	6	-97,213	211,367	9,072	0,001
119	NA	NA	1E-05	-0,00037	NA	0,01276	NA	-0,0033	0,221	6	-97,248	211,438	9,143	0,001
120	4E-05	NA	4E-05	NA	NA	NA	-0,01089	0,0146	0,220	6	-97,255	211,450	9,155	0,001

121	4E-05	NA	NA	-0,00067	NA	NA	-0,01392	0,0144	0,218	6	-97,292	211,525	9,229	0,001
122	6E-05	NA	NA	NA	0,00051	NA	-0,00648	NA	0,089	5	-99,117	211,567	9,272	0,001
123	5E-05	0,00088	NA	NA	0,0004	NA	NA	NA	0,089	5	-99,123	211,579	9,284	0,001
124	4E-05	NA	6E-05	NA	-0,00087	NA	NA	0,0136	0,214	6	-97,356	211,653	9,358	0,001
125	NA	0,00167	NA	-0,00054	NA	NA	-0,0105	0,0204	0,213	6	-97,366	211,672	9,377	0,001
126	3E-05	0,00138	NA	NA	NA	NA	-0,0105	0,0193	0,212	6	-97,379	211,698	9,403	0,001
127	6E-05	0,00048	NA	NA	NA	NA	-0,0021	NA	0,084	5	-99,186	211,706	9,411	0,001
128	3E-05	0,00189	NA	-0,00064	NA	NA	NA	0,0132	0,211	6	-97,397	211,736	9,441	0,001
129	NA	0,00176	NA	-0,0007	-0,0008	NA	NA	0,0188	0,203	6	-97,508	211,958	9,663	0,001
130	NA	0,00121	3E-05	-0,00064	NA	NA	NA	NA	0,073	5	-99,329	211,992	9,697	0,001
131	4E-05	0,00248	5E-05	-0,00036	NA	0,0113	NA	NA	0,324	7	-95,548	212,095	9,800	0,001
132	4E-05	0,00229	6E-05	NA	-0,0004	0,0122	NA	NA	0,321	7	-95,587	212,175	9,879	0,001
133	NA	0,00152	NA	NA	-0,0001	NA	-0,0095	0,0222	0,194	6	-97,648	212,237	9,941	0,001
134	7E-05	0,00160	6E-05	-0,00059	NA	NA	NA	NA	0,194	6	-97,657	212,254	9,959	0,001
135	3E-05	NA	NA	-0,00083	-0,00095	NA	NA	0,0124	0,193	6	-97,661	212,263	9,968	0,001
136	5E-05	NA	4E-05	-0,00026	NA	NA	NA	0,0089	0,193	6	-97,663	212,268	9,973	0,001
137	NA	NA	NA	-0,00067	-0,00069	NA	-0,01061	0,0194	0,193	6	-97,669	212,280	9,985	0,001
138	4E-05	0,00232	5E-05	NA	NA	0,0119	-0,0021	NA	0,318	7	-95,652	212,305	10,010	0,001
139	NA	NA	3E-05	-0,00074	-0,00042	NA	NA	NA	0,060	5	-99,499	212,331	10,036	0,001
140	NA	NA	4E-05	NA	-0,00069	NA	-0,00777	0,0200	0,191	6	-97,695	212,332	10,037	0,001
141	4E-05	0,00249	6E-05	NA	NA	0,0110	NA	0,0013	0,317	7	-95,667	212,335	10,040	0,001
142	3E-05	NA	NA	NA	-0,00009	NA	-0,01256	0,0174	0,191	6	-97,699	212,339	10,044	0,001
143	NA	0,00152	6E-05	NA	NA	NA	0,0055	NA	0,058	5	-99,519	212,371	10,076	0,001
144	NA	0,00084	NA	-0,0009	-0,0002	NA	NA	NA	0,058	5	-99,522	212,377	10,082	0,001
145	NA	0,00090	NA	-0,00089	NA	NA	-0,0007	NA	0,057	5	-99,533	212,399	10,104	0,001
146	NA	NA	4E-05	-0,00044	-0,00119	NA	NA	0,0172	0,188	6	-97,738	212,417	10,122	0,001
147	2E-05	0,00166	NA	NA	-0,0003	NA	NA	0,0171	0,188	6	-97,742	212,426	10,130	0,001
148	NA	NA	2E-05	-0,00063	NA	NA	-0,00148	NA	0,055	5	-99,563	212,460	10,164	0,001
149	NA	NA	2E-05	-0,00034	NA	NA	-0,01237	0,0183	0,185	6	-97,785	212,511	10,216	0,001
150	NA	0,00119	5E-05	NA	0,0002	NA	NA	NA	0,051	5	-99,614	212,562	10,267	0,001
151	NA	NA	NA	-0,00092	-0,00030	NA	-0,00131	NA	0,050	5	-99,625	212,583	10,288	0,001
152	3E-05	0,00175	NA	-0,00074	NA	0,0123	-0,0074	NA	0,309	7	-95,797	212,594	10,299	0,001
153	NA	0,00220	3E-05	-0,0005	-0,0007	0,0141	NA	NA	0,308	7	-95,827	212,654	10,359	0,001
154	3E-05	0,00186	NA	-0,0008	-0,0006	0,0125	NA	NA	0,306	7	-95,851	212,703	10,407	0,001
155	7E-05	0,00167	8E-05	NA	NA	NA	0,0022	NA	0,175	6	-97,930	212,800	10,505	0,001
156	7E-05	0,00155	8E-05	NA	0,0001	NA	NA	NA	0,174	6	-97,945	212,831	10,536	0,001
157	7E-05	NA	5E-05	-0,00072	-0,00056	NA	NA	NA	0,171	6	-97,991	212,924	10,629	0,001
158	NA	0,00240	5E-05	NA	-0,0006	0,0114	NA	0,0062	0,300	7	-95,965	212,931	10,636	0,001
159	NA	NA	5E-05	NA	-0,00020	NA	0,00256	NA	0,036	5	-99,801	212,936	10,641	0,001
160	7E-05	NA	4E-05	-0,00068	NA	NA	-0,00543	NA	0,169	6	-98,010	212,962	10,667	0,001
161	3E-05	0,00205	NA	-0,00072	NA	0,0136	NA	-0,0039	0,297	7	-96,012	213,025	10,730	0,000
162	NA	0,00229	3E-05	-0,00041	NA	0,0137	-0,0032	NA	0,296	7	-96,021	213,041	10,746	0,000
163	NA	0,00254	4E-05	-0,00031	NA	0,0126	NA	0,0018	0,294	7	-96,054	213,108	10,813	0,000
164	NA	0,00235	5E-05	NA	-0,0005	0,0142	0,0014	NA	0,294	7	-96,063	213,126	10,831	0,000
165	NA	0,00181	NA	-0,0008	-0,0005	0,0143	-0,0036	NA	0,294	7	-96,066	213,131	10,836	0,000
166	NA	0,00242	4E-05	NA	NA	0,0116	-0,0031	0,0051	0,292	7	-96,098	213,197	10,901	0,000
167	NA	0,00194	NA	-0,0008	-0,0007	0,0136	NA	0,0009	0,291	7	-96,116	213,233	10,938	0,000
168	6E-05	0,00081	NA	-0,00105	NA	NA	-0,0053	NA	0,157	6	-98,186	213,313	11,018	0,000
169	NA	0,00194	NA	-0,00061	NA	0,0129	-0,0065	0,0024	0,288	7	-96,170	213,341	11,046	0,000
170	6E-05	0,00098	NA	-0,0011	-0,0002	NA	NA	NA	0,151	6	-98,269	213,479	11,184	0,000
171	3E-05	NA	NA	-0,00083	-0,00058	0,01130	-0,00848	NA	0,283	7	-96,243	213,485	11,190	0,000
172	6E-05	NA	NA	-0,00104	-0,00014	NA	-0,00658	NA	0,150	6	-98,291	213,522	11,227	0,000
173	4E-05	NA	3E-05	-0,00063	-0,00101	0,01032	NA	NA	0,281	7	-96,276	213,551	11,256	0,000
174	NA	0,00074	NA	NA	0,0004	NA	-0,0002	NA	0,009	5	-100,131	213,595	11,300	0,000

175	7E-05	NA	6E-05	NA	-0,00011	NA	-0,00180	NA	0,147	6	-98,335	213,610	11,315	0,000
176	4E-05	NA	2E-05	-0,00055	NA	0,01030	-0,01018	NA	0,279	7	-96,313	213,626	11,331	0,000
177	2E-05	0,00165	NA	NA	NA	0,0119	-0,0066	0,0034	0,275	7	-96,373	213,746	11,451	0,000
178	4E-05	NA	NA	-0,00070	NA	0,01134	-0,01076	-0,0014	0,275	7	-96,374	213,748	11,452	0,000
179	3E-05	0,00164	NA	NA	0,0001	0,0133	-0,0059	NA	0,274	7	-96,399	213,797	11,502	0,000
180	4E-05	0,00232	7E-05	NA	-0,0006	NA	NA	0,0171	0,272	7	-96,422	213,844	11,549	0,000
181	4E-05	0,00221	6E-05	NA	NA	NA	-0,0059	0,0168	0,269	7	-96,480	213,959	11,664	0,000
182	3E-05	NA	NA	-0,00088	-0,00088	0,01269	NA	-0,0041	0,269	7	-96,485	213,970	11,675	0,000
183	4E-05	NA	4E-05	NA	-0,00045	0,01092	-0,00532	NA	0,269	7	-96,487	213,973	11,678	0,000
184	2E-05	0,00185	NA	NA	-0,0002	0,0129	NA	0,0008	0,266	7	-96,526	214,053	11,758	0,000
185	4E-05	NA	3E-05	NA	NA	0,00992	-0,00851	0,0015	0,264	7	-96,564	214,128	11,833	0,000
186	NA	0,00178	NA	NA	-0,0001	0,0124	-0,0056	0,0051	0,264	7	-96,568	214,136	11,841	0,000
187	4E-05	0,00248	6E-05	-0,00019	NA	NA	NA	0,0140	0,263	7	-96,578	214,157	11,862	0,000
188	4E-05	NA	5E-05	NA	-0,00073	0,01037	NA	0,0004	0,262	7	-96,587	214,175	11,880	0,000
189	NA	NA	1E-05	-0,00067	-0,00081	0,01294	-0,00524	NA	0,260	7	-96,631	214,262	11,967	0,000
190	NA	NA	NA	-0,00074	-0,00075	0,01206	-0,00712	0,0023	0,258	7	-96,653	214,306	12,011	0,000
191	4E-05	NA	3E-05	-0,00044	NA	0,01180	NA	-0,0061	0,255	7	-96,700	214,401	12,106	0,000
192	NA	NA	2E-05	-0,00062	-0,00107	0,01213	NA	0,0007	0,254	7	-96,726	214,452	12,157	0,000
193	3E-05	NA	NA	NA	-0,00013	0,01098	-0,00931	0,0025	0,245	7	-96,863	214,726	12,431	0,000
194	NA	NA	5E-06	-0,00050	NA	0,01169	-0,00998	0,0018	0,245	7	-96,870	214,741	12,445	0,000
195	NA	0,00228	6E-05	-0,0003	-0,0009	NA	NA	0,0206	0,244	7	-96,877	214,753	12,458	0,000
196	NA	NA	3E-05	NA	-0,00062	0,01071	-0,00552	0,0052	0,242	7	-96,908	214,815	12,520	0,000
197	4E-05	0,00147	NA	-0,00070	NA	NA	-0,0113	0,0165	0,242	7	-96,916	214,831	12,536	0,000
198	NA	0,00224	6E-05	NA	-0,0006	NA	-0,0030	0,0219	0,241	7	-96,923	214,847	12,551	0,000
199	6E-05	0,00070	NA	NA	0,0006	NA	-0,0053	NA	0,095	6	-99,042	215,025	12,730	0,000
200	NA	0,00222	4E-05	-0,00021	NA	NA	-0,0070	0,0205	0,233	7	-97,049	215,098	12,803	0,000
201	5E-05	NA	3E-05	-0,00043	NA	NA	-0,01212	0,0135	0,229	7	-97,113	215,226	12,931	0,000
202	4E-05	NA	5E-05	NA	-0,00052	NA	-0,00815	0,0157	0,227	7	-97,151	215,303	13,007	0,000
203	4E-05	NA	5E-05	-0,00051	-0,00106	NA	NA	0,0125	0,225	7	-97,174	215,348	13,053	0,000
204	3E-05	0,00165	NA	-0,0008	-0,0007	NA	NA	0,0151	0,224	7	-97,190	215,380	13,085	0,000
205	4E-05	NA	NA	-0,00079	-0,00050	NA	-0,01182	0,0153	0,224	7	-97,198	215,396	13,101	0,000
206	NA	0,00155	NA	-0,0007	-0,0005	NA	-0,0086	0,0209	0,219	7	-97,265	215,531	13,236	0,000
207	NA	0,00141	4E-05	-0,00058	NA	NA	0,0027	NA	0,075	6	-99,306	215,554	13,259	0,000
208	NA	0,00111	3E-05	-0,0007	-0,0002	NA	NA	NA	0,074	6	-99,315	215,570	13,275	0,000
209	3E-05	0,00139	NA	NA	0,0000	NA	-0,0107	0,0192	0,212	7	-97,378	215,755	13,460	0,000
210	NA	NA	3E-05	-0,00072	-0,00048	NA	0,00112	NA	0,060	6	-99,495	215,932	13,637	0,000
211	NA	0,00151	6E-05	NA	-0,0001	NA	0,0064	NA	0,059	6	-99,513	215,966	13,671	0,000
212	NA	0,00084	NA	-0,0009	-0,0002	NA	0,0001	NA	0,058	6	-99,522	215,984	13,689	0,000
213	NA	NA	3E-05	-0,00048	-0,00085	NA	-0,00831	0,0193	0,202	7	-97,535	216,069	13,774	0,000
214	7E-05	0,00147	6E-05	-0,0007	-0,0003	NA	NA	NA	0,196	7	-97,626	216,252	13,957	0,000
215	4E-05	0,00221	5E-05	-0,0005	-0,0006	0,0119	NA	NA	0,335	8	-95,334	216,269	13,974	0,000
216	7E-05	0,00155	6E-05	-0,00061	NA	NA	-0,0008	NA	0,194	7	-97,654	216,308	14,013	0,000
217	4E-05	0,00221	4E-05	-0,00045	NA	0,0116	-0,0041	NA	0,328	8	-95,476	216,551	14,256	0,000
218	4E-05	0,00245	5E-05	-0,00038	NA	0,0117	NA	-0,0010	0,324	8	-95,545	216,690	14,395	0,000
219	3E-05	0,00235	6E-05	NA	-0,0005	0,0106	NA	0,0036	0,323	8	-95,553	216,706	14,411	0,000
220	4E-05	0,00229	6E-05	NA	-0,0004	0,0121	0,0001	NA	0,321	8	-95,587	216,774	14,479	0,000
221	7E-05	0,00166	8E-05	NA	0,0000	NA	0,0024	NA	0,175	7	-97,929	216,858	14,563	0,000
222	4E-05	0,00234	5E-05	NA	NA	0,0106	-0,0030	0,0028	0,319	8	-95,632	216,864	14,568	0,000
223	7E-05	NA	4E-05	-0,00075	-0,00039	NA	-0,00326	NA	0,173	7	-97,958	216,917	14,621	0,000
224	3E-05	0,00166	NA	-0,0008	-0,0004	0,0126	-0,0057	NA	0,313	8	-95,726	217,051	14,756	0,000
225	NA	0,00229	4E-05	-0,0005	-0,0008	0,0121	NA	0,0041	0,310	8	-95,782	217,165	14,870	0,000
226	3E-05	0,00175	NA	-0,00074	NA	0,0124	-0,0073	-0,0003	0,309	8	-95,797	217,193	14,898	0,000
227	NA	0,00221	4E-05	-0,0005	-0,0007	0,0140	0,0001	NA	0,308	8	-95,827	217,254	14,959	0,000
228	3E-05	0,00183	NA	-0,0009	-0,0006	0,0133	NA	-0,0020	0,307	8	-95,841	217,281	14,986	0,000

229	6E-05	0,00081	NA	-0,0011	0,0000	NA	-0,0052	NA	0,157	7	-98,185	217,371	15,076	0,000
230	NA	0,00239	5E-05	NA	-0,0006	0,0114	-0,0002	0,0063	0,300	8	-95,965	217,530	15,235	0,000
231	NA	0,00233	3E-05	-0,00037	NA	0,0121	-0,0042	0,0035	0,298	8	-95,990	217,581	15,286	0,000
232	NA	0,00182	NA	-0,0008	-0,0005	0,0130	-0,0045	0,0028	0,295	8	-96,047	217,693	15,398	0,000
233	4E-05	NA	2E-05	-0,00068	-0,00070	0,01077	-0,00653	NA	0,290	8	-96,122	217,844	15,549	0,000
234	3E-05	NA	NA	-0,00084	-0,00057	0,01155	-0,00832	-0,0006	0,283	8	-96,242	218,083	15,788	0,000
235	4E-05	NA	3E-05	-0,00066	-0,00096	0,01131	NA	-0,0023	0,282	8	-96,263	218,126	15,831	0,000
236	4E-05	NA	2E-05	-0,00057	NA	0,01074	-0,00988	-0,0010	0,279	8	-96,310	218,221	15,926	0,000
237	4E-05	0,00223	7E-05	-0,0004	-0,0008	NA	NA	0,0161	0,279	8	-96,316	218,231	15,936	0,000
238	2E-05	0,00166	NA	NA	0,0000	0,0119	-0,0067	0,0033	0,275	8	-96,373	218,346	16,050	0,000
239	4E-05	0,00218	7E-05	NA	-0,0005	NA	-0,0034	0,0177	0,275	8	-96,386	218,372	16,077	0,000
240	4E-05	0,00212	5E-05	-0,00030	NA	NA	-0,0070	0,0159	0,273	8	-96,408	218,416	16,121	0,000
241	4E-05	NA	4E-05	NA	-0,00048	0,00981	-0,00601	0,0026	0,269	8	-96,471	218,541	16,246	0,000
242	NA	NA	1E-05	-0,00064	-0,00083	0,01163	-0,00601	0,0029	0,261	8	-96,612	218,824	16,529	0,000
243	NA	0,00214	5E-05	-0,0003	-0,0008	NA	-0,0036	0,0213	0,247	8	-96,840	219,281	16,986	0,000
244	3E-05	0,00139	NA	-0,0008	-0,0004	NA	-0,0099	0,0170	0,245	8	-96,865	219,331	17,036	0,000
245	4E-05	NA	4E-05	-0,00055	-0,00070	NA	-0,00876	0,0146	0,241	8	-96,936	219,473	17,178	0,000
246	NA	0,00135	4E-05	-0,0007	-0,0004	NA	0,0047	NA	0,078	7	-99,260	219,520	17,225	0,000
247	7E-05	0,00150	6E-05	-0,0007	-0,0003	NA	0,0007	NA	0,196	8	-97,625	220,849	18,554	0,000
248	4E-05	0,00215	5E-05	-0,0006	-0,0006	0,0119	-0,0012	NA	0,336	9	-95,329	221,516	19,221	0,000
249	4E-05	0,00223	5E-05	-0,0005	-0,0007	0,0114	NA	0,0012	0,336	9	-95,330	221,518	19,223	0,000
250	4E-05	0,00222	4E-05	-0,00044	NA	0,0112	-0,0044	0,0008	0,328	9	-95,474	221,805	19,510	0,000
251	3E-05	0,00232	6E-05	NA	-0,0004	0,0105	-0,0008	0,0038	0,323	9	-95,551	221,958	19,663	0,000
252	3E-05	0,00167	NA	-0,0008	-0,0004	0,0125	-0,0057	0,0002	0,313	9	-95,726	222,308	20,013	0,000
253	NA	0,00225	4E-05	-0,0005	-0,0007	0,0121	-0,0009	0,0044	0,310	9	-95,780	222,417	20,122	0,000
254	4E-05	NA	2E-05	-0,00068	-0,00070	0,01074	-0,00654	0,0001	0,290	9	-96,122	223,101	20,806	0,000
255	4E-05	0,00206	6E-05	-0,0004	-0,0006	NA	-0,0041	0,0168	0,282	9	-96,264	223,386	21,091	0,000
256	4E-05	0,00217	5E-05	-0,0005	-0,0006	0,0112	-0,0016	0,0017	0,336	10	-95,322	227,568	25,273	0,000