Universidade Federal de Minas Gerais
Instituto de Ciências Biológicas
Departamento de Botânica
Programa de Pós-Graduação em Biologia Vegetal

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MONIQUE PERINI

CONTRIBUIÇÕES PARA RESTAURAÇÃO DA MATA ATLÂNTICA

Tese apresentada ao Programa de Pós-Graduação em Biologia Vegetal do Departamento de Botânica do Instituto de Ciências Biológicas da Universidade Federal de Minas Gerais, como requisito parcial à obtenção do título de Doutora em Biologia Vegetal.

Área de Concentração: Fisiologia Vegetal e Ecologia

BELO HORIZONTE – MG

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Orientador: Prof. Dr. José Pires de Lemos Filho
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Dr. José Pires de Lemos Filho

Dra. Valéria Hollunder Klippel

Dr. Matheus Lopes Souza

Dr. Marcel Giovanni Costa França

Dr. Evandro Luiz Mendonça Machado

DEDICO ESTA TESE AO MEU PAI EUDES PERINI *(in memoriam)*

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Sumário

RESUMO GERAL

Devido sua localização litorânea, a Floresta Atlântica sofre com perturbações antrópicas como o desmatamento, desde o período colonial. Aos poucos a floresta foi dando lugar a áreas urbanas, pastagens e agricultura. Após o uso desenfreado de recursos, o ambiente encontra-se diante de perturbações que dificultam mecanismos naturais de regeneração, logo, a restauração florestal se faz necessária. Diante de tantos desafios essa tese teve como objetivo contribuir com a restauração da Floresta Atântica no Sudeste de Minas Gerais, por meio de três capítulos: (1) Conhecimento tradicional sobre espécies florestais: diferentes tempos, diferentes visões; (2) Chuva de sementes em cronossequência de restauração da Floresta Atlântica; (3) Gramínea exótica prejudica a restauração da Floresta Atlântica no sudeste do Brasil. A resconstrução da comunidade mais próxima possível das características funcionais naturais é um desafio, principalmente quando se trata de áreas distantes de fragmentos conversados ou antigas pastagens que ainda contam com a presença de gramíneas exóticas. Os projetos de restauração florestal têm como referências áreas próximas conversadas, no entanto, o termo referência tem como base a atual florística da área e nem sempre leva em consideração a floresta primária que estava instalada anteriormente ao desmatamento, logo, nosso primeiro capítulo confronta o saber tradicional e formal, com base em listas geradas por entrevistas a idosos e jovens e listas publicadas. Esse capítulo foi desenvolvido em duas áreas com histórico de conservação distinto: Santa Teresa – ES uma área conservada e com alta biodiversidade e Aimorés – MG, área que sofreu com a exploração de madeira, inundação para construção de hidrelétrica e ferrovia. Nossos resultados sugerem que a superexploração no passado ou a raridade natural de espécies florestais são fatores que justificam a ausência de espécies citadas pela população idosa, assim como, apontamos a importância de ações para a manutenção do conhecimento tradicional, com ações que motivam os jovens a adquirir conhecimentos sobre a vegetação hoje sob o domínio do idoso. Também foi destacada a relevância do conhecimento tradicional, além do conhecimento formal para a escolha de espécies para restauração florestal. Para a determinação do sucesso e avanço sucessional da área restaurada há variáveis padrões analisadas, como substituição de espécies ao longo do tempo conforme o grupo ecológico e modo de vida. Esses padrões são verificados por meio da chuva de sementes, logo, nosso segundo capítulo buscou identificar a resposta da chuva de sementes frente a variáveis ambientais ao longo de uma cronossequência de restauração, investigamos o potencial da comunidade vegetal ao longo de uma cronossequência de restauração trabalhando em três áreas com idade de 5, 10 e 20 anos de restauração. Notamos em intervalo de 20 anos avanço sucessional por meio da composição chuva de sementes, além disso, o índice de área foliar influencia diretamente a chuva de sementes. Para a restauração de antigas pastagens ainda há outro desafio, a presença de gramíneas exóticas com alta capacidade competitiva e elevada produção de sementes, logo, verificar mecanismos que minimizam o impacto das exóticas e colaboram com o estabelecimento das nativas também é um fator que contribui com o sucesso da restauração. Sendo assim, no terceiro capítulo buscamos avaliar os fatores bióticos e abióticos que atuam no estabelecimento de recrutas em área conservada e outra em restauração, dominada por *Urochloa brizantha*. Nosso principal achado sugere que a maior disponibilidade de recursos na área em restauração favorece a alta produtividade da gramínea, que também resulta em alta proporção de sementes em relação às espécies florestais na chuva de sementes. Nossos resutados sugerem que é interessante aproveitar o conhecimento tradicional para o planejamento de ações de restauração da Mata Atlântica. Observamos também, com base na chuva de sementes, indícios de uma trajetória positiva na restauração da Mata Atlântica promovidas pelo Instituto Terra. Entre as dificuldades de restauração florestal em áreas previamentes utilizadas como pastagem verificamos que a disponibilidade de recursos, principalmente luz favorece o crescimento e produção de sementes de *U. brizantha*, desfavorecendo a restauração.

Palavras-chave: Ambiente degradado; Conhecimento tradicional; Ecologia; Propágulos; *Urochloa brizantha*.

ABSTRACT

Due to its coastal location, the Atlantic Forest has suffered from anthropogenic disturbances such as deforestation since the colonial period. Gradually the forest gave way to urban areas, pastures and agriculture. After the unbridled use of resources, the environment is faced with disturbances that hinder natural mechanisms of regeneration, therefore, forest restoration is necessary. Faced with so many challenges, this thesis aimed to contribute to the restoration of the Atlantic Forest in the Southeast of Minas Gerais, through three chapters: (1) Traditional knowledge about forest species: different times, different views; (2) Seed rain in chronossequence of restoration of the Atlantic Forest; (3) Exotic grass impairs the Atlantic Forest restoration in southeast Brazil. The reconstruction of the community as close as possible to the natural functional characteristics is a challenge, especially when it comes to areas distant from fragments talked about or old pastures that still have the presence of exotic grasses. The forest restoration projects are based on the areas discussed nearby, however, the term reference is based on the current floristics of the area and does not always take into account the primary forest that was installed before deforestation, so our first chapter confronts knowledge traditional and formal, based on lists generated by interviews with the elderly and young people and published lists. This chapter was developed in two areas with a different conservation history: Santa Teresa - ES a conserved area with high biodiversity and Aimorés - MG, an area that suffered from the exploitation of wood, flooding for the construction of a hydroelectric and railroad. Our results suggest that overexploitation in the past or the natural rarity of forest species are factors that justify the absence of species mentioned by the elderly population, as well as, we point out the importance of actions for the maintenance of traditional knowledge, with actions that motivate young people to acquire knowledge about vegetation today under the control of the elderly. The relevance of traditional knowledge was also highlighted, in addition to formal knowledge for the choice of species for forest restoration. To determine the success and succession of the restored area, there are standard variables analyzed, such as the replacement of species over time according to the ecological group and way of life. These patterns are verified through seed rain, so our second chapter sought to identify the response of seed rain in the face of environmental variables over a restoration chronosequence, we investigate the potential of the plant community over a restoration chronosequence by working in three areas aged 5, 10 and 20 years of restoration. We noticed a successional advance in 20 years through the composition of seed rain. In addition, the availability of light directly influences the seed rain. For the restoration of old pastures, there is still another challenge, the presence of exotic grasses with high competitive capacity and high seed production, therefore, verifying mechanisms that minimize the impact of exotic ones and collaborate with the establishment of native ones is also a factor that contributes with successful restoration. Therefore, in the third chapter we seek to evaluate the biotic and abiotic factors that act in the establishment of recruits in a conserved area and another in restoration, dominated by *Urochloa brizantha*. Our main finding suggests that the greater availability of resources in the area under restoration favors the high productivity of the grass, which also results in a high proportion of seeds in relation to forest species in the seed rain. Our results suggest that it is interesting to take advantage of traditional knowledge for planning actions to restore the Atlantic Forest. We also observed, based on the seed rain, signs of a positive trajectory in the restoration of the Atlantic Forest promoted by Instituto Terra. Among the difficulties of forest restoration in areas previously used as pasture, we verified that the availability of resources, mainly light, favors the growth and production of *U. brizantha* seeds, disfavoring restoration.

Keywords: Degraded environment; Traditional knowledge; Ecology; Propagules; *Urochloa brizantha*.

INTRODUÇÃO GERAL

Durante séculos a Floresta Atlântica sofreu altos níveis de perturbações antrópicas como o desmatamento e a fragmentação de habitats para dar lugar, principalmente, a áreas de pastagem e agricultura. Após anos de uso para agricultura, o ambiente tende a se tornar degradado, não apresentando mais as mesmas condições ideais para a produção (Durigan et al., 2000; Yang et al., 2003). Em áreas de intenso uso agrícola, encontram-se diversos distúrbios e perturbações que dificultam mecanismos naturais de regeneração florestal como rebrotas, disponibilidade de agentes dispersores de sementes, além da distância a fragmentos florestais conservados que serviriam como fonte de propágulos (Lamb et al., 2005; Shono et al., 2007).

O termo restauração florestal propõe a reconstrução da comunidade, mais próxima possível das características funcionais naturais, considerando o histórico da área, as condições atuais e o entorno (Rodrigues & Gandolf, 1996), sendo oferecidas diversas metodologias eficazes para o sucesso dessa intervenção (Shono et al., 2007). A escolha do modelo de restauração deve ir além da caracterização das espécies visando o processo de sucessão florestal. Não considerar os parâmetros de dinâmica das florestas, pode levar a restauração do ambiente ao declínio, proporcionando a construção de florestas vazias e com o estágio sucessional estagnado (Reford, 1992; Almeida, 1996; Hobbs & Norton, 1996). A sucessão ecológica consiste na substituição gradual das espécies ao longo do tempo, sendo um processo estocástico que ocorre por diferentes trajetórias com base na dinâmica da floresta (Pickett & McDonnell, 1989). No entanto, em áreas em processo de restauração pode-se haver o comprometimento da dinâmica florestal, uma vez que não ocorra o manejo adequado, principalmente quando se trata de antigas pastagens e que ainda há ocorrência de gramíneas exóticas. A invasão de áreas em restauração por espécies exóticas é um problema enfrentado pelos ecossistemas cujo sua biodiversidade se mantém ameaçada.

O estabelecimento e dominância de gramíneas exóticas é frequentemente associado à baixa diversidade de espécies nativas e à alta capacidade competitiva dos invasores em obter recursos disponíveis (Mack et al., 2000). Um ciclo reprodutivo rápido e uma alta produção de sementes facilita o sucesso das exóticas, o que, por sua vez, promove a perda de biodiversidade (Hughes et al., 1991; D'antonio & Vitousek, 1992). Além de sua vantagem competitiva sobre as espécies nativas quanto a luz e recursos hídricos disponíveis, as gramíneas exóticas podem liberar compostos alelopáticos que prejudicam ou inibem o crescimento de plantas nativas em regeneração (Kato-Noguchi et al., 2014), sendo uma das causas das dificuldades na restauração biótica da Floresta Atlântica, devido à falta de conhecimento sobre a biodiversidade, a natureza da persistência da espécie e a falta de métodos economicamente viáveis para o controle dessas espécies invasoras (Mack et al., 2000).

Em antigas pastagens, a dinâmica dos ecossistemas florestais pode ser influenciada por outros fatores além da ocorrência de gramíneas exóticas como, a disponibilidade de sementes na área. A chuva de sementes por sua vez terá influência de mecanismos bióticos e abióticos como, presença agentes dispersores, predadores, incidência de ventos, (Li et al., 2012; Barrett, 2013). Em comunidades vegetais, a chuva de sementes tem o papel de participar no processo de recrutamento de novos indivíduos, agindo diretamente na manutenção dos ecossistemas com períodos de maior e menor produção e deposição de sementes (Barbosa et al., 2012).

Visto que o recrutamento de novos indivíduos ocorre de acordo com a disponibilidade de sementes no local, devemos considerar a origem dessas sementes a fim de compreender parte da comunidade potencial que irá se instalar na floresta (Harper, 1977). A semente pode ter origem local, sendo chamada de autóctone ou ser proveniente de áreas vizinhas, alóctones (Van Der Pijl, 1982), nesse caso, as sementes autóctones contribuem para a regeneração das espécies já existentes no local e as alóctones, são sementes imigrantes que tem importante função na manutenção da variabilidade genética da população e riqueza da área (Martinez-Ramos & Soto-Castro, 1993; Campos et al., 2009). A compreensão da dinâmica da chuva de sementes pode subsidiar informações importantes a respeito da composição e estrutura da comunidade, bem como avaliar o estágio sucessional da área, com base nos parâmetros de recrutamento (Tabarelli et al., 2014; Toscan, 2014). Assim, entedemos que, a partir do momento que se conhece as espécies que estão se estabelecendo no local, podemos especular sobre o futuro da comunidade, com base também nas condições abióticas que o ambiente está oferecendo.

Nesse sentido, a composição florística, estrutura e fisiologia da comunidade vegetal pode ser observada ao longo de cronossequência com a substituição das espécies por meio do processo de sucessão ecológica (Pickett & McDonnell, 1989). Esse processo sucessional pode ser dividido em diferentes estágios conforme as características da vegetação, em que, conforme a Resolução CONAMA 002 de 18 de março de 1994, o estágio inicial consiste na colonização da área com o estabelecimento das primeiras espécies com densidade máxima de 100 árvores/ha, DAP> 10 cm e altura média do dossel de até 10 m; áreas com estágio intermediário apresentam indivíduos com até 40 cm de DAP, altura do dossel de até 17 m e área basal menor que 35m²/ha; o estágio avançado é caracterizado por uma formação vegetal complexa, com índice de diversidade elevado e altura média do dossel maior que 30 m (Brasil, 1994). Para que seja observada essa modificação gradual na vegetação, devemos considerar a substituição das espécies, que por sua vez, conforme o ambiente é alterado, as espécies passam a apresentar novas exigências, ou seja, o estágio sucessional também pode ser identificado conforme a classificação do grupo ecológico das espécies presentes na área (Budowsky, 1965).

A classificação das espécies varia conforme as características do vegetal, adotadas pelo gestor, no entanto, normalmente é considerada velocidade de crescimento, tolerância ou não à luminosidade, tempo de vida e atributos reprodutivos, podendo ser pioneiras ou não pioneiras (secundárias iniciais, tardias ou climácicas) (Budowsky, 1970; Gandolfi et al., 1995). Nesse caso, as espécies pioneiras são caracterizadas por apresentar rápido crescimento com ciclo de vida curto, sendo tolerantes à luminosidade constante, além de produzirem grande quantidade de sementes para reprodução; as espécies climácicas, apresentam características diversas das pioneiras, ou seja, crescimento lento, adaptadas à ambientes sombreados, ciclo de vida longo e menor produção de sementes; já as secundárias, são classificadas como transitórias ou intermediárias a essas características (Gonçalves et al., 2003). Essas informações são importantes, principalmente, para implantação de projetos de restauração florestal e devem ser sugeridas, pois ambientes degradados são caracterizados por solos com baixa fertilidade, erodidos, incidência luminosa direta, ausência de agentes polinizadores e dispersores, logo, devemos utilizar espécies que suas características condizem com o ambiente tornando o projeto viável (Shono et al., 2007).

Utilizar espécies pioneiras e secundárias iniciais em projetos de restauração, tem o objetivo de recobrir o solo rapidamente, condicionando o crescimento e estabelecimento de novas espécies, todo esse processo tem em vista a garantia do avanço sucessional da área, mas a substituição das espécies pode ser influenciada pelas estratégias adotadas pelo gestor no projeto de restauração. Além do grupo ecológico, outras técnicas também podem auxiliar no avanço sucessional, como o investimento nas interações ecológicos, pois como mencionado, a grande diversidade vegetal em florestas tropicais proporciona constantes recursos para fauna, que contribuirão para a perpetuação das espécies (Rodrigues et al., 2009). Rodrigues & Gandolfi (1998) destacaram que a chegada da fauna e as microcondições climáticas da área devem ser um assunto relevante na implantação de projetos de restauração, pois caso contrário, a sucessão secundária pode estar comprometida. Conforme os autores, apenas abandonar a área para que a restauração ocorra sem considerar as disponibilidades do ambiente para o estabelecimento da vegetação e a chegada de novas sementes ao longo do tempo que irão compor o banco de sementes do solo, não seria uma alternativa viável. Ewel (1980), considerou os principais fatores contribuintes para o avanço do estágio sucessional, as síndromes de dispersão e a composição do banco de sementes do solo.

Como visto, áreas em restauração devem contar com fragmentos adjacentes para o processo de sucessão, os quais irão participar como fonte de novas sementes, além de contar também com a presença de sementes no solo compondo o banco de sementes, que atuam como reservatórios de sementes com potencial para germinação e que poderão se estabelecer, originando novos indivíduos em momentos oportunos, como por exemplo, com aberturas de clareiras, em ambientes sombreados ou após distúrbios (Ewel, 1980; Baker, 1989). Alguns mecanismos tendem a ocorrer conforme o tempo de sucessão, por exemplo, mecanismos de facilitação com aumento da riqueza e diversificação da composição da chuva de sementes e banco de sementes após o desaparecimento de espécies dominantes, além do surgimento de sementes de espécies lenhosas com o tempo de sucessão, que pode indicar um mecanismo de tolerância desenvolvido pelas espécies (Maza-Villalobos et al., 2011).

Áreas que estão sendo restauradas são ambientes abertos e a falta de um dossel contínuo, favorece a incidência de ventos, logo, a dispersão anemocória torna-se mais eficiente (Howe & Smallwood, 1983). No entanto, em florestas em estágio sucessional avançado, a estrutura da comunidade condiciona o estabelecimento da fauna, sendo abrigo e oferecendo alimento, nesse caso, a zoocoria tende a prevalecer (Fenner, 1985; Mikich & Silva, 2001; Liebsch & Acra, 2007). Sendo assim, além da objetividade na escolha das espécies utilizadas na restauração, outros atributos também podem contribuir para o sucesso pleno da (re) colonização da área com estratégias atrativas a fauna, com investimento em corredores ecológicos, por exemplo, contribuindo para a diversidade genética e as redes de interações com maior proximidade da área em processo de restauração a ecossistemas referência (Stanturf et al., 2014).

Áreas conservadas são tomadas como ecossistemas referência e utilizadas como um padrão de comparação e avaliação para projetos de restauração florestal (Hallett et al., 2013; Shackelford et al., 2013). No entanto, é necessário conhecimento temporal e espacial sobre o ecossistema, além de mútiplas informações que contribuem com a qualidade e precisão dos dados antes de tomar uma área como referência (White & Walker, 1997). Registros históricos como estudos paleoecológicos, pesquisas do senso comum, fotos e estudos publicados são ferramentas que fornecem informações sobre a dinâmica do ecossistema, bem como o estágio sucessional em que ele se encontra, além disso, essas informações também podem contribuir com projetos de restauração de áreas similares (Jackson & Hobbs, 2009; Balaguer et al., 2014). Nesse sentido, é preciso cautela ao tomar uma área como referência, porém devemos salientar sobre a importância de fragmentos conservados próximos de áreas degradadas ou que estão em processo de restauração, pois essas áreas atuam como fomento de diásporos, impactando na regeneração natural, além de servirem como área de transição da fauna, sabendo que, dificilmente a fauna atravessa áreas abertas, enfatizando mais uma dificuldade de restaurar antigas pastagens.

Torna-se evidente a importância de se pensar em estratégias viáveis para a implantação de projetos de restauração da Floresta Atlântica levando em consideração a ecologia e interação das espécies a fim de garantir o sucesso da restauração. Considerando a relevância dos estudos que abordam essa temática, o objetivo desta tese foi compreender os desafios enfrentados por projetos de restauração, em especial de antigas pastagens, contribuindo com informações que auxiliem tais projetos como padrões da dinâmica das comunidades vegetais em ambientes que estão em restauração em diferentes classes de idade e caracterizar as dificuldades encontradas na implementação desses projetos. Para compreender mecanismos de como o ecossistema degradado reage diante de tantas variáveis ao longo do processo de restauração, esta tese foi dividida em três capítulos: (1) Conhecimento tradicional sobre espécies florestais: diferentes tempos, diferentes visões, cujo o objetivo foi investigar o conhecimento tradicional entre diferentes públicos acerca das espécies florestais da Mata Atlântica e comprar esse tipo de conhecimento com o conhecimento formal publicado por meio de levantamentos florísticos de áreas conservadas; (2) Chuva de sementes em cronossequência de restauração da Floresta Atlântica, buscando avaliar o efeito de fatores abióticos na densidade e riqueza de espécies da chuva de sementes ao longo do tempo de restauração; (3) Gramínea exótica prejudica a restauração da Floresta Atlântica no sudeste do Brasil, onde avaliamos o efeito da incidência luminosa e de variáveis edáficas na regeneração natural e na biomassa de *Urochoa brizanta*.

CAPÍTULO I

TRADITIONAL KNOWLEDGE ABOUT FOREST SPECIES: DIFFERENT TIMES, DIFFERENT VIEWS

Submetido: Economic Botany

Abstract
The utility of traditional knowledge in drawing up restoration and conservation plans for the Brazilian Atlantic Forest still receives little attention. In the present study we sought identify the threats of loss of the traditional knowledge about forest species as well exemplify how it could be use as complement to the formal knowledge in the Atlantic Forest restoration. The traditional knowledge about flora was assessed to determine whether it differ according to age of people and landscape conservation status. The list of species from the traditional knowledge differed from those from formal botanical surveys and mention some species known to occur in the Atlantic Forest that did not appear in the list of botanical formal surveys. This result suggests the natural rarity of these species and/or drastic reduction of occurrence due to overexploitation in the past. The results point to the importance of actions for maintaining traditional knowledge with actions that motivate young people to acquire knowledge about vegetation today under the domain of elderly. The relevance of traditional knowledge in addition to formal knowledge for the choice of species for forest restoration was also highlighted.

Keywords: Atlantic Forest; Ethnobotany; Ethnoecology; Local community; Reference ecosystem.

Introduction

The Atlantic Forest in eastern Brazil in addition to environmental services provides resources to society, including natural food and fibers, wood for different purposes, among others (Parron and Garcia 2015). The use of resources, as well the agricultural expansion, triggered the process of deforestation, which has led to habitat fragmentation and threats to biodiversity (Foley et al. 2011; Hansen et al. 2013; Santos-Silva et al. 2016). There are no alternatives other than protecting and conserving remaining areas and the execution of restoration projects to maintain ecosystem services and mitigate the effects of climate change. However, despite the theoretical and empirical basis already available for forest restoration, as highlighted by Benyei et al. (2019), concrete advances are still needed that involve the participation of local communities.

The recognition of primitive natural ecosystems as references, which are sometimes used as indicators of the success of restoration projects, has often been indicated as fundamental for the implementation of such plans (Aronson et al. 1995; Brewer and Menzel 2009; Hobbs 2007). The reference ecosystem is used as a basic parameter of comparison, that is, to evaluate the progress of the project, since, generally, the restoration goal seeks to reach as close as possible to the reference ecosystem (Londe et al. 2020). In this sense, it is essential to observe a series of environmental characteristics of an area before taking it as primitive and as a reference. For that it is, necessary to take in account different types of reference information, as well as mapping the multiple sources of information to understand patterns of change (Suganuma et al. 2013). In addition to the concern of having reference information, the fact that human society interacts with natural resources in focal areas of restoration must also be considered and thus it is important to consider the contributions of human actions and culture (Biró et al. 2019).

Considering that the local population is the largest holder of knowledge about management practices that led to the current condition, the traditional knowledge can provide historical information about the state of the ecosystem and its past use (Balaguer et al. 2014, Reyes-Garcia et al. 2019). The development of strategies for restorantion and sustainable use of forests and formulation of policies using of traditional knowledge also can contribute to the conservation of the threatened species (Pío-León et al. 2017). However, in many areas that need restoration, formal knowledge does can not be used used to provide ecological information to support restoration strategies. Because the formal survey of ecological data often requires time for research and publication of results, the search for traditional knowledge becomes a support tool to forest restoration plans. (Meli et al. 2014; Graham et al. 2016). Thus, the understanding the relationship between traditional knowledge of the use of natural resources can favors the execution and success of conservation projects and consequent forest restoration (McDonald 1977; Albuquerque and Andrade 2002). From this perspective, traditional knowledge information combined with formal knowledge offered by inventories of flora and ecological data, would lead to better management strategies or instruments for biological and cultural conservation. The complementary use of both traditional and formal knowledge is a way to balance interests and values between scientists, politicians and the local population, and conserve biological and cultural diversity (Monroy-Ortiz et al. 2018).

Although ethnoecological studies have the adult and elderly public in common, it is possible that traditional knowledge is heading towards extinction, as this group of elderly people inevitably walk towards the end of their life cycle carrying traditional knowledge with them (Ponte and Dias 2016). A lack of interaction and exchange of traditional knowledge among people and communities can lead to the loss of this type of information (Peixoto and Silva 2011). The ease of access to new information by new generations distances the valuation of traditional knowledge that could contribute to the conservation and management of natural resources (Amorozo 2002; Veiga-Júnior 2008; Lisboa et al. 2017).

With the expectation of emphasizing how traditional knowledge about forest species can been lost over time and how this knowledge can be include in forest restoration plans for the Atlantic Forest, the present study sought to answer the following questions: (1) The past and present life style of the people determine their knowledge in relation to native plant species? (2) Does the state of conservation of the landscape in which the interviewees live determine their knowledge about the flora of the Atlantic Forest? (3) Does the most cited botanical species by the community are also included in the published floristic surveys of local forest fragments? The answers of these questions can contribute to lighting about the compatibility of the use of traditional and formal knowledge to select species for forest restoration programs.

Material and Methods

Study area

The present work involved informants from two municipalities in the Southeast Region of Brazil with different realities regarding the conservation of the Atlantic Forest: Aimorés in the state of Minas Gerais and Santa Teresa in the state of Espírito Santo (Fig. 1). The municipality of Aimorés (19°29‘45‘‘S, 41°03 ‘50‘‘W), encompasses 134,877 ha and 25,193 inhabitants, referred to as "aimorenses", 80% of which live in an urban area (IBGE 2018). Aimorés is inserted in the region of Vale do Rio Doce under the Atlantic Forest domain, with the predominant formation being Seasonal Semideciduous Forest, according to the phytogeographic divisions of IBGE (1992). The forest was progressively replaced by areas of pasture and coffee plantations throughout the course of colonization. In addition, the disordered use of wood and the construction of the Vitória-Minas railway and the Aimorés hydroelectric plant also contributed to the process of forest destruction due to the demand for firewood, fires caused by sparks launched by locomotives and the flooding of stretches of forest for the hydroelectric plant. Currently, Aimorés has 73% of its total area for agriculture and livestock (pasture), and 21% of secondary vegetation in the Atlantic Forest. With a history of degradation, the municipality has areas designated as Área de Proteção Ambiental (APA; area of environmental preservation) and Reserva Particular do Patrimônio Natural (RPPN; private reserve of natural heritage), such as the Instituto Terra to combat deforestation, in which approximately 710 hectares are in the process of forest restoration, (Instituto Terra 2019; IBGE 2020). The per capita income in reais of Aimorés, according to IBGE 2017, was 16,877.78. Among the sectors of the economy, agriculture and livestock are the least relevant, followed by the secondary sector, in the area of food industries and mineral extraction and by the tertiary sector (commercial activity and civil construction) (IBGE 2018).

Santa Teresa is located in the central mesoregion of Espírito Santo (19°56‘12‘‘S, 40°35‘28‘‘W), with an area of 68,320 ha and a population of 21,815 inhabitants, referred to as “teresenses” (IBGE 2018). The municipality is under the Atlantic domain with vegetal formations of Dense Ombrophilous Forest and is one of the municipalities that make up the Corredor Central da Mata Atlântica (central corridor of the Atlantic Forest; Ministério do Meio Ambiente 2006). The municipality has 28% of its total territory for agriculture and livestock and 52% of secondary vegetation (IBGE 2020), of which 16% are protected by Unidades de Conservação (conservation units; Ministério do Meio Ambiente 2006; Silva et al. 2010). Santa Teresa is a world record region for biodiversity (Mendes and Padovan 2000). A total of 476 tree species of 178 genera and 66 botanical families were found in one hectare (Thomaz and Monteiro 1997), surpassing known values for tropical forests throughout the world, even the Amazon (Viana 2000; INCAPER 2013). The municipality contains areas of integral protection, such as Estação Biológica de Santa Lúcia and Reserva Biológica Augusto Ruschi, which have high species biodiversity indexes and connect forest fragments rich in endemic, rare and endangered species (IPEMA 2004). In addition to conserved areas, the rugged relief combined with the region’s climate of mild temperatures, high humidity due to intense rains throughout the year and soils with low nutritional status, make the region of Santa Teresa unsuitable for traditional agriculture such as coffee, thereby also contributing to local conservation (Feitoza et al. 1999; Silva et al. 2010). The per capita income in reais of Santa Teresa, according to IBGE 2017, was 19,353.67. Among the sectors of the economy, agriculture is the most relevant followed by industry (IBGE 2017).

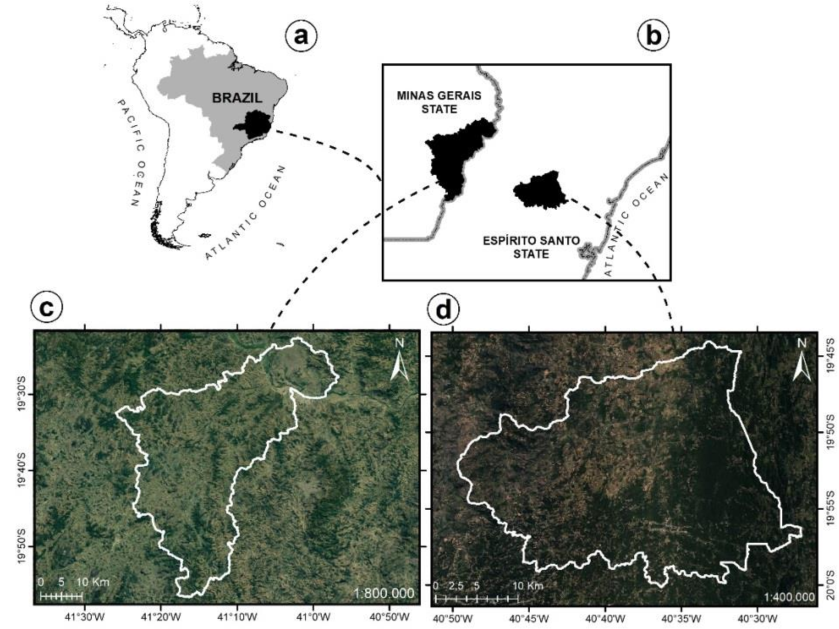


Figure 1. Location of the study areas emphasizing the current degree of degradation and conservation of the areas. (A) Location of states in Brazil; (B) Location of municipalities in the states; (C) Aimorés -MG; (D) Santa Teresa- ES.

Data collection

Data were collected in the months of January, February and March 2019. The interviewees were divided into two groups: young people aged between 15 and 29 years, and elderly people aged 60 and over. A total of 100 people was interviewed, with 25 young and 25 elderly from each municipality. The interviewees were located at random by informal meetings with people being approached on the street or at fairs, squares or even, in some cases, at their homes. Data were collected using the participatory research model through interviews with semi-structured questionnaires and open-ended questions based on the traditional knowledge of the local social subject (Marconi and Lakatos 1999). Two models of scripts suitable for each public (young and elderly) were adopted, which comprised questions about floristic composition, use and importance of the local flora in the past and present, and the awakening of young people's interest or lack of interest in nature (Supplementary Material 1 – Quiz 1 and Quiz 2). Respondents were able to freely discuss the issues addressed as the questions presented great flexibility thus allowing interviewees to delve into elements that emerged during the conversation (Albuquerque and Lucena 2004). Every conversation was recorded, with prior authorization from the interviewees, and later transcribed.

Profile of the informants

More than 60% of the interviewees were female, with 70% from Aimorés and 52% from Santa Teresa. The mean ages for young and elderly respondents in Santa Teresa were 20 and 77 years, respectively, while in Aimorés they were 18 and 68 years. All the elderly people interviewed in Santa Teresa were retired; 36% of them had been farmers, while the rest were divided among former domestic workers (12%), drivers (12%), and entrepreneurs (8%), among others. Of the young from Santa Teresa, 76% were students, 24% of which were in higher education, and 24% only worked. More than 80% of the elderly of Aimorés were retired; their former professions included domestic workers (48%) and farmers (20%), among others. Of the young, 72% were students, 4% of which were in higher education, and 28% only worked, exclusively in commerce. It should be noted that the respondents from Santa Teresa were older and and had 20% more in higher education than the respondents from Aimorés.

Data analysis

After the interviews, floristic lists were generated for each municipality according to the use class of the species. Associations between degree of knowledge (according to the number of species mentioned, i.e., richness) and age group, location, gender, profession and uses of species were analyzed by Chi-square (χ^2) test at 5% probability using R (Core Team 2014). The information was organized into five classes to assess the ways in which species were used: food, domestic construction (houses, windows, furniture, musical instruments), rural construction (fences, plows, tool handles), fuel (firewood and coal) and medicinal.

Confirmation of scientific names and the origin of the species mentioned by the entreviews in each municipality were based on the Lista de Espécies da Flora do Brasil (2018). Family identification followed the classification system of Angiosperm Phylogeny Group IV (APG IV 2016). The lists obtained from traditional knowledge were compared with the lists of formal knowledge published by Thomaz and Monteiro (1997) and Saiter and Thomaz (2014) for Santa Teresa and Oliveira-Filho et al. (2005) for Aimorés, seeking to identify in the list of floristic surveys the species mentioned by the interviewees in the two municipalities. This research is part of the activity of access to Associated Traditional Knowledge and was registered with SisGen (Sistema Nacional de Gestão do Patrimônio Genético e do conhecimento tradicional associado), in compliance with the provisions of Law No. 13,123/ 2015 and its regulations under number AD07AA8 (Supplementary Material 2).

Results

A total of 116 botanical species were obtained from the 100 interviews, with 111 species being recorded for the municipality of Santa Teresa and 75 for Aimorés. The sum of the totals for the municipalities exceeds the total number of species because there were species in common to both areas and thus cited more than once (Table Supplementary 1). The municipality of Santa Teresa has a large area of native forest compared to the municipality of Aimorés and, therefore, even indirectly, young people from Santa Teresa are more accustomed to botanical species (Table Supplementary 2). This was confirmed by the statistically significant difference ($\chi^2 = 6.64$, $p=0.03$) between the number of native species mentioned by the young people of the two municipalities.

The young people of Santa Teresa mentioned 42 species, 60% of them native to the Atlantic Forest, while those of Aimorés, mentioned only 29 species, 48% native.

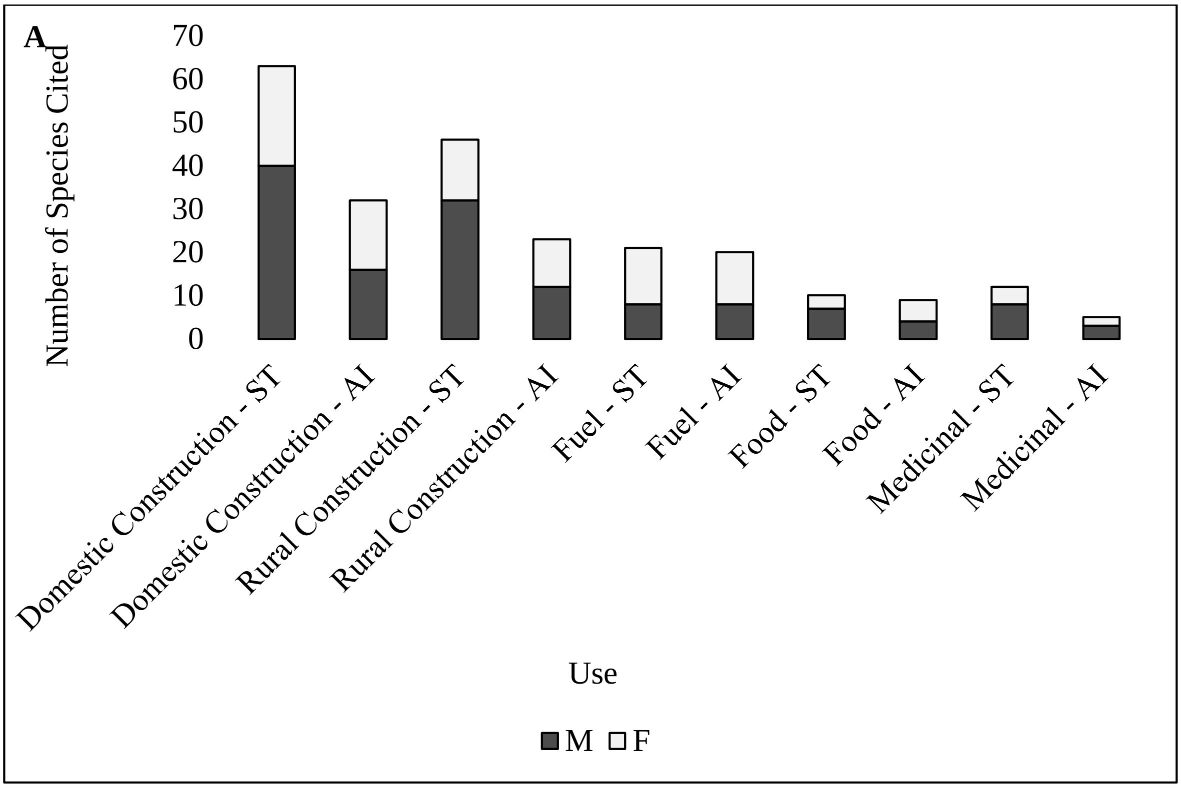
Of the young people interviewed, 72% in each location were students. For Santa Teresa, 48% were students of basic education (first and second level), 24% were in university education (architecture, law, mechanical engineering, veterinary medicine and pedagogy) and 28% worked (freelancers and teachers), while for Aimorés 68 % of students attended basic education, 4% university education (accounting science course) and 28% worked specifically in commerce (Supplementary Table 3). The average number of species cited among primary school students in Santa Teresa was 5 species and in Aimorés 4 species, among those attending university education in Santa Teresa there were 4 species and in Aimorés, one species. While young people who only worked, the average of species mentioned in both places was 4 species. Regardless of the level of education of young people, the number of species mentioned is relatively low compared to the elderly.

In relation to the elderly, the number of native species was predominant (Table Supplementary 2) with no statistical differences between the municipalities. For the total cited species by the elderly, 86% and 73% were native in Santa Teresa and Aimorés, respectively. These results indicate that the state of municipal conservation indirectly influences the young people's botanical knowledge, while for the elderly, who for the most part were exposed to experiences in the field in their youth, the status of municipal conservation did not directly influence traditional knowledge.

The Chi-square test indicated a significant difference (χ^2= 8.52, p=0.001) in the number of species cited by elderly and young people in Santa Teresa, with the elderly citing 62% of the recorded species. However, no statistical difference in the number of species cited by young and elderly respondents was observed for the municipality of

Aimorés. There was a significant difference in degree of knowledge according to gender only for elderly people of Santa Teresa (χ^2= 10.41, p=0.004), with the number of species cited by men exceeding that cited by women (Fig. 2A). There was no significant difference between genders of young people.

Professions that provided direct contact with nature, such as logging and farming, influenced the number of species mentioned, especially for elderly men in Santa Teresa with farmers citing 53 species and loggers citing 32 species. The species most cited by the elderly, regardless of municipality, were those for domestic construction (houses, furniture etc.), followed by rural construction (fences, tool handles, etc.) and fuel (burning, coal) (Fig. 2A). Fruit species, common in backyards and supermarkets, were the most recalled among young people, followed by those for domestic construction. The percentage of medicinal species known to young people was below 1%. Young people in the municipality of Santa Teresa were more heterogeneous in their knowledge of species than were young people of Aimorés (Fig. 2B).



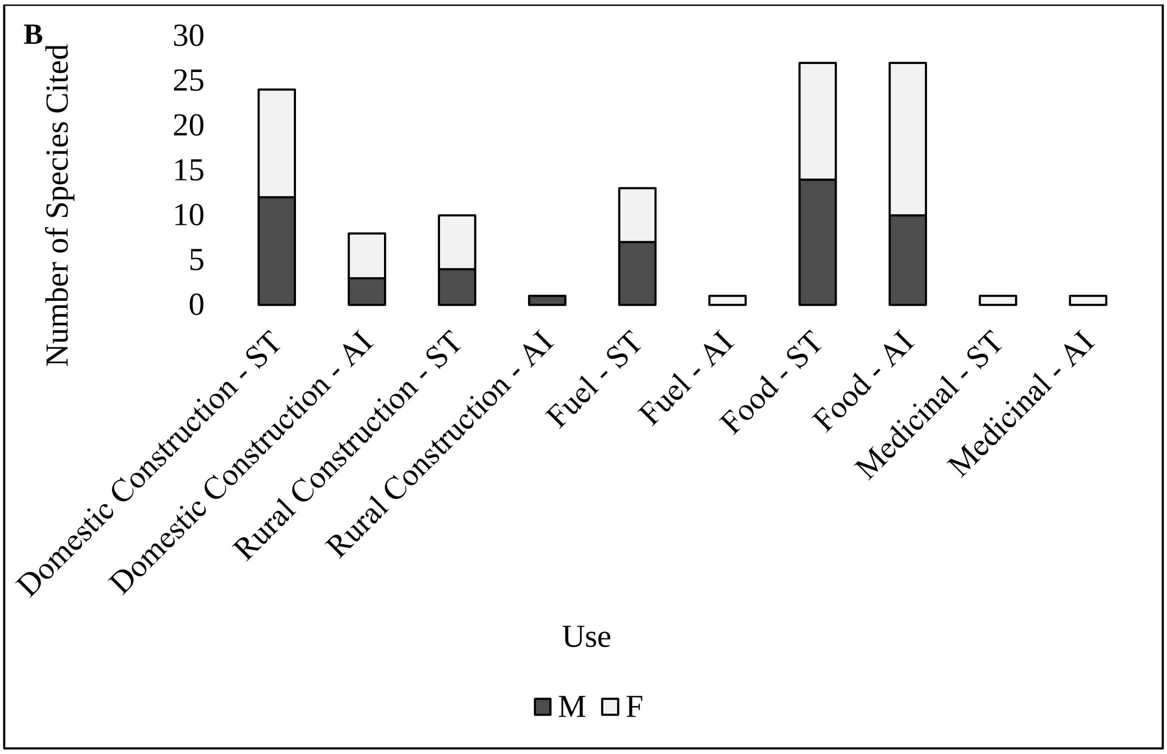


Figure 2. (A) Distribution of the number of species cited by the elderly (60 years and older) from the municipalities of Santa Teresa, Espírito Santo (ST), and Aimorés, Minas Gerais (AI), according to use and to gender, male (M) and female (F). (B) Distribution of the number of species cited by young people (between 15 and 29 years) of the municipalities of Santa Teresa, Espírito Santo (ST), and Aimorés, Minas Gerais (AI), according to use and to gender, male (M) and female (F). *Some young respondendts mentioned a species but were unaware of its use.

Among the species most cited among young people, the exotic species *Mangifera indica* L. stood out in both municipalities, with 23% and 48% citation in Santa Teresa and Aimorés, respectively. Among the elderly, the natives *Goniorrhachis* sp. and *Aspidosperma polyneuron* Müll.Arg. were the most cited species, with more than 30% of the elderly in the municipality of Santa Teresa citing them, while in Aimorés 37% of the elderly cited *Aspidosperma* sp. and 20% cited *Goniorrhachis* sp. (Table 1). Of the species most cited by young of Aimorés, 10% were native, while 50%

of those cited by young of Santa Teresa were native. All the species most cited by the elderly were native.

Table 1. Species most cited by young and elderly respondents in the municipalities of Santa Teresa, Espírito Santo, and Aimorés, Minas Gerais.

Santa Teresa - ES					
Young			Elderly		
Species	No. of citations	Origin	Species	No. of citations	Origin
Tabebuia/Handroanthus sp.	11	Native	*Goniorrhachis* sp.	25	Native
Mangifera indica L.	10	Exotic	*Aspidosperma polyneuron* Müll.Arg.	21	Native
Artocarpus heterophyllus Lam.	8	Exotic	*Cariniana legalis* (Mart.) Kuntze	16	Native
Aspidosperma polyneuron Müll.Arg	9	Native	*Tabebui/Handroanthu a* sp.	15	Native
Aimorés - MG					
Young			Elderly		
Species	No. of citations	Origin	Species	No. of citations	Origin
Mangifera indicai L.	14	Exotic	*Aspidosperma polyneuron* Müll.Arg.	17	Native
Cocos nucifera L.	10	Exotic	*Goniorrhachis* sp.	9	Native
Malpighia glabra L.	9	Exotic	*Tabebuia/Handroanthu* sp.	6	Native
Paubrasilia echinata (Lam.) Gagnon, H. C. Lima & G. P. Lewis	7	Native	*Anadenanthera* sp. e *Cedrela fissilis* Vell.	5	Native

Comparison of the species most mentioned by the interviewees with tree species of a floristic survey conducted in the municipality of Aimorés by Oliveira-Filho et al. (2005), and in Santa Teresa by Thomaz and Monteiro (1997) and Saiter and Thomaz (2014), revealed a few species in common. The list fron the traditional knowledge for Aimorés had two species in common with the published list — *Cedrela fissilis* Vell. and *Tabebuia* sp. — while that for Santa Teresa had only *Tabebuia* sp. in common with the published lists (Table Supplementary 2 and 4). The species with the highest density in Santa Teresa, according to Thomaz and Monteiro (1997) and Saiter and Thomaz (2014), were *Euterpe edulis* Mart., *Ocotea aciphylla* (Nees & Mart.) Mez, *Unonopsis riedeliana* R.E.Fr., and *Eriotheca macrophylla* (K. Schum.) A. Robyns, which were not mentioned during the interviews. Among the native species mentioned by the interviewees, 10% are not included in the published floristic lists. In addition, there are species that are not among the most mentioned, but are on the lists of traditional knowledge and are also on the published lists, they point out *Euterpe edulis* Mart., *Hymenaea* sp., *Inga* sp. And *Melanoxylon brauna* Schott.

When asked about the interest about the knowledge and use of natural resources, the young and elderly in the municipalities analyzed were unanimous in answering that the direct dependence on nature influenced the knowledge about species (Fig. 3A and B). However, when inquiring about the lack of interest of young people in knowledge related to forest species, 69% of young people from Santa Teresa stated that technology and convenience, associated with the ease of access to the products in supermarkets, are precursors of the current lack of interest among young people. Meanwhile, 65% of young people form Aimorés related the lack of interest in this knowledge to technology and the absence of natural qualities attractive to people (Fig. 4A). For elderly people in Santa Teresa (53%), the lack of interest of young people in nature is related to the need to study, due to the lack of guidance and encouragement on the part of parents. Sixty percent of elderly people in Aimorés justify this current lack of interest due to technology, lack of time and other types of entertainment (Fig. 4B).

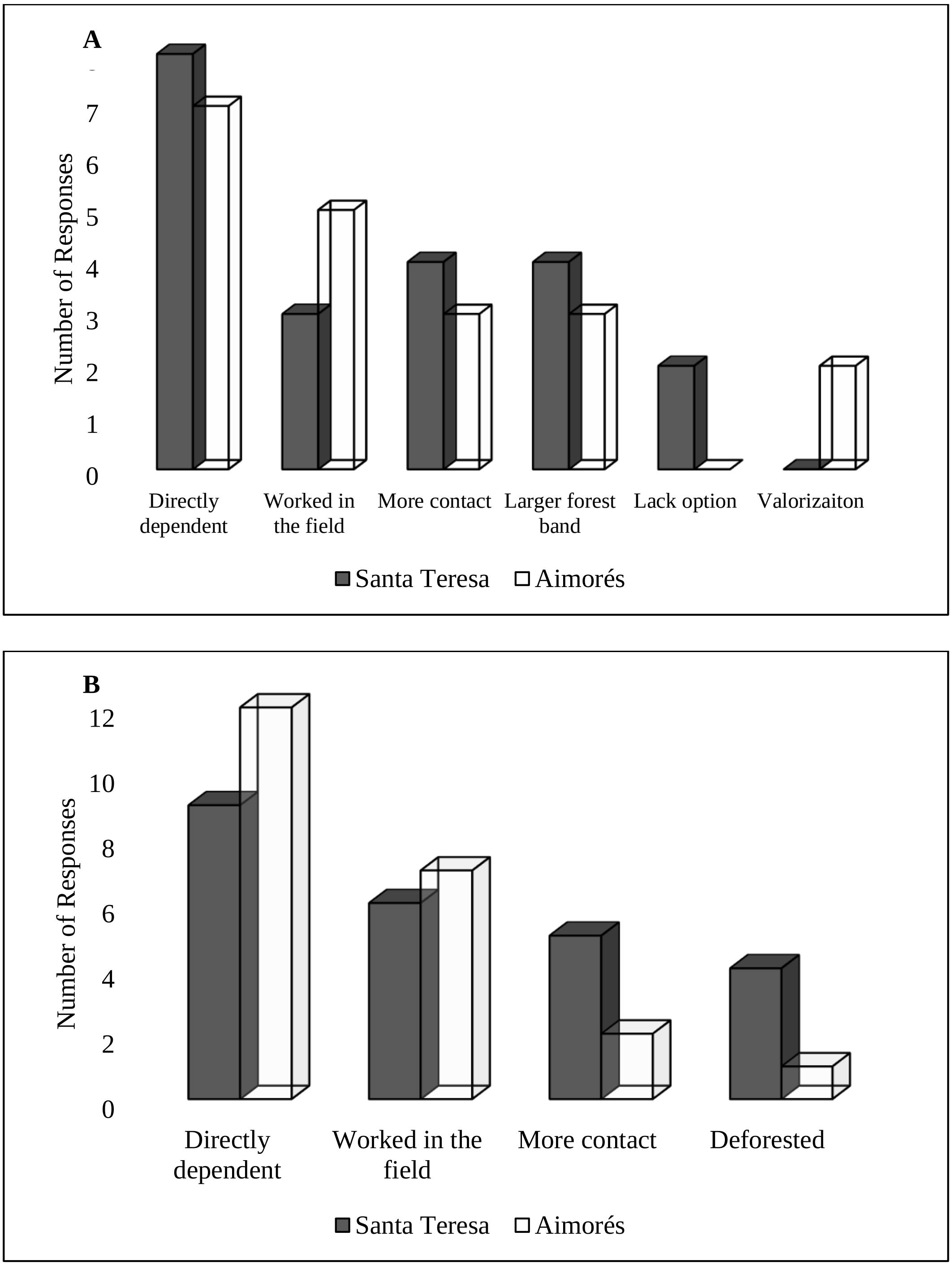


Figure 3. (A) Responses of young people from the municipalities of Santa Teresa and Aimorés to questions about the interest of the elderly in the knowledge of forest species and their use. (B) Responses of elderly from the municipalities of Santa Teresa and Aimorés to questions about their interest in the knowledge of forest species and their use.

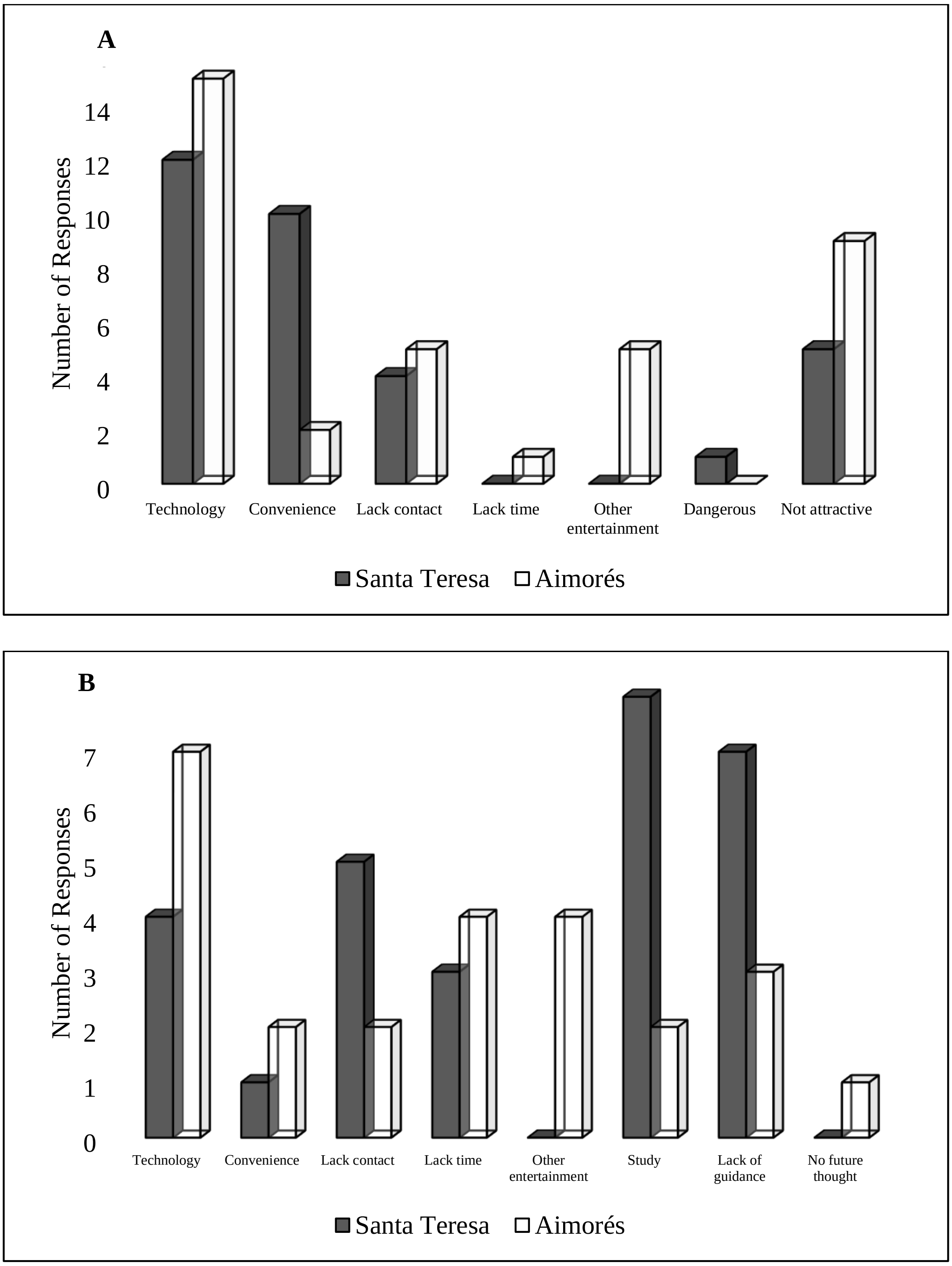
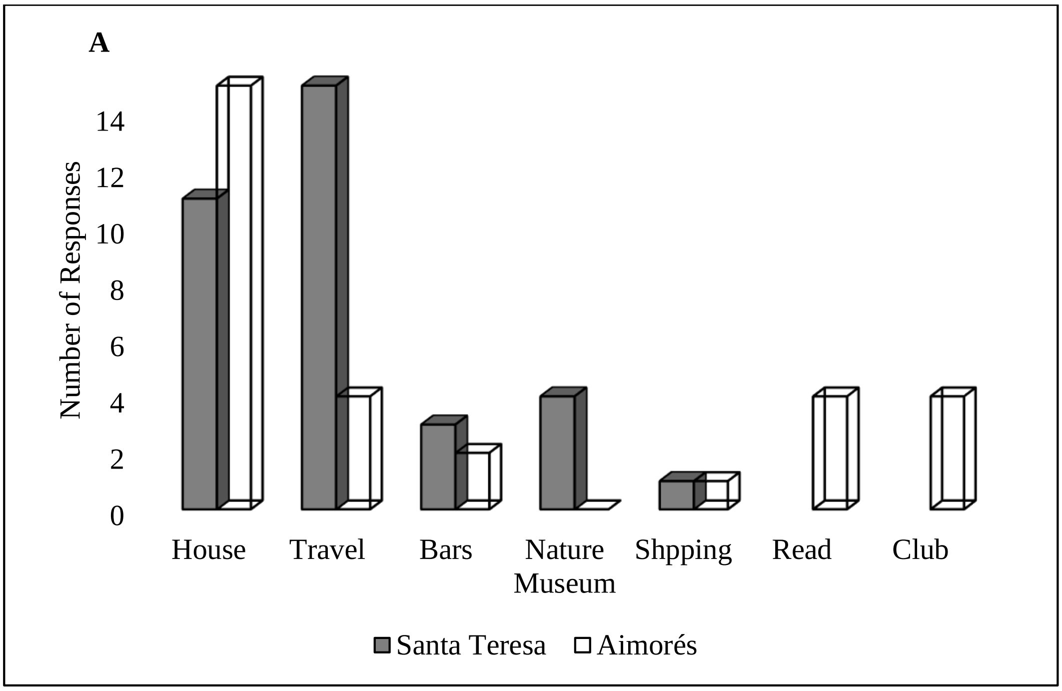


Figure 4. (A) Responses of young people from Santa Teresa and Aimorés to the question of the lack of interest of young people in forest species. (B) Responses of elderly people from Santa Teresa and Aimorés to the question about the lack of interest of young people in forest species.

For leisure, more than 30% of young people in Santa Teresa and 47% in Aimorés routinely access the internet or television. Forty-one percent of young people from Santa Teresa reported having contact with green areas at country homes, farms, beaches or at Instituto Nacional da Mata Atlântica. In Aimorés, only 10% of the young people reported having frequent contact with green or natural areas (Fig. 5A). The elderly reported that, in their youth, contact with forest areas was intense even during leisure time. Forty percent of elderly people in Santa Teresa and 60% of Aimorés confessed that due to the need to work daily, leisure time was limited to attending masses or religious festivities. However, they also highlighted fishing, football, wheel games, river bathing, among others, as leisure (Fig. 5B).



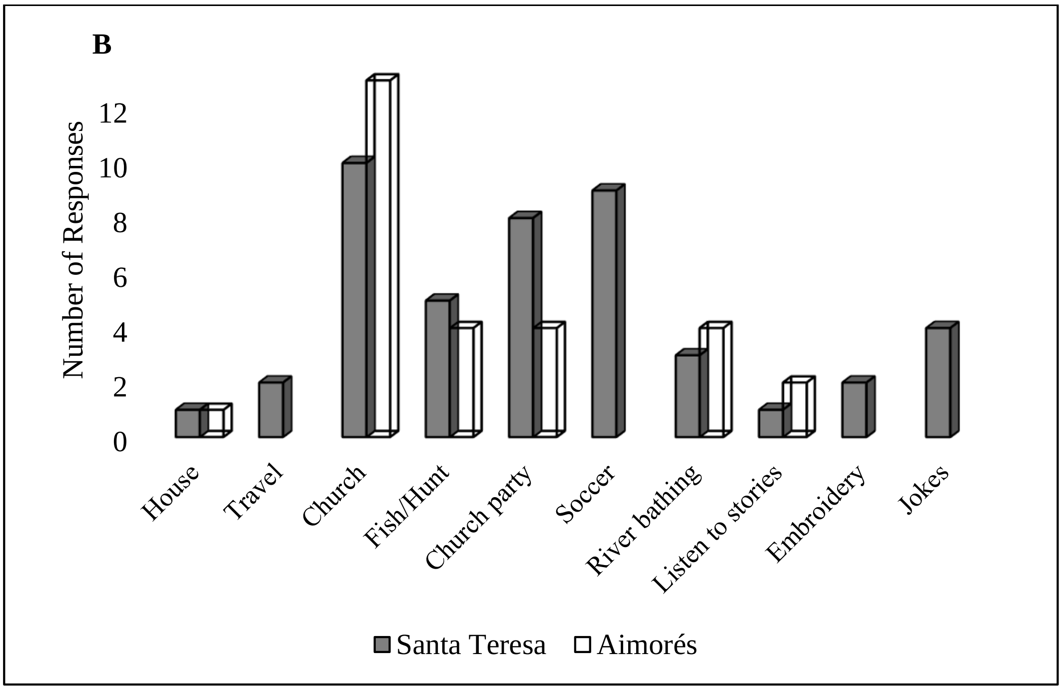


Figure 5. (A) Responses of young people from Santa Teresa and Aimorés about activities carried out exclusively as a form of leisure or entertainment. (B) Responses of elderly people from Santa Teresa and Aimorés on activities carried out exclusively as a form of leisure or distraction.

Discussion

A greater traditional knowledge has been frequentlfy reported in regions of high biological diversity where populations often maintain direct contact with the natural environment (Primack and Rodrigues 2006). Consistent with these reports, a positive effect in the number of species cited by young people of the municipality with better state of conservation of the natural landscape was registred. This was observed despite of the restricted knowledge about species among young when compared with ederly people. Our results suggest that more than the current state of forest conservation, the memory about the utility of species in the past determined the higher number of native species of the Atlantic forest mentioned by the elderly. The traditional knowledge that was consolidated and remembered, mainly by the elderly, is related to intense contact with natural areas and the result of cumulative processes over time (Gomes 2014).

The the limited knowledge about native forest species by young individuals, even those in the municipality where there is significant preserved Atlantic Forest, indicates the rapid erosion of local knowledge and the need for initiatives for its preservation (Benyei et al. 2019). The region that encompasses the studied municipalities was historically occupied by indigenous groups of the macro-jê linguistic-cultural stem (Baeta and Mattos 2007), Botocudos peoples who began to suffer genocide at the end of the 18^{th} century (Krenak 2009). This indicates that knowledge about the floristic resources of the Atlantic Forest has long been experiencing a process of erosion that continues today.

In addition to age, gender and profession of the interviewees also influenced their degree of knowledge of botanical species. Professions with greater contact with the environment, such as loggers and farmers, which are generally male, contributed significantly to the number of species mentioned. There is a tendency in ethnobotanical studies for men to show a greater degree of knowledge of forest species for the use of wood, while women commonly recognize species related to the medicinal field. This tendency is because knowledge is accumulated according to experiences and work divisions among genders. Therefore, even in the face of the current scenario of women's independence and freedom, experiences are still lacking in several aspects to consolidate this type of knowledge (Lucena et al. 2007; Voeks 2007; Viu et al. 2010). Young people, who currently have little contact with forest areas, hardly know or remember the species. This litlle knowledge among the young, regardless of gender, is related to the lack of interest in the knowledge and experiences of older people. "Listening to stories" was among the leisure activities recorded for the elderly, which may also contribute to their greater accumulated knowledge about forest resources. Traditional knowledge is passed on for generations through informal conversations in daily life in the domestic environment, where, at the same time, theoretical and practical knowledge is acquired through observations, explanations and codifications; however, young people today are impatient or unmotivated to listen to older people (Pasa and Ávila 2010; Viu et al. 2010).

The view of the elderly towards young people's lack of interest in traditional knowledge may be linked to a lack of parental guidance and the need to study. For the elderly, studying means migrating to urban areas and abandoning rural areas or interior cities. Authors such as Caldart (2003) and Rocha et al. (2018) have discussed and problematized the theme in economic, social and educational aspects, stating that current rural education projects have gained strength and there is no longer a need to leave the countryside. However, according to the elderly interviewed in the present research, rural exodus is still an alternative for professional success. Changes in habits and lifestyle over generations can affect the dynamics of traditional knowledge due to economic, political, social, cultural, and environmental changes (Paniagua-Zambrana et al. 2014). The knowledge of the elderly regarding the use and importance of forest species, in the eyes of young people, is summed up as strict dependence on nature. This view becomes worrying because young people do not associate populational well-being with basic services promoted by the environment, such as provisioning food and water. There is a range of studies aimed at integrating man and nature that associate technological advancement and the migration of rural populations to urban areas due to the disinterest of young people in traditional knowledge about botanical species and their use, including in the medical field, due to the lack of contact, practicality and easy access to goods on shelves and the internet (Amorozo 2002; Veiga-Júnior 2008; Lisboa et al. 2017). The lack of contact with green areas can be a precursor for the lack of interest in traditional knowledge on behalf of young people.

Our results indicate that most young people have access to the internet or television as leisure, which can explain the little interest in knowledge related to forest species due to the lack of contact with these environments. It is noted that young people’s memory of botanical species is summarized in fruit species commonly found in squares, backyards, on streets and even in supermarkets. Their justification for this reduced contact is based on the lack of time due to studies or work, lack of interest, or even less because they believe they no longer need the natural environment or knowledge about forest species. However, it is necessary to emphasize the need to exercise caution when interpreting relationships between age and ethnoecological knowledge. The experience of the elderly with culture and traditional knowledge over time has been identified as a way of safeguarding the traditional knowledge they built by themselves, while young people still need this exposure for knowledge formation and maturity (Westman and Yongvanit 1995; Voeks and Leony 2004; Viu et al. 2010).

Sociocultural factors interfere with traditional knowledge among age groups (Sop et al. 2012). Like what was found in the present study, Fentahun and Hager (2009) noted that an individual's routine acts directly on their degree of ethnobotanical knowledge. Times have changed and, in the present study, when comparing the present and the past, the reports of the elderly reveal that even in their youth their leisure time was spent in contact with forest areas. According to the interviewees, the simple routine of attending church on Sundays was related to the natural environment because it was necessary to cross forest fragments on foot, horseback or by bicycle. In addition, frequent visitations to rivers for bathing or fishing and listening to stories told by elders were as seen as intertainment. Currently, however, young people are interested in keeping social networks up to date and frequenting bars, restaurants, and clubs, emphasizing once again that traditional ethnobotanical knowledge can go a long way towards extinction.

In the present study, the more extensive presence of forest conservation areas implied high number of native forest species mentioned by young people. The municipality of Santa Teresa has a large native forest area compared to the municipality of Aimorés, and so, even indirectly, young people from Santa Teresa are more accustomed to botanical species. The young from Aimorés remembered exotic fruit species in addition to the brazilwood, *Paubrasilia echinata* (Lam.) Gagnon, H. C. Lima and G. P. Lewis, which are species present in the daily lives of these young people. *P. echinata* is one of the most talked about species in schools in the historical context of its exploitation (Schwartz 1998) and the very origin of the name of the country, which may have promoted the association of the species with its occurrence in the conserved forests of Aimorés. It is common for the species most cited by interviewees to be related to their use in the daily lives of everyone, as well as the nature of their relationship and contact (Camou-Guerrero et al. 2008; Sop et al. 2012).

Among the species mentioned by the young people from Santa Teresa, *Tabebuia* sp., *Handroanthus* sp., *Mangifera indica* L., *Artocarpus heterophyllus* Lam. and *Aspidosperma polyneuron* Müll.Arg stand out. *Tabebuia* sp./ *Handroanthus* sp., known for their beauty and flowers with exuberant colors, are widely used in urban afforestation (Carvalho 2003), while *M. indica* and, *A. heterophyllus* are common in domestic backyards in Brazilian cities composing orchards that feed residents (Algranti 1997). In its turn, *A. polyneuron* has excellent wood for carpentry and joinery (Campos-Filho and Sartorelli 2015). The food and economic value of these species make them common in the daily lives of young people, facilitating the recall and knowledge of these species. The most common species cited by the elderly of both municipalities were destined for domestic and rural construction and fuel, such as: *Goniorrhachis* sp., *Aspidosperma polyneuron* Müll.Arg., *Cariniana legalis* (Mart.) Kuntze and, *Tabebuia* sp./ *Handroanthus* sp.. Based on the interviews, it was found that these species were the most extracted from the Atlantic Forest in the 1950s and 1960s for the construction of houses, furniture, fences, and firewood.

When comparing traditional and formal knowledge, it is noted that the species with the highest density in forests in the municipality of Santa Teresa in the 1990s were not those mentioned by most respondents. When determining the floristic composition of Estação Biológica de Santa Lúcia in the municipality of Santa Teresa, Thomaz and Monteiro (1997) found the species with the highest densities to be: *Euterpe edulis* Mart., *Ocotea aciphylla* (Nees & Mart.) Mez, *Unonopsis riedeliana* R.E.Fr., and *Eriotheca macrophylla* (K.Schum.) A. Robyns. Since the species with the highest densities in the conserved area differ from those mentioned by interviewees, it is possible to wonder whether the species extracted in earlier times were not the most frequent in the area, or even, were the most extracted species exhausted before the execution of the scientific research. However, when analyzing the floristic lists of Thomaz and Monteiro (1997), Oliveira-Filho et al. (2005) and Saiter and Thomaz (2014), it is observed that although they occur in smaller number, there are still species in Aimorés such as *Cedrela fissilis* Mart. and *Tabebuia* sp, while in Santa Teresa only *Tabebuia* sp.

The native species mentioned by the people interviewed have in common a wide range of occurrence between Ombrophilous and Seasonal Semideciduous Forests throughout the states of Espírito Santo and Minas Gerais (Lista da Flora do Brasil 2018). It was expected that for the municipality with the greatest representation of preserved areas of Atlantic Forest (Santa Teresa) the tree species mentioned in the interviews would still be present, even if on a small scale, in the forest remnants. However, contrary to what was expected, it was in the municipality with the lowest degree of preserved forest coverage (Aimorés), which has an impactful history of degradation, that a greater number of species mentioned were listed in the floristic surveys. However, it should be noted that active restoration projects are developed in Aimorés in which native species make up their base (Instituto Terra 2019), which may be a cause of the result obtained here.

In a study about culturally important species for dry forest, Suárez et al. (2012) observed that the species used in restoration projects, produced in nurseries, were not always those that fall into the category of overexploitation or moreuseful to the people. Still, according to the authors, neglecting the demands of the population considerably minimizes their interest in such projects. So, as pointed by Monroy-Ortiz et al. (2018), a way to balance interests and values between scientists, politicians and the population is to complement formal knowledge with information from traditional knowledge, that is, to consider species whose presence is in the memory of the inhabitants of the localities, but they are not represented in studies of the flora of the forest remnants. The development of a perspective focused on searching for comprehensive knowledge about the ecosystem and and the community illustrates the importance of taking care to use only the formal knowledge as base to define the reference ecosystem as a restoration goal. The discrepancy between the list obtained from the interviews in this study and the reference lists suggests that the definition of reference ecosystems based on the scientific species lists can be improved by adding traditional knowledge of the population surrounding the areas to be restored, notably that accumulated by the elderly.

Conclusion

The state and extent of forest preservation areas seens do affect the knowledge about flora by young people wile a memory of the past use of plants determine the higher knowledge by ederly people. A way of life more disconnected from the natural environment and/or the lack of effective educational programs for valuing nature's resources, seems to be the cause of low traditional knowledge about the native flora by young people. Our results showed that attention is needed to establish criteria for forest restoration, since species present in the published floristic inventories differs from those of the traditional knowledge acquired over the years by people who have experienced the deforestation process. The integration of traditional knowledge of the local elderly population with the formal knowledge would support better choise of species to restore degraded areas.

References

Albuquerque U P, Andrade LHC (2002) Traditional botanical knowledge and conservation in an area of caatinga in Pernambuco state, Northeast Brazil. Acta Botanica Brasilica 3: 273-285.

Albuquerque UP, Lucena RFP (2004) Seleção e escolha dos informantes. Page 189 In: Albuquerque UP, Lucena RFP (org.) Métodos e técnicas na pesquisa etnobotânica. Recife – PE. Livro Rápido/NUPEEA.

Algranti LM (1997) História da vida privada no Brasil: cotidiano e vida privada na América portuguesa. São Paulo: Companhia das Letras. 154p.

Amorozo MCM (2002) Uso e diversidade de plantas medicinais em Santo Antônio do Leverger, MT, Brasil. Acta Botânica Brasílica 2: 189-203.

Aronson J, Dhillion S, Le Floc'h E (1995) On the need to select an ecosystem of reference, however imperfect: a reply to Pickett and Parker. Restoration Ecology 1:1-3.

Baeta AM, Mattos IM (2007) A serra da onça e os índios do Rio Doce: uma perspectiva etnoarqueológica e patrimonial. Habitus 5:39-62.

Balaguer, L., Escudero, A., Martín-Duque, J. F., Mola, I., & Aronson, J. (2014). The historical reference in restoration ecology: Re-defining a cornerstone concept. Biological Conservation, 176, 12–20. doi:10.1016/j.biocon.2014.05.007

Benyei P, Arreola G, Reyes-García V (2019). Storing and sharing: A review of indigenous and local knowledge conservation initiatives. Ambio 49:218-230.

Biró, M., Molnár, Z., Babai, D., Dénes, A., Fehér, A., Barta, S., Sáfián, L., Kis, A., Demeter, L., Öllerer, K. (2019). Reviewing historical traditional knowledge for innovative conservation management: A re-evaluation of wetland grazing. Science of The Total Environment. doi:10.1016/j.scitotenv.2019.02.292

Brewer JS, Menzel T (2009) A method for evaluating outcomes of restoration when no reference sites exist. Restoration Ecology 17: 4-11.

Caldart R S (2003) A escola do campo em movimento. Currículo sem Fronteiras 3: 60-81.

Carvalho PER (2003) Espécies Arbóreas Brasileiras. 1ª ed. Brasília: Embrapa.

Camou-Guerrero A, Reyes-García V, Martínez-Ramos M, Casas A (2008) Knowledge and use value of plant species in a Rarámuri community: A gender perspective for conservation. Human Ecology, 36: 259–272.

Campos-Filho EM, Sartorelli PAR (2015) Guia de árvores com valor econômico. Agroicone, Iniciativa INPUT. São Paulo. 144p.

Feitoza LR, Castro LLF, Resende M, Zangrande MB, Stocking M, Borel RMA, Fullin EA, Cerqueira AF, Salgado JS, Feitoza HN, Stock LA, Dessaune-filho N (1999) Mapa das Unidades Naturais do Estado do Espírito Santo. Governo do Estado do Espírito Santo, Secretaria de Estado da Agricultura, Empresa Capixaba de Pesquisa Agropecuária, Universidade Federal de Viçosa, University of East Anglia, Conselho Nacional de Desenvolvimento Científico e Tecnológico, Instituto Pró-Natura: Vitória.

Fentahun MT, Hager H (2009) Exploiting locally available resources for food and nutritional security enhancement: Wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. Food Security 1: 207–219.

Foley JA, Ramankutty N, Brauman KA (2011) Solutions for a cultivated planet. Nature 478: 337–342.

Gomes GC (2014) As árvores nativas e o saber local como contribuição à sustentabilidade de agroecossistemas familiares na Serra dos Tapes (RS). PhD Thesis, Universidade Federal de Pelotas, Pelotas.

Graham, L. L. B., Giesen, W., & Page, S. E. (2016). A common-sense approach to tropical peat swamp forest restoration in Southeast Asia. Restoration Ecology, 25(2), 312–321. doi:10.1111/rec.12465

Hansen MC, Potapov PV, Moore R (2013) High-resolution global maps of 21st-century forest cover change. Science, 342: 850–853.

Hobbs RJ (2007) Setting effective and realistic restoration goals: Key directions for research. Restoration Ecology 15: 354-357.

Instituto Brasileiro de Geografia e Estatística (IBGE). Estimativas da população residente no Brasil e unidades da federação com data de referência em 1º de julho de 2018.

Instituto Brasileiro de Geografia e Estatística (IBGE). Banco de dados de informações ambientais. Acessado em 10 de agosto de 2020 < https://bdiaweb.ibge.gov.br/#/consulta/vegetacao>

Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER). 2013. Programa de Assistência Técnica e Extensão Rural: Proater 2011 – 2013. Santa Teresa, ES: INCAPER.

Instituto de Pesquisas da Mata Atlântica. 2004. Conservação da Mata Atlântica no Estado do Espírito Santo: Cobertura florestal, unidades de conservação e fauna ameaçada (Programa Centros para a Conservação da Biodiversidade – Conservação Internacional do Brasil). Vitória, ES: IPEMA.

Instituto Terra. «Projeto Aimorés» (PDF). Consultado em 18 de janeiro de 2019. Arquivado do original (PDF) em 19 de Janeiro de 2019

Krenak G (2009) Genocídio e resgate dos "Botocudo". Estudos Avançados 23:195-204.

Lisboa M S, Pinto AS, Barreto PA, Ramos YJ, Silva MQOR, Caputo MC, Almeida MZ (2017) Ethnobotanical study in community quilombola Salamina/Putumujú in Maragogipe, Bahia. Revista Fitos 11: 1-118.

List of Species of Flora of Brazil. Jardim Botânico do Rio de Janeiro. (2018, January 20). Retrieved from http://floradobrasil.jbrj.gov.br.

Londe, V., Turini Farah, F., Ribeiro Rodrigues, R., & Roberto Martins, F. (2020). Reference and comparison values for ecological indicators in assessing restoration areas in the Atlantic Forest. Ecological Indicators, 110, 105928. doi:10.1016/j.ecolind.2019.105928

Lucena RFP, Araújo EL, Albuquerque UP (2007) Does the local availability of woody Caatinga plants (Northeastern Brazil) explain their use value. Economic Botany, 61: 347- 361.

Marconi M A, Lakatos EM (1999) Técnicas de pesquisa. 3. Ed. São Paulo: Atlas.

McDonald DR (1977) Food taboos: A primitive environmental protection agency (South America). Anthropos 1: 734–748.

Ministério do Meio Ambiente (MMA) (2006) O corredor central da Mata Atlântica: uma nova escala de conservação da biodiversidade. Brasília, DF: MMA.

Meli, P., Martínez-Ramos, M., Rey-Benayas, J. M., & Carabias, J. (2014). Combining ecological, social and technical criteria to select species for forest restoration. Applied Vegetation Science, 17(4), 744–753. doi:10.1111/avsc.12096

Mendes SL, Padovan MP (2000) A Estação Biológica de Santa Lúcia, Santa Teresa, Espírito Santo. Boletim do Museu de Biologia Mello Leitão, 12: 7–34.

Monroy-Ortiz, C., García-Moya, E., Romero-Manzanares, A., Luna-Cavazos, M., & Monroy, R. (2018). Traditional and formal ecological knowledge to assess harvesting and conservation of a Mexican Tropical Dry Forest. Journal of Environmental Management, 214, 56–65. doi:10.1016/j.jenvman.2018.02.072

Oliveira-Filho AT, Tameirão-Neto E, Carvalho WAC, Werneck M, Brina AE, Vidal CV, Rezende SC, Pereira JAA (2005) Análise florística do compartimento arbóreo de áreas de Floresta Atlântica sensu lato na região das bacias do leste (Bahia, Minas Gerais, Espírito Santo e Rio de Janeiro). Rodriguésia 56: 185–235, 2005.

Paniagua-Zambrana NY, Bussmann RW, Blacutt E, Macía MJ (2014) Los Chácobo y las Palmeras. Ethnobotany Research and Applications 13:1-96.

Pasa MC, Ávila G (2010) Riverine and plant resources: the etnobotany in Rondonópolis, Mato Grosso, Brazil. Interações 11: 195-204.

Parron LM, Garcia JR (2015) Ecosystem services: concepts, classification, indicators and related aspects. Page 1-374 In: Empresa Brasileira de Pesquisa Agropecuária Serviços Ambientais em Sistemas Agrícolas e Florestais do Bioma Mata Atlântica. Recurso Eletrônico, Brasília, DF.

Peixoto AL, Silva IM (2011) Saberes e usos de plantas: legados de atividades humanas no Rio de Janeiro. Editora PUC Rio, 227 p.

Pío-León, J. F., Delgado-Vargas, F., Murillo-Amador, B., León-de-la-Luz, J. L., Vega-Aviña, R., Nieto-Garibay, A., Cordoba-Matson, M., Ortega-Rubio, A. (2017). Environmental traditional knowledge in a natural protected area as the basis for management and conservation policies. Journal of Environmental Management, 201, 63–71. doi:10.1016/j.jenvman.2017.06.032

Ponte M, Dias E (2016) Diversity of ethnobotanical uses of the azorean native flora. Woods, games, symbolism and ornamentation. Interações 17: 577-590.

Primack RB, Rodrigues E (2006) Biologia da conservação. Londrina: Midiograf, 328p.

R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Reyes-García V, Fernández-Llamazares A, McElwee P, Molnár Z, Öllerer K, Wilson SJ, Brondizio E (2019) The contributions of Indigenous Peoples and Local Communities to ecological restoration. Restoration Ecology. 27:03-08.

Rocha SFM, Ghiggi G, Chaves PM, Pereira DA (2018) Contributions of Paulo Freire's human activity for the nowadays field education. Revista Diálogo Educacional 18: 949-973.

Saiter F Z, Thomaz LD (2004) Revisão da lista de espécies arbóreas do inventário de Thomaz & Monteiro (1997) na Estação Biológica de Santa Lúcia: o mais importante estudo fitossociológico em florestas montanas do Espírito Santo. Boletim do Museu de Biolologia Mello Leitão (N. Sér.) 34:101-128.

Santos-Silva EE, Almeida WR, Tabarelli M, Peres CA (2016) Habitat fragmentation and the future structure of tree assemblages in a fragmented Atlantic forest landscape. Plant Ecology 217: 1129–1140.

Silva HP, Boscolo OH, Fontana A, Obermüller FA, Moreira FFS (2010) Caracterização socioambiental e epidemiológica das populações humanas de duas áreas protegidas de Santa Teresa, ES: subsídios para políticas públicas de conservação e saúde. Boletim Museu de Biologia Mello Leitão, 27:85-104.

Schwartz J (1998) Um Brasil em tom menor: Pau-Brasil e Antropofagia. Revista de Crítica Literária Latino-Americana 47: 53-65.

Sop TK, Oldeland J, Bognounou F, Schmiedel U, Thiombiano A (2012) Ethnobotanical knowledge and valuation of woody plant species: A comparative analysis of three ethnic groups from the sub-sahel of Burkina Faso. Environment Development and Sustainability 14:627– 649.

Suárez A, Williams-Linera G, Trejo C, Valdez-Hernández JI, Cetina-Alcalá VM, Vibrans H (2011) Local knowledge helps select species for forest restoration in a tropical dry forest of central Veracruz, Mexico. Agroforestry Systems, 85(1): 35–55. doi:10.1007/s10457-011-9437-9

Suganuma MS, Assis GB, Melo ACG, Durigan G (2013) Reference ecosystems for riparian forest restoration: are there any patterns of biodiversity, forest structure and functional traits? Revista Árvore 37: 835-847.

Thomaz LD, Monteiro R (1997) Florística e Fitossociologia da Floresta Atlântica na Estação Biológica de Santa Lúcia. Boletim Museu de Biologia Mello Leitão, 7:03-48.

Veiga-Junior VF (2008) Estudo do consumo de plantas medicinais na Região Centro-Norte do Estado do Rio de Janeiro: aceitação pelos profissionais de saúde e modo de uso pela população. Revista Brasileira de Farmacognosia 18: 308-313.

Viana VM (2000) Desenvolvimento sustentável e conservação das florestas brasileiras. Page 23-28. In: Diegues AC, Viana VM (Orgs.) Comunidades Tradicionais e Manejo dos Recursos Naturais da Mata Atlântica. 1 ed. Campinas: NUPAUB/ LASTROP.

Viu AFM, Viu MAO, Campos, LZO (2010) Etnobotany: a gender question? Revista Brasileira de Agroecologia 5: 138-147.

Voeks RA, Leony A (2004) Forgetting the forest: Assessing medicinal plant erosion in Eastern Brazil. Economic Botany 58: 294-306.

Voeks RA (2007) Are women reservoirs of traditional plant knowledge? Gender, ethnobotany and globalization in northeast Brazil. Singapore Journal of Tropical Geography, 28: 7–20.

Westman L, Yongvanit S (1995) Biological diversity and community lore in northeastern Thailand. Journal of Ethnobiology 15: 71-87.

Supplementary Material

Quiz 1. Questionnaire model adopted for the elderly public.

Name: ___________________________________Age: __Sex: ____

Retired? ___________ Profession: ______________________

Naturalness: _________________________

When you were young, did you live in the countryside? ____

Location: ___________How long have you lived here?

1. Which species of trees dominated the woods? What were the most important species? As for cutting wood, what is its purpose? As for the use of medicinal plants. Which were the most used?

Species	Utility

(FOOD, DOMESTIC AND RURAL CONSTRUCTIONS, FUEL, MEDICINAL)

2. Were there invasive species like bamboo, brachiaria or others? Which was the most common?

3. Why in the past were people more interested in nature? (Ex .: food, medical use, income, direct contact with nature)

4. Currently, young people have little interest in nature. In your opinion, is there an explanation? (Advancement of medicine and technology, ease of access).

5. Do you think contact with nature is important? Justify.

6. What was / is your contact with forest areas? (weekly, daily)

7. What places do you / used to go as a leisure area?

8. Was there previously concern about the destruction of the forests? is today?

9. Was the tree day celebrated? Like?

10. Did you learn anything or was there a discussion about it at school?

11. And today, is there explicit concern and attitudes towards preserving the forest? Comment.

12. Are you aware or have you heard about the forest code? Talk about.

13. What do you think about forest inspection and the fines that apply to offenders?

14. How important is forest restoration?

15. Do you know of any forest restoration experience? (Place, species used ...) Your opinion on that.

Quiz 2. Questionnaire model adopted for the young public.

Name: ________ Age: _______ Gender: ____

Student? ____ Course: __________ Place of birth: _________________________

Does it reside inside? ____ Location: ______ How long have you lived here? ________

1. Which species of trees dominate / dominated the woods? What are the most important species? As for cutting wood, what was its purpose? As for the use of medicinal plants. Which was / are the most used?

Species	Utility

(FOOD, DOMESTIC AND RURAL CONSTRUCTIONS, FUEL, MEDICINAL)

2. There are invasive species of the Atlantic Forest. Could you name any?

3. Why in the past were people more interested in nature? (Ex .: food, medical use, income, direct contact with nature)

4. Currently, young people have little interest in nature. In your opinion, is there an explanation? (Advancement of medicine and technology, ease of access).

5. Do you think contact with nature is important? Justify.

6. Have you had direct contact with nature? Where (last three locations)? What is your contact with forest areas? (weekly, daily)

7. What places do you usually go as a leisure area?

8. Was there previously concern about the destruction of the forests? is today? Comment.

9. Do you celebrate tree day? Like?

10. Did you learn anything or is there a discussion about this topic at school?

11. And today, is there explicit concern and attitudes towards preserving the forest? Comment.

12. Are you aware or have you heard about the forest code? Talk about.

13. What do you think about forest inspection and the fines that apply to offenders?

14. How important is forest restoration?

15. Do you know of any forest restoration experience? (Place, species used ...) Your opinion on that.

Supplementary Material 2. Proof of registration of this research in SisGen.

Ministério do Meio Ambiente

CONSELHO DE GESTÃO DO PATRIMÔNIO GENÉTICO

SISTEMA NACIONAL DE GESTÃO DO PATRIMÔNIO GENÉTICO E DO CONHECIMENTO TRADICIONAL ASSOCIADO

Comprovante de Cadastro de Acesso Cadastro nº AD07AA8

A atividade de acesso ao Conhecimento Tradicional Associado, nos termos abaixo resumida, foi cadastrada no SisGen, em atendimento ao previsto na Lei nº 13.123/2015 e seus regulamentos.

Número do Cadasro: AD07AA8

Usuário: **Monique Perini**

CPF: **140.058.477-90**

Objeto do Acesso: **Conhecimento Tradicional Associado (CTA)**

Finalidade do Acesso: **Pesquisa**

- Fonte do CTA

CTA de origem não identificável

Título da Atividade: **Conhecimento tradicional sobre espécies florestais**

- Equipe

Monique Perini - Universidade Federal de Minas Gerais

José Pires de Lemos Filho - Universidade Federal de Minas Gerais

Data do Cadastro: **17/08/2020 19:42:53**

Situação do Cadastro: **Concluído**

Conselho de Gestão do Patrimônio Genético

SISTEMA NACIONAL DE GESTÃO DO PATRIMÔNIO GENÉTICO E DO CONHECIMENTO TRADICIONAL ASSOCIADO - SISGEN

Table 1. Number of species cited by municipality according to age and gender (F = feminine; M = masculine). *The sum of the totals for the municipalities exceeds the total number of species because there were species in common to both areas and thus cited more than once.

Age	**Elderly**		**Total**	**Young**		**Total**	**Total species cited**
Municipality/Gender	**F**	**M**		**F**	**M**		
Santa Teresa, ES	38	61	69	28	31	42	111
Aimorés, MG	31	31	46	24	15	29	75
Total of all areas							116*

Table 2. Species and origin (E = exotic; N = native) cited by respondents (elderly and young) of the municipalities of Santa Teresa, state of Espírito Santo, and Aimorés, state of Minas Gerais, in the Southeast Region of Brazil.

Family	**Species**	**Origin**	**Popular Name**	**Santa Teresa, ES**		**Aimorés, MG**	
				Elderly	**Young**	**Elderly**	**Young**
Anacardiaceae	*Anacardium occidentale* L.	E	Cajueira			x	
Anacardiaceae	*Astronium concinnum* Schott	N	Guaribu Preto	x		x	
Anacardiaceae	*Astronium graveolens* Jacq.	N	Gibatão	x			
Anacardiaceae	*Goniorrhachis* sp.	N	Guaribu Amarelo	x		x	
Anacardiaceae	*Goniorrhachis* sp.	N	Guaribu Sabão	x	x		
Anacardiaceae	*Mangifera indica* L.	E	Mangueira		x	x	x
Anacardiaceae	*Schinus acutifolius* Engl.	E	Aroeira			x	x
Anacardiaceae	*Spondias mombin* L.	E	Cajá				x
Annonaceae	*Annona squamosa* L.	E	Pinha		x		x
Annonaceae	*Rollinia deliciosa* Saff.	N	Biriba	x			
Apocynaceae	*Aspidosperma* sp.	N	Peroba	x	x	x	x
Apocynaceae	*Aspidosperma* sp.	N	Peroba Sobra	x		x	
Apocynaceae	*Aspidosperma* sp.	N	Peroba Amarela			x	
Apocynaceae	*Aspidosperma* sp.	N	Perobinha			x	
Apocynaceae	*Aspidosperma* sp.	N	Peroba Branca	x			
Araucariaceae	*Araucaria* sp.	N	Araucária		x		
Arecaceae	*Cocos nucifera* L.	E	Coqueiro		x		x
Arecaceae	*Euterpe edulis* Mart.	E	Palmito Juçara	x	x	x	
Bignoniaceae	*Handroanthus albus* (Cham.) Mattos	N	Ipê Amarelo	x		x	
Bignoniaceae	*Handroanthus heptaphyllus* (Vell.) Mattos	N	Ipê Rosa		x		
Bignoniaceae	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos	N	Ipê Roxo	x	x	x	

Bignoniaceae	*Jacaranda mimosifolia* D. Don	N	Jacarandá	x	x	x	
Bignoniaceae	*Tabebuia/ Handroanthus* sp.	N	Ipê	x	x	x	x
Bignoniaceae	*Zeyheria tuberculosa* (Vell.) Bureau ex Verl.	N	Ipê Boia	x			
Boraginaceae	*Tournefortia paniculata* var. austrina I.M.Johnst.	N	Marmelinho			x	
Caryocaraceae	*Caryocar brasiliense* Cambess.	N	Pequi			x	
Chrysobalanaceae	*Licania rigida* Benth.	E	Oiticica			x	
Chrysobalanaceae	*Licania tomentosa* (Benth.) Fritsch	E	Oiti		x		
Crassulaceae	*Sedum mexicanum* Britt.	E	Balsamo	x			
Euphorbiaceae	*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.	E	Seringueira		x		x
Euphorbiaceae	*Joannesia princeps* Vell.	N	Boleira	x		x	x
Euphorbiaceae	*Mabea paniculata* Spruce ex Benth.	E	Mamoninha			x	
Euphorbiaceae	*Ricinus communis* L.	N	Mamona	x			
Fabaceae	*Abarema langsdorffii* (Benth.) Barneby & J.W.Grimes	N	Farinha Seca	x		x	
Fabaceae	*Anadenanthera colubrina* (Vell.) Brenan	N	Angico Branco			x	
Fabaceae	*Anadenanthera macrocarpa* (Benth.) Brenan	N	Angico Rosa	x			
Fabaceae	*Anadenanthera* sp	N	Angico	x	x	x	
Fabaceae	*Andira anthelmia* (Vell.) Benth.	N	Angelim Margoso	x			
Fabaceae	*Andira legalis* (Vell.) Toledo	N	Angelim Doce	x			
Fabaceae	*Andira fraxinifolia* Benth.	N	Andira	x			
Fabaceae	*Apuleia leiocarpa* (Vogel) J.F.Macbr.	N	Garapa	x			
Fabaceae	*Bauhinia forficata* Link.	N	Pata de Vaca		x		
Fabaceae	*Centrolobium tomentosum* Guillem. ex Benth.	N	Ariba	x			
Fabaceae	*Copaifera langsdorffii* Desf.	N	Copaíba	x		x	
Fabaceae	*Diplotropis purpurea* (Rich.) Amshoff	N	Macanaíba	x	x	x	
Fabaceae	*Hymenaea* sp.	N	Jatobá	x	x	x	
Fabaceae	*Hymenaea* sp.	N	Jataúba	x			
Fabaceae	*Hymenaea* sp.	N	Rapoca	x			
Fabaceae	*Hymenolobium petraeum* Ducke	E	Angelim Pedra	x		x	
Fabaceae	*Inga* sp.	N	Ingá	x		x	x
Fabaceae	*Inga thibaudiana* DC.	N	Ingá Facão	x			
Fabaceae	*Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz	N	Pau Ferro		x		
Fabaceae	*Melanoxylon brauna* Schott	N	Brauna	x	x	x	
Fabaceae	*Myroxylon balsamum* (L.) Harms	N	Óleo Vermelho	x			
Fabaceae	*Paubrasilia echinata* (Lam.) Gagnon, H. C. Lima & G. P. Lewis	N	Pau Brasil		x		x
Fabaceae	*Peltogyne recifencis* Ducke.	E	Roxinho	x			
Fabaceae	*Pithecellobium saman* (Jacq.) Benth.	N	Feijão Cru	x			
Fabaceae	*Plathymenia reticulata* Benth.	N	Vinhático		x		
Fabaceae	*Platycyamus regnellii* Benth.	N	Pereira	x	x		x
Fabaceae	*Pterodon emarginatus* Vogel	N	Sucupira	x			
Fabaceae	*Pterodon* sp.	N	Orelha de Macaco				
Lamiaceae	*Tectona grandis* L.	E	Teca		x		
Lauraceae	*Cinnamomum verum* J.Presl	E	Canela	x			
Lauraceae	*Nectandra rubra* (Mez) C.K.Allen	N	Loro Vermelho			x	

Lauraceae	*Ocotea porosa* (Nees & Mart.) Barroso	N	Imbúia	x			
Lauraceae	*Persea americana* Mill.	N	Abacateiro	x			
Lecythidaceae	*Bertholletia excelsa* Bonpl.	E	Castanheira		x		x
Lecythidaceae	*Cariniana legalis* (Mart.) Kuntze	N	Jequitibá rosa	x	x	x	
Lecythidaceae	*Couratari asterotricha* Prance	N	Imbirema	x			
Lecythidaceae	*Lecythis lanceolata* Poir.	N	Sapucainha	x			
Lecythidaceae	*Lecythis lurida* (Miers) S.A.Mori	N	Inuíba	x			
Lecythidaceae	*Lecythis pisonis* Cambess.	N	Sapucaia	x		x	
Lecythidaceae	*Lecythis* sp.	N	Sapucaiu	x			
Malpighiaceae	*Malpighia glabra* L.	N	Acerola		x		x
Malvaceae	*Ceiba* sp.	N	Barriguda				x
Meliaceae	*Cedrela fissilis* Vell.	N	Cedro	x		x	
Meliaceae	*Swietenia macrophylla* King	N	Mogno		x		
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	E	Fruta Pão		x		x
Moraceae	*Artocarpus heterophyllus* Lam.	E	Jaqueira	x	x	x	x
Moraceae	*Bagassa guianensis* Aubl.	E	Poluna	x			
Moraceae	*Ficus americana* Aubl.	N	Mata Pau	x		x	
Moraceae	*Ficus doliaria* (Miq.) Mart.	N	Gameleira			x	
Moraceae	*Morus* sp.	N	Amora		x		x
Musaceae	*Musa* sp.	N	Banana		x		x
Myristicaceae	*Virola bicuhyba* (Schott ex Spreng.) Warb.	N	Bicuíba	x			
Myrtaceae	*Acca sellowiana* Berg.	N	Goiaba do Mato	x			
Myrtaceae	*Eucalyptus* sp.	E	Eucalipto		x		x
Myrtaceae	*Eugenia uniflora* L.	N	Pitanga		x		x
Myrtaceae	*Psidium cattleyanum* Sabine	N	Araçaúna	x			
Myrtaceae	*Psidium guajava* L.	N	Goiabeira		x		x
Myrtaceae	*Syzygium* sp.	E	Jambo		x		x
Oleaceae	*Olea europaea* L.	E	Oliveira		x		
Oxalidaceae	*Averrhoa carambola* L.	E	Carambola		x		x
Phytolaccaceae	*Gallesia integrifolia* (Spreng.) Harms	N	Pau d'alho	x			
Pinaceae	*Pinus* sp.	E	Pinheiro	x			
Poaceae	*Olyra latifolia* L.	N	Taquara			x	
Rosaceae	*Malus domestica* Borkh.	E	Macieira		x		x
Rosaceae	*Prunus* sp.	N	Cerejeira	x	x		x
Rubiaceae	*Genipa americana* L.	N	Genipapo	x		x	
Rutaceae	*Balfourodendron riedelianum* (Engl.) Engl.	N	Marfim		x		
Rutaceae	*Citrus reticulata* Blanco	E	Mexirica			x	
Rutaceae	*Citrus* sp.	E	Laranja			x	x
Rutaceae	*Citrus* sp.	E	Limoeiro		x		x
Rutaceae	*Raputia magnifica* Engl.	N	Arapoca	x		x	
Sapindaceae	*Cupania oblongifolia* Mart.	N	Pau Magro	x		x	
Sapindaceae	*Talisia esculenta* (Cambess.) Radlk.	N	Pitomba	x			
Sapotaceae	*Manilkara amazonica* (Huber) Standley	E	Paraju	x	x	x	
Sapotaceae	*Pouteria bapeba* T.D.Penn.	N	Bapeba	x			

Urticaceae	*Cecropia* sp.	N	Embaúba			x	
Vitaceae	*Vitis* sp.	N	Parreira				x
Vochysiaceae	*Erisma uncinatum* Warm.	E	Cambará Rosa			x	
Indetermined	-	-	Guaitiseca	x		x	
Indetermined	-	-	Leiteira	x		x	
Indetermined	-	-	Ubicacum	x			
Indetermined-	-	-	Cirupira	x			
TOTAL		E		9	17	12	15
		N		56	25	32	14

Table 3. Number of species cited among young people from Santa Teresa (ST) and Aimorés (AI) according to their occupation.

Locality	Number of Interviewees	Occupation	Number of cited species	Average of species pe
ST	12	Basic education	60	5
ST	6	University education	25	4
ST	7	Workers	29	4
AI	17	Basic education	72	4
AI	1	University education	1	1
AI	7	Workers	25	4

Table 4. Floristic survey of tree species in the municipality of Aimorés, Minas Gerais (AIM) performed by Oliveira-Filho et al. (2005) and in the municipality of Santa Teresa, Espírito Santo (ST) by Thomaz & Monteiro (1997) and Saiter & Thomaz (2014).

Family	**Species**	**AIM**	**ST**
Achariaceae	*Carpotroche brasiliensis* (Raddi) A.Gray	x	
Anacardiaceae	*Astronium concinnum* Schott	x	
Anacardiaceae	*Astronium fraxinifolium* Schott	x	
Anacardiaceae	*Astronium graveolens* Jacq.	x	
Anacardiaceae	*Cyrtocarpa caatingae* J.D.Mitchel & D.C.Daly	x	
Anacardiaceae	*Tapirira guianensis* Aubl.	x	x
Annonaceae	*Anaxagorea dolichocarpa* Sprague & Sandw.	x	
Annonaceae	*Annona dolabripetala* Raddi		x
Annonaceae	*Guatteria australis* A. St.-Hil.		x
Annonaceae	*Guatteria odontopetala* Mart.	x	
Annonaceae	*Guatteria sellowiana* Schltdl.		x

Annonaceae	*Oxandra martiana* (Schltdl.) R.E.Fr.	x	
Annonaceae	*Oxandra* sp.		x
Annonaceae	*Pseudoxandra spiritus-sancti* Maas		x
Annonaceae	*Rollinia laurifolia* Schltdl.	x	
Annonaceae	*Rollinia sylvatica* (A. St.Hil.) Mart.	x	
Annonaceae	*Unonopsis sanctae-teresae* Maas & Westra		x
Annonaceae	*Xylopia decorticans* D.M.Johnson & Lobão		x
Apocynaceae	*Aspidosperma cylindrocarpon* Müll.Arg.	x	
Apocynaceae	*Aspidosperma parvifolium* A. DC.		x
Apocynaceae	*Aspidosperma ramiflorum* Müll.Arg.	x	
Apocynaceae	*Aspidosperma spruceanum* Benth. ex Müll.Arg		x
Apocynaceae	*Geissospermum laeve* (Vell.) Miers	x	
Apocynaceae	*Himatanthus bracteatus* (A. DC.) Woodson		x
Apocynaceae	*Himatanthus lanceifolius* (Müll.Arg.) Woodson	x	
Apocynaceae	*Lacmellea pauciflora* (Kuhlm.) Markgr.		x
Apocynaceae	*Rauvolfia capixabae* I.Koch & Kin.-Gouv.		x
Apocynaceae	*Tabernaemontana hystrix* (Steud.) A.DC	x	
Apocynaceae	*Tabernaemontana laeta* Mart.	x	
Aquifoliaceae	*Ilex dumosa* Reissek		x
Aquifoliaceae	*Ilex paraguariensis* A. St.-Hil.		x
Araliaceae	*Schefflera calva* (Cham.) Frodin & Fiaschi		x
Araliaceae	*Schefflera grandigemma* Fiaschi		x
Araliaceae	*Schefflera kollmannii* Fiaschi		x
Araliaceae	*Schefflera ruschiana* Fiaschi & Pirani		x
Arecaceae	*Astrocaryum aculeatissimum* (Schott) Burret	x	
Arecaceae	*Attalea burretiana* Bondar		x
Arecaceae	*Attalea oleifera* Barb.Rodr.	x	
Arecaceae	*Euterpe edulis* Mart.	x	x
Arecaceae	*Geonoma schottiana* Mart.		x
Arecaceae	*Polyandrococos caudescens* (Mart.) Barb.Rodr.	x	
Arecaceae	*Syagrus pseudococos* (Raddi) Glassman		x
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	x	
Asteraceae	*Vernonanthura discolor* (Spreng.) H.Rob.		x
Asteraceae	*Vernonanthura ferruginea* (Less.) H.Rob.	x	
Asteraceae	*Vernonanthura phosphorica* (Vell.) H.Rob.	x	
Asteraceae	*Vernonanthura puberula* (Less.) H.Rob.	x	
Bignoniaceae	*Jacaranda microcalyx* A.H. Gentry		x
Bignoniaceae	*Jacaranda puberula* Cham.	x	
Bignoniaceae	*Paratecoma peroba* (Record) Kuhlm.	x	
Bignoniaceae	*Sparattosperma leucanthum (Vell.) K.Schum.*	x	
Bignoniaceae	*Tabebuia chrysotricha* (Mart.) Standl.	x	
Bignoniaceae	*Tabebuia riodocensis* A.Gentry	x	

Bignoniaceae	*Tabebuia roseoalba* (Ridl.) Sandwith		x
Bignoniaceae	*Tabebuia serratifolia* (Vahl) Nichols	x	
Boraginaceae	*Cordia* sp.		x
Boraginaceae	*Cordia superba* Cham.	x	
Boraginaceae	*Cordia taguahyensis* Vell.	x	
Boraginaceae	*Cordia trachyphylla* Mart.		x
Burseraceae	*Protium brasiliense* Engl.		x
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand		x
Calophyllaceae	*Kielmeyera membranacea* Casar.	x	
Calophyllaceae	*Kielmeyera occhioniana* Saddi		x
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.	x	
Cardiopteridaceae	*Citronella paniculata* (Mart.) R.A. Howard		x
Caricaceace	*Jacaratia heptaphylla* (Vell.) A.DC.		x
Caryocaraceae	*Caryocar edule* Casar.		x
Celastraceae	*Cheiloclinium cognatum* (Miers) A.C. Sm.		x
Celastraceae	*Cheiloclinium* sp.		x
Celastraceae	*Maytenus brasiliensis* Mart.		x
Celastraceae	*Maytenus obtusifolia* Mart.		x
Celastraceae	*Salacia elliptica* (Mart. ex Schult.) G. Don		x
Celastraceae	*Salacia nemorosa* Lombardi		x
Celastraceae	*Tontelea martiana* (Miers.) A.C. Sm.		x
Chrysobalanaceae	*Couepia grandiflora* Benth.		x
Chrysobalanaceae	*Couepia macrophylla* Spruce ex Hook. f.		x
Chrysobalanaceae	*Couepia venosa* Prance		x
Chrysobalanaceae	*Hirtella hebeclada* Moric ex A. DC.		x
Chrysobalanaceae	*Hirtella triandra* Sw.	x	
Chrysobalanaceae	*Licania hypoleuca* Benth.	x	
Chrysobalanaceae	*Licania kunthiana* Hook. f.		x
Chrysobalanaceae	*Licania leptostachya* Benth		x
Chrysobalanaceae	*Licania micrantha* Miq.		x
Chrysobalanaceae	*Licania octandra* (Hoffmgg. ex Roem. & Schult.)		x
Chrysobalanaceae	*Licania parvifolia* Huber		x
Chrysobalanaceae	*Licania salzmannii* (Hook. f.) Fritsch		x
Chrysobalanaceae	*Licania spicata* Hook.f.	x	
Chrysobalanaceae	*Parinari littoralis* Prance		x
Chrysobalanaceae	*Parinari obtusifolia* Hook. f.		x
Clusiaceae	*Clusia melchiorii* Gleason		x
Clusiaceae	*Garcinia brasiliensis* Mart.		x
Clusiaceae	*Garcinia gardneriana* (Planch. & Triana) Zappi		x
Clusiaceae	*Tovomita fructipendula* (Ruiz & Pav.) Cambess.		x
Clusiaceae	*Tovomita leucantha* (Schltdl.) Planch. & Triana		x
Clusiaceae	*Tovomitopsis saldanhae* Engl.		x

Combretaceae	*Terminalia januariensis* DC.	x	
Combretaceae	*Terminalia phaeocarpa* Eichl.	x	
Connaraceae	*Connarus detersus* Planch.		x
Cunoniaceae	*Lamanonia ternata* Vell.		x
Dichapetalaceae	*Stephanopodium blanchetianum* Baill.		x
Elaeocarpaceae	*Sloanea garckeana* K. Schum.		x
Elaeocarpaceae	*Sloanea guianensis* (Aubl.) Benth.		x
Elaeocarpaceae	*Sloanea hirsuta* (Schott) Planch. ex Benth.		x
Elaeocarpaceae	*Sloanea monosperma* Vell.	x	
Elaeocarpaceae	*Sloanea nitida* G.Don.		x
Elaeocarpaceae	*Sloanea obtusifolia* (Moric.) K. Schum.		x
Elaeocarpaceae	*Sloanea stipitata* Spruce	x	
Erythropalaceae	*Erythroxylum macrophyllum* Cav.		x
Erythropalaceae	*Erythroxylum cuspidifolium* Mart.		x
Erythroxylaceae	*Erythroxylum flaccidum* Salzm.	x	
Erythroxylaceae	*Erythroxylum pulchrum* A. St.-Hil	x	x
Erythroxylaceae	*Erythroxylum squamatum* Sw.		x
Euphorbiaceae	*Alchornea glandulosa* Poepp. & Endl.	x	
Euphorbiaceae	*Alchornea triplinervia* (Spreng.) Müll. Arg.		x
Euphorbiaceae	*Aparisthmium cordatum* (Juss.) Baill.		x
Euphorbiaceae	*Cnidoscolus pubescens* (Pax) Pax	x	
Euphorbiaceae	*Croton celtidifolius* Baill.	x	
Euphorbiaceae	*Croton floribundus* Spreng.		x
Euphorbiaceae	*Croton verrucosus* Radcl.-Sm.& Govaerts	x	
Euphorbiaceae	*Manihot anomala* Pohl	x	
Euphorbiaceae	*Maprounea guianensis* Aubl.		x
Euphorbiaceae	*Pausandra morisiana* (Casar.) Radlk.	x	x
Euphorbiaceae	*Sebastiania schottiana* (Müll.Arg.) Müll.Arg.	x	
Euphorbiaceae	*Tetrorchidium rubrivenium* Poepp. & Endl.	x	
Fabaceae	*Abarema brachystachya* (DC.) Barneby & J.W.Grimes		x
Fabaceae	*Abarema jupunba* (Willd.) Urban	x	
Fabaceae	*Abarema* sp.		x
Fabaceae	*Acacia polyphylla* DC.	x	
Fabaceae	*Amburana cearensis* (Allem.) A.C.Sm.	x	
Fabaceae	*Anadenanthera colubrina* (Vell.) Brenan	x	
Fabaceae	*Andira fraxinifolia* Benth.		x
Fabaceae	*Apuleia leiocarpa* J.F.Macbr	x	
Fabaceae	*Bauhinia dumosa* Benth.	x	
Fabaceae	*Caesalpinia ferrea* Benth.	x	
Fabaceae	*Copaifera langsdorffii* Desf.		x
Fabaceae	*Dalbergia brasiliensis* Vogel	x	
Fabaceae	*Dalbergia foliolosa* Benth	x	x

Fabaceae	*Dalbergia miscolobium* Benth.		x
Fabaceae	*Deguelia costata (Benth.) Az.Tozzi*	x	
Fabaceae	*Deguelia hatschbachii* Az.Tozzi	x	
Fabaceae	*Dialium guianense* (Aubl.) Sandw.	x	
Fabaceae	*Diplotropis incexis* Rizzini & A. Mattos		x
Fabaceae	*Erythrina verna* Vell.	x	
Fabaceae	*Goniorrhachis marginata* Taub.	x	
Fabaceae	*Hymenaea aurea* Y.T. Lee & Langenh.	x	x
Fabaceae	*Hymenaea courbaril* L.		x
Fabaceae	*Hymenolobium janeirense* Kuhlm.	x	x
Fabaceae	*Inga capitata* Desv.	x	x
Fabaceae	*Inga cylindrica* (Vell.) Mart.		x
Fabaceae	*Inga densiflora* Benth.		x
Fabaceae	*Inga edulis* Mart.	x	
Fabaceae	*Inga flagelliformis* (Vell.) Mart.	x	x
Fabaceae	*Inga lenticellata* Benth.		x
Fabaceae	*Inga marginata* Willd.	x	
Fabaceae	*Inga subnuda* Salzm. ex Benth.		x
Fabaceae	*Inga tenuis* (Vell.) Mart.		x
Fabaceae	*Inga thibaudiana* DC.		x
Fabaceae	*Inga vestita* Benth.		x
Fabaceae	*Lonchocarpus campestris* Benth.	x	
Fabaceae	*Lonchocarpus virgilioides* Benth.	x	
Fabaceae	*Machaerium brasiliense* Vogel	x	
Fabaceae	*Machaerium cantarellianum* Hoehne	x	
Fabaceae	*Machaerium dimorphandrum* Hoehne	x	
Fabaceae	*Machaerium hirtum* (Vell.) Stellfeld	x	
Fabaceae	*Machaerium incorruptibile* Allemão	x	
Fabaceae	*Machaerium nictitans* (Vell.) Benth.	x	
Fabaceae	*Machaerium stipitatum* (DC.) Vogel	x	
Fabaceae	*Melanoxylon brauna* Schott	x	x
Fabaceae	*Mimosa artemisiana* Heringer & Paula	x	
Fabaceae	*Myroxylon peruiferum* L.f.	x	
Fabaceae	*Ormosia ruddiana Y*akovlev		x
Fabaceae	*Parapiptadenia pterosperma* (Benth.)	x	
Fabaceae	*Peltogyne angustiflora* Ducke		x
Fabaceae	*Peltophorum dubium* (Spreng.) Taub.	x	
Fabaceae	*Piptadenia paniculata* Benth.	x	
Fabaceae	*Pithecellobium dulce* (Roxb.) Benth.		x
Fabaceae	*Plathymenia reticulata* Benth.	x	
Fabaceae	*Platymiscium floribundum* Vogel	x	
Fabaceae	*Pseudopiptadenia contorta* (DC.)	x	

Fabaceae	*Pseudopiptadenia leptostachya* (Benth.)	x	
Fabaceae	*Pseudopiptadenia* sp. nov.		x
Fabaceae	*Pterocarpus rohrii* Vahl.	x	
Fabaceae	*Pterogyne nitens* Tul.	x	
Fabaceae	*Sclerolobium densiflorum* Benth.		x
Fabaceae	*Sclerolobium striatum* Dwyer		x
Fabaceae	*Senna multijuga* (Rich.) H.S. Irwin & Barneby		x
Fabaceae	*Stryphnodendron polyphyllum* Mart.	x	
Fabaceae	*Swartzia acutifolia* Vogel	x	
Fabaceae	*Swartzia apetala* Raddi	x	x
Fabaceae	*Swartzia macrostachya* Benth.	x	
Fabaceae	*Swartzia myrtifolia* J.E.Smith	x	x
Fabaceae	*Swartzia oblata* R.S.Cowan		x
Fabaceae	*Sweetia fruticosa* Spreng.	x	
Fabaceae	*Vatairea heteroptera* (Allem.) Ducke	x	
Fabaceae	*Zollernia ilicifolia* (Brongn.) Vogel		x
Fabaceae	*Zollernia magnifica* A.M. Carvalho & Barneby		x
Hernandiaceae	*Sparattanthelium botocudorum* Mart.		x
Humiriaceae	*Humiriastrum spiritu-sancti* Cuatrec.		x
Humiriaceae	*Vantanea compacta* (Schnizl.) Cuatrec.		x
Hypericaceae	*Vismia brasiliensis* Choisy		x
Hypericaceae	*Vismia guianensis* (Aubl.) Pers.	x	
Lacistemataceae	*Lacistema aggregatum* (P.J.Bergius) Rusby	x	
Lacistemataceae	*Lacistema pubescens* Mart.	x	
Lacistemataceae	*Lacistema robustum* Schnizl.	x	x
Lairaceae	*Beilschmiedia taubertiana* (Schwacke & Mez)		x
Lamiaceae	*Vitex orinocensis* H. B. & K.		x
Lamiaceae	*Vitex* sp.		x
Lauraceae	*Aniba intermedia* (Meisn.) Mez	x	
Lauraceae	*Beilschmiedia linharensis* Sa. Nishida & van der L.D.		x
Lauraceae	*Beilschmiedia* sp.		x
Lauraceae	*Cinnamomum riedelianum* Kosterm.		x
Lauraceae	*Cinnamomum* sp.		x
Lauraceae	*Cryptocarya aschersoniana* Mez		x
Lauraceae	*Cryptocarya saligna* Mez	x	x
Lauraceae	*Cryptocarya velloziana* P.L.R. de Moraes		x
Lauraceae	*Endlicheria paniculata* (Spreng.) J.F. Macbr.		x
Lauraceae	*Licaria armeniaca* (Nees) Kosterm.	x	
Lauraceae	*Licaria guianensis* Aubl.		x
Lauraceae	*Licaria* sp. 1		x
Lauraceae	*Mezilaurus glabriantha* F.M.Alves & V.C.Souza		x
Lauraceae	*Nectandra lanceolata* Nees	x	

Lauraceae	*Nectandra membranacea* (Sw.) Griseb.	x	
Lauraceae	*Ocotea aciphylla* (Nees) Mez		x
Lauraceae	*Ocotea brachybotra* (Meisn.) Mez	x	x
Lauraceae	*Ocotea catharinensis* Mez		x
Lauraceae	*Ocotea corymbosa* (Meisn.) Mez		x
Lauraceae	*Ocotea cryptocarpa* Baitello		x
Lauraceae	*Ocotea daphnifolia* (Meisn.) Mez		x
Lauraceae	*Ocotea dispersa* (Nees) Mez	x	x
Lauraceae	*Ocotea divaricata* (Nees) Mez	x	x
Lauraceae	*Ocotea domatiata* Mez		x
Lauraceae	*Ocotea elegans* Mez		x
Lauraceae	*Ocotea lancifolia* (Schott) Mez		x
Lauraceae	*Ocotea longifolia* H.B. & K.		x
Lauraceae	*Ocotea odorifera* (Vell.) Rohwer		x
Lauraceae	*Ocotea pluridomatiata* Quinet		x
Lauraceae	*Ocotea puberula* (Rich.) Nees	x	x
Lauraceae	*Ocotea pulchra* Vattimo		x
Lauraceae	*Ocotea silvestris* Vattimo		x
Lauraceae	*Ocotea* sp. 1		x
Lauraceae	*Ocotea* sp. 2		x
Lauraceae	*Ocotea* sp. 3		x
Lauraceae	*Ocotea* sp. 4		x
Lauraceae	*Ocotea* sp. 5		x
Lauraceae	*Ocotea* sp. 6		x
Lauraceae	*Ocotea* sp. 7		x
Lauraceae	*Ocotea spixiana* (Nees) Mez		x
Lauraceae	*Ocotea teleiandra* (Meisn.) Mez		x
Lauraceae	*Ocotea tenuiflora* (Nees) Mez		x
Lauraceae	*Ocotea velutina* (Nees) Rohwer		x
Lauraceae	*Persea caesia* Meisn.		x
Lauraceae	*Persea* sp.		x
Lauraceae	*Phyllostemonodaphne geminiflora*	x	
Lauraceae	*Urbanodendron verrucosum* (Nees) Mez	x	
Lecythidaceae	*Cariniana legalis* (Mart.) Kuntze	x	
Lecythidaceae	*Couratari asterotricha* Prance	x	
Lecythidaceae	*Eschweilera ovata* (Camb.) Miers	x	
Lecythidaceae	*Lecythis lurida* (Miers) S.A.Mori	x	
Lecythidaceae	*Lecythis pisonis* Camb.	x	
Loganiaceae	*Antonia ovata* Pohl	x	
Loganiaceae	*Strychnos* sp.		x
Malphigiaceae	*Barnebya dispar* (Griseb.) W.R. Anderson & B. X L.D.		x
Malphigiaceae	*Byrsonima alvimii* W. R. Anderson		x

Malphigiaceae	*Byrsonima sericea* DC.	x	
Malphigiaceae	*Byrsonima variabilis* A. Juss.		x
Malvaceae	*Eriotheca macrophylla* (K. Schum.) A. Robyns		x
Malvaceae	*Eriotheca pentaphylla* (Vell.) A.Robyns	x	
Malvaceae	*Guazuma ulmifolia* Lam.	x	
Malvaceae	*Hydrogaster trinervis* Kuhlm.		x
Malvaceae	*Luehea divaricata* Mart. & Zucc.	x	
Malvaceae	*Pachira calophylla* (K. Schum.) Fern. Alonso		x
Malvaceae	*Pseudobombax grandiflorum* (Cav.) A.Robyns	x	
Malvaceae	*Pterygota brasiliensis* Allemão	x	
Malvaceae	*Sterculia chicha* A. St.Hil.	x	
Melastomataceae	*Meriania tetramera* Wurdack		x
Melastomataceae	*Miconia budlejoides* Triana		x
Melastomataceae	*Miconia calvescens* DC.	x	
Melastomataceae	*Miconia capixaba* R. Goldenberg		x
Melastomataceae	*Miconia cinnamomifolia* (A. DC.) Naud.		x
Melastomataceae	*Miconia dodecandra* (Desr.) Cogn.		x
Melastomataceae	*Miconia doriana* Cogn.		x
Melastomataceae	*Miconia fasciculata* Gardner	x	
Melastomataceae	*Miconia latecrenata* (DC.) Naudin		x
Melastomataceae	*Miconia lepidota* DC.		x
Melastomataceae	*Miconia octopetala* Cogn.		x
Melastomataceae	*Miconia polyandra* Gardner		x
Melastomataceae	*Miconia prasina* (Sw.) DC.	x	x
Melastomataceae	*Mouriri doriana* Saldanha ex Gogn.		x
Melastomataceae	*Mouriri glazioviana* Cogn.		x
Melastomataceae	*Mouriri regeliana* Cogn.		x
Meliaceae	*Cabralea canjerana* (Vell.) Mart.		x
Meliaceae	*Cedrela fissilis* Vell.	x	
Meliaceae	*Guarea macrophylla* Vahl	x	x
Meliaceae	*Trichilia elegans* A.Juss.	x	
Meliaceae	*Trichilia emarginata* (Turcz) C.DC.		x
Meliaceae	*Trichilia lepidota* Mart.	x	x
Meliaceae	*Trichilia silvatica* C. DC.		x
Meliaceae	*Trichilia* sp		x
Monimiaceae	*Mollinedia fruticulosa* Perkins		x
Monimiaceae	*Mollinedia gilgiana* Perkins		x
Monimiaceae	*Mollinedia salicifolia* Perkins		x
Monimiaceae	*Mollinedia schottiana* (Spreng.) Perkins	x	
Monimiaceae	*Mollinedia* sp.		x
Monimiaceae	*Mollinedia stenophylla* Perkins		x
Moraceae	*Brosimum gaudichaudii* Trécul	x	

Moraceae	*Brosimum guianense* (Aubl.) Huber	x	
Moraceae	*Brosimum lactescens* (S.Moore) C.C.Berg		x
Moraceae	*Clarisia ilicifolia* (Spreng.) Lanj. & Rossb.	x	
Moraceae	*Ficus arpazusa* Casar.		x
Moraceae	*Ficus gomelleira* Kunth & Bouché	x	
Moraceae	*Ficus obtusiuscula* (Miq.) Miq.	x	
Moraceae	*Maclura tinctoria* (L.) D.Don.	x	
Moraceae	*Sorocea guilleminiana* Gaudich.	x	x
Myristicaceae	*Virola gardneri* (A. DC.) Warb.	x	x
Myrtaceae	*Blepharocalyx eggersii* (Kiaersk.) Landrum		x
Myrtaceae	*Calyptranthes clusiifolia* (Miq.) O. Berg		x
Myrtaceae	*Calyptranthes grandifolia* O.Berg	x	x
Myrtaceae	*Calyptranthes lucida* Mart.	x	
Myrtaceae	*Calyptranthes pauciflora* O. Berg		x
Myrtaceae	*Calyptranthes pulchella* DC.		x
Myrtaceae	*Calyptranthes* sp. 1		x
Myrtaceae	*Calyptranthes* sp. 2		x
Myrtaceae	*Calyptranthes* sp. 3		x
Myrtaceae	*Calyptranthes* sp. 4		x
Myrtaceae	*Calyptranthes* sp. 5		x
Myrtaceae	*Calyptranthes* sp. 6		x
Myrtaceae	*Calyptranthes* sp. 7		x
Myrtaceae	*Calyptranthes* sp. 8		x
Myrtaceae	*Calyptranthes* sp. 9		x
Myrtaceae	*Calyptranthes widgreniana* O. Berg		x
Myrtaceae	*Campomanesia aromatica* (Aubl.) Griseb.		x
Myrtaceae	*Campomanesia guaviroba* (DC.) Kiaersk.		x
Myrtaceae	*Campomanesia laurifolia* Gardner		x
Myrtaceae	*Eugenia acutata* Miq.		x
Myrtaceae	*Eugenia candolleana* DC.		x
Myrtaceae	*Eugenia cerasiflora* Miq.		x
Myrtaceae	*Eugenia copacabanensis* Kiaersk.		x
Myrtaceae	*Eugenia cuprea* (O.Berg) Nied.	x	
Myrtaceae	*Eugenia egensis* DC.		x
Myrtaceae	*Eugenia excelsa* O. Berg		x
Myrtaceae	*Eugenia florida* DC.	x	
Myrtaceae	*Eugenia fusca* O.Berg		x
Myrtaceae	*Eugenia goiapabana* Sobral & Mazine		x
Myrtaceae	*Eugenia handroana* D.Legrand	x	
Myrtaceae	*Eugenia itapemirimensis* Cambess.		x
Myrtaceae	*Eugenia neoglomerata* Sobral	x	x
Myrtaceae	*Eugenia oblongata* O. Berg		x

Myrtaceae	*Eugenia persicifolia* O. Berg		x
Myrtaceae	*Eugenia piloensis* Cambess.		x
Myrtaceae	*Eugenia platyphylla* O. Berg		x
Myrtaceae	*Eugenia platysema* O. Berg		x
Myrtaceae	*Eugenia pruniformis* Cambess.		x
Myrtaceae	*Eugenia rostrata* O. Berg		x
Myrtaceae	*Eugenia rugosissima* Sobral		x
Myrtaceae	*Eugenia* sp. 1		x
Myrtaceae	*Eugenia* sp. 2		x
Myrtaceae	*Eugenia* sp. 3		x
Myrtaceae	*Eugenia* sp. 4		x
Myrtaceae	*Eugenia speciosa* Camb.	x	
Myrtaceae	*Eugenia stictopetala* DC.	x	x
Myrtaceae	*Eugenia subundulata* Kiaersk.		x
Myrtaceae	*Eugenia uniflora* L.	x	
Myrtaceae	*Eugenia xiriricana* Mattos		x
Myrtaceae	*Gomidesia palustris* (DC.) Kausel		x
Myrtaceae	*Gomidesia pubescens* (DC.) D. Legrand		x
Myrtaceae	*Gomidesia schaueriana* O. Berg		x
Myrtaceae	*Marlierea clausseniana* (O.Berg) Kiaersk.	x	
Myrtaceae	*Marlierea eugenioides* (Cambess.) D.Legrand		x
Myrtaceae	*Marlierea excoriata* Mart.		x
Myrtaceae	*Marlierea obscura* O. Berg		x
Myrtaceae	*Marlierea regeliana* O. Berg		x
Myrtaceae	*Marlierea silvatica* (Gardner) Kiaersk.		x
Myrtaceae	*Marlierea* sp.		x
Myrtaceae	*Myrcia amazonica* DC.		x
Myrtaceae	*Myrcia crocea* (Vell.) Kiaersk.		x
Myrtaceae	*Myrcia fallax* (Rich.) DC.	x	
Myrtaceae	*Myrcia montana* Cambess.		x
Myrtaceae	*Myrcia multiflora* (Lam.) DC.	x	
Myrtaceae	*Myrcia plusiantha* Kiaersk.		x
Myrtaceae	*Myrcia pubipetala* Miq.		x
Myrtaceae	*Myrcia racemosa* (O. Berg) Kiaersk.		x
Myrtaceae	*Myrcia rufula* Miq.	x	
Myrtaceae	*Myrcia* sp. 1		x
Myrtaceae	*Myrcia* sp. 2		x
Myrtaceae	*Myrcia* sp. 3		x
Myrtaceae	*Myrcia* sp. 4		x
Myrtaceae	*Myrcia* sp. 5		x
Myrtaceae	*Myrcia* sp. 6		x
Myrtaceae	*Myrcia* sp. 7		x

Myrtaceae	*Myrcia splendens* DC.		x
Myrtaceae	*Myrcia subrugosa* Kiaersk.		x
Myrtaceae	*Myrciaria disticha* O. Berg		x
Myrtaceae	*Myrciaria floribunda* (H. West ex Willd.) O. Berg	x	x
Myrtaceae	*Myrciaria glomerata* O.Berg	x	
Myrtaceae	*Neomitranthes glomerata* (D. Legrand) D. Legrand		x
Myrtaceae	*Neomitranthes warmingiana* (Kiaersk.) Mattos		x
Myrtaceae	*Pimenta pseudocaryophyllus* (Gomes) Landrum		x
Myrtaceae	*Plinia* cf. *involucrata* (O. Berg) McVaugh		x
Myrtaceae	*Plinia renatiana* G. M. Barroso & Peixoto		x
Myrtaceae	*Plinia rivularis* (Cambess.) Rotman		x
Myrtaceae	*Psidium guineense* Sw.	x	
Myrtaceae	*Psidium* sp. 1		x
Myrtaceae	*Psidium* sp. 2		x
Myrtaceae	*Siphoneugena dussii* (Krug & Urb.) Proença		x
Nyctaginaceae	*Bougainvillea glabra* Choisy	x	
Nyctaginaceae	*Guapira hirsuta* (Choisy) Lundell	x	
Nyctaginaceae	*Guapira laxa* (Netto) Furlan		x
Nyctaginaceae	*Guapira obtusata* (Jacq.) Little		x
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	x	x
Nyctaginaceae	*Guapira venosa* (Choisy) Lundell	x	x
Nyctaginaceae	*Ramisia brasiliensis* Oliver	x	
Ochnaceae	*Elvasia capixaba* Fraga & Saavedra		x
Ochnaceae	*Ouratea castaneifolia* (DC.) Engl.	x	
Ochnaceae	*Ouratea cuspidata* (A.St.-Hil.) Engl.		x
Olacaceae	*Heisteria perianthomega* (Vell.) Sleumer		x
Olacaceae	*Heisteria silvianii* Schwacke	x	x
Olacaceae	*Tetrastylidium grandifolium* (Baill) Sleumer		x
Oleaceae	*Chionanthus ferrugineus* (Gilg) P.S.Green	x	
Oleaceae	*Chionanthus micranthus* (Mart.) Lozano & Fuertes		x
Pentaphyllacaceae	*Ternstroemia brasiliensis* Cambess.		x
Pentaphyllacaceae	*Ternstroemia* sp.		x
Peraceae	*Chaetocarpus echinocarpus* (Baill.) Ducke	x	
Peraceae	*Pera heteranthera* (Schrank) I.M.Johnst.		x
Peraceae	*Pogonophora schomburgkiana* Miers	x	
Phyllanthaceae	*Hieronyma alchorneoides* Allem.		x
Phyllanthaceae	*Hieronyma oblonga* (Tul.) Müll. Arg.		x
Phyllanthaceae	*Margaritaria nobilis* L. f.		x
Phytolaccaceae	*Gallesia integrifolia* (Spreng.) Harms	x	
Phytolaccaceae	*Seguieria americana* L.	x	
Piperaceae	*Piper arboreum* Aubl.	x	
Polygonaceae	*Coccoloba declinata* (Vell.) Mart.		x

Polygonaceae	*Coccoloba* sp.		x
Primulaceae	*Myrsine lancifolia* Mart.		x
Primulaceae	*Myrsine* sp. nov.		x
Primulaceae	*Myrsine umbellata* Mart.		x
Primulaceae	*Myrsine venosa* A. DC.		x
Proteaceae	*Roupala consimilis* Mez		x
Proteaceae	*Roupala* sp.		x
Putranjivaceae	*Drypetes sessiliflora* Allem.		x
Quiinaceae	*Quiina glaziovii* Engl.		x
Rosaceae	*Prunus brasiliensis* (Cham. & Schltdl.) Dietrich.		x
Rosaceae	*Prunus myrtifolia* (L.) Urb.		x
Rubiaceae	*Alseis floribunda* Schott	x	
Rubiaceae	*Amaioua intermedia* Mart.		x
Rubiaceae	*Amaioua pilosa* K. Schum.		x
Rubiaceae	*Bathysa australis* (St. Hil.) Benth & Hook. f.		x
Rubiaceae	*Bathysa mendoncaei* K.Schum.	x	
Rubiaceae	*Bathysa nicholsonii* K.Schum.	x	
Rubiaceae	*Bathysa stipulata* (Vell.) C. Presl		x
Rubiaceae	*Cordiera myrciifolia* (K.Schum.) C.H.Perss. & Delprete		x
Rubiaceae	*Faramea oligantha* Müll. Arg.		x
Rubiaceae	*Faramea pachyantha* Müll. Arg.		x
Rubiaceae	*Genipa americana* L.	x	
Rubiaceae	*Guettarda uruguensis* Cham. & Schltdl	x	
Rubiaceae	*Ixora* sp.		x
Rubiaceae	*Palicourea croceoides* Desv,	x	
Rubiaceae	*Posoqueria acutifolia* Mart.		x
Rubiaceae	*Posoqueria latifolia* (Rudge) Roem. & Schult.		x
Rubiaceae	*Psychotria carthagenensis* Jacq	x	
Rubiaceae	*Psychotria carthagenensis* Jacq.		x
Rubiaceae	*Psychotria vellosiana* Benth.		x
Rubiaceae	*Remijia ferruginea* DC.	x	
Rubiaceae	*Rudgea recurva* Müll. Arg.		x
Rubiaceae	*Simira glaziovii* (K. Schum.) Steyerm.		x
Rubiaceae	*Simira sampaioana* (Standl.) Steyerm.		x
Rubiaceae	*Stachyarrhena krukovii* Standl.		x
Rutaceae	*Balfourodendron riedelianum* (Engl.) Engl.	x	
Rutaceae	*Galipea jasminiflora* (A. St.Hil.) Engl.	x	
Rutaceae	*Hortia brasiliana* Vand. ex. DC.		x
Rutaceae	*Metrodorea nigra* A. St.Hil.	x	
Rutaceae	*Neoraputia alba* (Nees) Emmerich	x	
Rutaceae	*Zanthoxylum caribaeum* Lam.	x	
Sabiaceae	*Meliosma chartacea* Lombardi		x

Salicaceae	*Banara serrata* (Vell.) Warb.		x
Salicaceae	*Casearia arborea (Rich.) Urb.*		x
Salicaceae	*Casearia commersoniana* Cambess.		x
Salicaceae	*Casearia decandra* Jacq.	x	x
Salicaceae	*Casearia pauciflora* Camb.	x	
Salicaceae	*Casearia* sp. 1		x
Salicaceae	*Casearia* sp. 2		x
Salicaceae	*Casearia ulmifolia* Vahl	x	
Salicaceae	*Xylosma prockia* (Turcz.) Turcz.	x	
Sapindaceae	*Allophylus laevigatus* Radlk.		x
Sapindaceae	*Allophylus petiolulatus* Radlk.		x
Sapindaceae	*Cupania crassifolia* Radlk.		x
Sapindaceae	*Cupania emarginata* Cambess.		x
Sapindaceae	*Cupania furfuracea* Radlk.		x
Sapindaceae	*Cupania oblongifolia* Mart.	x	
Sapindaceae	*Cupania racemosa* (Vell.) Radlk.	x	
Sapindaceae	*Cupania rubiginosa* (Poir.) Radlk.	x	
Sapindaceae	*Cupania scrobiculata* Rich.		x
Sapindaceae	*Matayba arborescens* (Aubl.) Radlk.		x
Sapindaceae	*Matayba guianensis* Aubl.	x	x
Sapindaceae	*Talisia cupularis* Radlk.		x
Sapindaceae	*Talisia subalbens* Radlk.	x	
Sapindaceae	*Talisia cerasina* (Benth.) Radlk.		x
Sapotaceae	*Chrysophyllum flexuosum* Mart.		x
Sapotaceae	*Chrysophyllum gonocarpum* (Mart. & Eichler) Engl.	x	x
Sapotaceae	*Chrysophyllum lucentifolium* Cronq.	x	
Sapotaceae	*Chrysophyllum* sp. 1		x
Sapotaceae	*Chrysophyllum* sp. 2		x
Sapotaceae	*Chrysophyllum splendens* Spreng.	x	x
Sapotaceae	*Diploon cuspidatum* (Hoehne) Cronquist		x
Sapotaceae	*Ecclinusa ramiflora* Mart.		x
Sapotaceae	*Manilkara longifolia* (A. DC.) Dubard		x
Sapotaceae	*Manilkara subsericea* (Mart.) Dubard	x	
Sapotaceae	*Micropholis compta* Pierre		x
Sapotaceae	*Micropholis crassipedicellata* (Mart. & Eichler) Pierre		x
Sapotaceae	*Micropholis gardneriana* (A. DC.) Pierre		x
Sapotaceae	*Micropholis guyanensis* (A. DC.) Pierre		x
Sapotaceae	*Micropholis* sp.		x
Sapotaceae	*Micropholis venulosa* (Mart. & Eichler) Pierre		x
Sapotaceae	*Pouteria bangii* (Rusby) T.D. Penn.		x
Sapotaceae	*Pouteria bullata* (S. Moore) Baehni		x
Sapotaceae	*Pouteria caimito* (Ruiz & Pav.) Radlk.	x	x

Sapotaceae	*Pouteria coelomatica* Rizzini		x
Sapotaceae	*Pouteria cuspidata* (A. DC.) Baehni		x
Sapotaceae	*Pouteria gardneri* (Mart. & Miq.) Baehni		x
Sapotaceae	*Pouteria grandiflora* (A. DC.) Baehni		x
Sapotaceae	*Pouteria guianensis* Aubl.		x
Sapotaceae	*Pouteria macahensis* T.D. Penn.		x
Sapotaceae	*Pouteria pachycalyx* T.D.Penn.	x	
Sapotaceae	*Pouteria reticulata* (Engler) Eyma		x
Sapotaceae	*Pouteria sagotiana* (Baill.) Eyma		x
Sapotaceae	*Pouteria* sp. 1		x
Sapotaceae	*Pouteria* sp. 2		x
Sapotaceae	*Pradosia lactescens* (Vell.) Radlk.		x
Simaroubaceae	*Simarouba amara* Aubl.		x
Siparunaceae	*Siparuna bifida* (Poepp. & Endl.) A.DC.		x
Solanaceae	*Solanum sooretamum* Carvalho		x
Symplocaceae	*Symplocos celastrinea* Mart. ex Miq.		x
Symplocaceae	*Symplocos nitens* (Pohl) Benth.		x
Symplocaceae	*Symplocos tetrandra* Mart.		x
Thymaelaceae	*Daphnopsis martii* Meisn.		x
Urticaceae	*Cecropia glaziovii* Snethl.	x	
Urticaceae	*Cecropia hololeuca* Miq.	x	x
Urticaceae	*Cecropia pachystachya* Trécul	x	
Urticaceae	*Coussapoa microcarpa* (Schott) Rizzini		x
Urticaceae	*Coussapoa pachyphylla* Akkermans & C.C. Berg		x
Urticaceae	*Pourouma bicolor* (Trécul) C.C. Berg & van Heusden		x
Urticaceae	*Pourouma guianensis* Aubl.		x
Vochysiaceae	*Qualea cryptantha* (Spreng.) Warm.	x	
Vochysiaceae	*Vochysia dasyantha* Warm.	x	
Vochysiaceae	*Vochysia rectiflora* Warm.		x
Vochysiaceae	*Vochysia santaluciae* M.C. Vianna & Fontella		x
Winteraceae	*Drimys brasiliensis* Miers		x

CAPÍTULO II

SEED RAIN IN CHRONOSSEQUENCE OF RESTORATION OF THE ATLANTIC FOREST







Abstract

Anthropogenic disturbances cause losses that affect natural forest recovery processes. Among these processes stands out the seed rain that acts in the recruitment of individuals in the plant community with the supply of propagules that contribute to the colonization of the areas. To investigate the potential recovery of the plant community between 5, 10 and 20 years of forest restoration, we evaluated the richness and density of propagules in the seed rain and its association with environmental variables. For that, the seed rain was evaluated monthly for one year in 40 collectors distributed in three areas at different ages of restoration and an area of conserved forest taken as a reference of Atlantic Forest in the southeastern region of Brazil. The seed rain in this study included 8096 seeds. The analysis of the composition of propagules in the restoration sequence allowed to observe successional progress during the forest restoration. Sites under restoration for 5 and 10 years showed no difference in the composition of the seed rain, which showed a predominance of exotic grasses and greater seed deposition at the end of the rainy season. In the oldest area under restoration (20 years old) and in the reference area, greater overlap of tree-shrub species and lower seed density was observed. No monthly pattern of seed rain deposition was observed in the restoration chronosequence even in areas with similar species composition. The soil characteristics were not related to seed rain, but seed deposition is influenced especially by the leaf area index, in areas of predominantly open canopy (lower leaf area index), greater deposition of exotic grass seeds was verified.

Keywords: Semideciduous Forest; Light Limitation; Tropical Forest Restoration

Introduction

The Atlantic Forest is home to a biota with high diversity, richness and endemic species, but has suffered from anthropic disturbances since the colonial period associated with urban expansion and economic cycles. For these conditions, it is included among the biodiversity hotspots (Mittermeier et al., 2004). After centuries of exploration, the biome is fragmented into small forest patches surrounded by cultivation or grazing areas, leading to loss of species diversity (Ribeiro et al., 2009; Hansen et al. 2013; Santos-Silva et al., 2016). Anthropogenic disturbances cause losses that affect natural flora and fauna restoration processes, making it necessary to carry out conservation, management, and restoration plans for degraded areas (Martínez-Garza et al., 2011). Forest restoration is based on the reconstruction of biological diversity and the functioning of ecological processes and interactions (Rodrigues & Gandolfi, 2004; Bellotto et al., 2009). For the forest restoration project to be successful, it is necessary that the species be replaced over time through a process that occurs through different trajectories, the forest dynamics (Pickett & McDonnell, 1989).

The dynamics of forest ecosystems, including those in ecological restoration, are influenced by the deposition of seed rain. The seed rain participates in the recruitment process of individuals in the plant community, with the supply of propagules that contribute to the colonization of areas and, consequently, with the increase of the richness of local species (Araujo et al., 2004). Seed rain presents patterns that vary according to abiotic factors, such as temperature and precipitation, and biotics, such as availability of dispersers, which reflect in the floristic composition of the area (Richards, 1998; Barbosa & Pizo, 2006; Li et al., 2012; Toscan, 2014). The dynamics of seed rain may be sufficient for natural colonization of degraded areas (Buisson et al., 2006; Blackham et al., 2013), however, this success varies according to the history of soil degradation, light incidence, hydric deficit, in addition to the availability of pollinating and dispersing fauna, which are limiting factors for the establishment of vegetation, contributing to the successional advance (Howe & Smallwood, 1982; Richards, 1998; Shono et al., 2007).

Restoration areas tend to replace species as local environmental conditions become favorable for the establishment of new species and this substitution can be observed, initially, in the composition of the seed rain (Martínez- Garza et al., 2011; Maza-Villalobos et al., 2011; Wolfe et al., 2019). Species substitution occurs gradually with changes in functional groups, successional categories and even dispersion syndromes (Brancalion et al., 2009). Herbaceous species tend to give way to shrub species, just as those tolerant to constant light and fast growing (pioneer) tend to be replaced by long-lived and slow-growing species (Buisson et al., 2006; Brancalion et al., 2009). In addition, the formation of a continuous canopy provides shelter, perch, food for the fauna, that is established in the place contributing to the pollination and dispersion of the seeds (Rodrigues et al., 2009; La Mantia et al., 2019).

Studies on chronosequence seed rain indicate that the age of the forest directly influences the diversity of seed species, especially when it comes to areas whose predominant dispersion is biotic (Ingle, 2003; Teegalapalli et al., 2010). Piotto et al. (2019) when assessing the spatial and seasonal variation of chronosequence seed rain in the Atlantic Forest, they reported that more than the proximity to an area of mature forest, the age of the secondary forest influences the diversity of seed rain and consequently on regeneration natural area. Liebsch et al. (2008) evaluated floristic and ecological changes in plant communities after disturbances in the tropical forests and observed that the disturbance time is another factor that affects the distribution and diversity of species, however, over time the forests tend to become gradually recover. In addition, the arrival of seeds through dispersion is also influenced by the local plant community that acts as a filter for dispersers according to the resources offered, such as food and shelter (Kirk, 2018).

In this study, we evaluated multiple factors of variation in seed rain during the restoration of the Atlantic Forest in southeastern Brazil. Although the behavior of seed rain in forest environments in the Neotropics has been reported in the literature (Richards, 1998; Barbosa & Pizo, 2006; Li et al., 2012; Toscan, 2014; Horacková et al., 2019), we are not aware of studies that sought to evaluate changes in seed rain in an Atlantic Forest restoration chronosequence, nor the effect of factors abiotics linked to soil and canopy cover (but see Piotto et al., 2019 for seed rain in the chronosequence of secondary forests in tropical rainforests). Here, we evaluate the monthly deposition of seeds in three forest fragments with different restoration times after using the area as pasture and mature forest reference area, with no record of disturbance in the last 40 years. We try to evaluate, after the end of grazing activities, the time for the density, richness and functional characteristics of the rain species of the seeds to be similar to a mature forest. Our hypothesis is that the density and species richness of the seed rain increase with the time of restoration, as well as a greater similarity in the composition of the species of seed rain between the areas with longer restoration time and the area of mature forest. In addition, we evaluated the effects of light and soil on the density and richness of species present in the seed rain over a chronosequence.

Material and Methods

Study Site

The study was conducted at Instituto Terra (www.institutoterra.org), Aimorés, state of Minas Gerais, Southeast Brazil (19° 53 ' S, 41° 09 ' W, Figure 1). Instituto Terra has an extension of 710ha, the predominant soil in the region is classified as argisoil (Amaral et al., 2004), under seasonal Semideciduous Forest type vegetation (Veloso et al., 1991), characterized by vegetation that loses part of its leaves during the dry season, between April and September, with an average rainfall of 53mm. The average annual temperature is 28º C and an average rainfall of 953 mm (Silva et al., 2016).

Previously, a significant part of the area was pasture for cattle raising, but in 1999, the forest restoration process of the property began. Since then, the property has not been used for agricultural and pasture purposes. Annually, different portions of the property are selected and prepared for planting native species from the Atlantic Forest. The preparation of the area for planting consists of manual cutting around the well and fertilization of open wells with 200 grams of simple superphosphate. Twelve months after planting, the soil is fertilized with 100 grams of NPK 20-5-20 per plant, and ant management and manual weeding are carried out around each plant. Spacing of 2x2m is used for planting native species of the Atlantic Forest and after three years of planting there is an enrichment of the area with replanting of native species in the first planting lines.

We used a restoration chronosequence as a study system, considering three areas at different ages of restoration divided according to the age of planting, being a 'recent' area, an area under restoration for 5 years; 'intermediate' area, area under restoration for 10 years; 'old' area, area under restoration for 20 years, and a reference area, taken as control, which has been in natural regeneration for over 40 years without anthropogenic disturbances. These locations are relatively close, with a maximum distance of 5.3 km between them and had the same forest restoration area (Figure 1).

Figure 1. Location of the study areas, being: 1. The area has been under restoration for 20 years; 2. Restoration area for 10 years; 3. Restoration area for 5 years; and 4. Reference area.

Seed Rain

Ten seed collectors were systematically distributed in each study area. In order to obtain better representation of the area, were installed five permanent plots with dimensions of 20x20m, subdivided into two subplots, with a fixed collector in the center of each subplot, with the purpose of distributing collectors in a systematic way sampling homogeneous throughout the area. The collectors presented structure composed of plastic tubes, nylon grille in 2mm mesh, with dimensions of 0,75x 0,75m and 1 m of soil height. The material was collected monthly between January to December 2018. The field procedure consisted of manual extraction of the material and their deposition in plastic bags which were sent to the seed laboratory, located at Instituto Terra. In the laboratory the material was quantified and identified.

After identification, the seeds were classified according to the dispersion syndrome, biotic and / or abiotic. Zoochoric and epizoochoric species were classified as biotic dispersion, and the anemochoric and autochoric, abiotic. Only primary dispersion syndromes were considered. The species were also classified according to their ecological group and life form, following Swaine & Whitmore (1988), as pioneer or climax species and non-pioneer species, according to their germination speed, and woody, herbaceous or grass.

The evaluation of the seed rain was carried out in 12 months continuously. During the sampling period, the average temperature varied between 27.5 and 21.8 °C (maximum and minimum value). The precipitation peak was in February month (218.6 mm), with August being the month with the lowest precipitation (4.6 mm) (Supplementary Figure 1).

Canopy Cover and Soil Sampling

The canopy cover (leaf area index –LAI) at each point were each seed collector were installed was estimated from hemispheric photos taken with a Nikon Coolpix 5400 digital camera positioned on a tripod, coupled with a hemispherical fisheye-converted FC-59 lens, facing the canopy, 1.5 m above the ground, levelled, and aligned to the north. Photos were taken in each area in January and July 2018, in early morning or late afternoon. These photos were analyzed to estimate the leaf area index (LAI) using Gap Light Analyzer (GLA) software, version 2.0 (Frazer et al., 1999).

The soil sampling was carried out at a depth of 0 - 20 cm, in a total of twenty-five samples per area. The soil chemical and textural analyses followed the protocols described by Embrapa (1997). The variables analyzed were: phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), aluminun (Al), and sodium (Na), pH, organic matter, and sand, silt, and clay contents.

Statistical Analyses

We used generalized linear mixed effects models to test the effects of the of restoration time and months on monthly seed rain density and diversity. This same analysis was also performed using the monthly seed rain density separated by ecological groups. In all models, restoration time class and months were treated as a categorical variable where each site and month was a level, as there was no a priori expectation that temporal changes in any response variable would be linear. The parcels within the restored fragments were initially included in all models as a random intercept. Within each forest restoration area, we evaluated the correlation between seed rain and species richness with monthly precipitation through Spearman's.

To assess the composition of the species deposited in the seed rain in each area we performed non-metric multidimensional scaling (NMDS) using two dimensions. Differences in species composition were analysed using the Permutational Multivariate Analysis of Variance Using Distance Matrices (Adonis) with the Bray-Curtis similarity index as a distance measure with 1000 permutations. These analyzes were performed comparing the composition among the areas with different ages of restoration.

The soil variables and LAI of the locations were then compared using generalized linear models (GLMs), with Gaussian error distribution (Crawley, 2000). We performed multiple regression analyses by GLM to investigate possible associations between density and richnessof the deposited species seed and soil variables and the LAI between sites. In this case, density and richness were used as response variables, while the LAI and soil characteristics were used as the explanatory variable. This same analysis was also performed using the monthly seed rain density separated by ecological groups. Using Spearman's rank correlation coefficient (r<0.6), collinearity was evaluated separately between the soil predictor variables (Supplementary Table 2). Thus, variables correlated were not used together in any of the elaborated models. To determine the most explicative variables the in model, we used an approach based on the second-order Akaike Information Criterion (AIC), where the best model is indicated by the smallest AIC value (Burnham et al., 2011; Niinemets, 2015; Souza et al., 2018). These analyses were performed using functions implemented in the 'AICcmodavg' and ‘psych’ packages.

Results

The seed rain throughout this study included 8096 seeds, distributed in 3872 seeds deposited in the restoration area of 5 years, 2626 seeds in the restoration area of 10 years, 957 seeds in the restoration of 20 years and 641 seeds in the reference forest area. The seed rain had 28 species and eight families (Table 2). Fabaceae was a family with the largest number of species found in the seed rain in all areas of this study (43%), while 21% of the registered seed species are grasses (Poaceae), occurring mainly in areas in recent restoration and intermediate (for 5 and 10 years in restoration). Throughout the analysis, only *Peltophorum dubium* (Spreng.) Taub. (Fabaceae) occurred in all areas. Of the seeds registered, 77% presented abiotic dispersion (anemochory or autochory) as the predominant primary dispersion syndrome. The number of species with abiotic dispersion syndrome was greater than the biotic dispersion in all analyzed sites (Table 2).

Table 2. List of species found in the seed rain in the study areas of Instituto Terra, Aimorés, MG, accompanied by the dispersion type and ecological group, with P = pioneers; NP = non- pioneer.

Family	Species	Dispersion	Ecological Group	Time of restoration			
				5 years	10 years	20 years	Reference
Anacardiaceae	*Myracrodruon urundeuva* Allemão	Abiotic	NP	X	X		
Bignoniaceae	*Inga vera* Willd.	Biotic	P	X		X	X
Bignoniaceae	*Zeyheria tuberculosa* (Vell.) Bureau ex Verl.	Abiotic	NP			X	X
Euphorbiaceae	*Croton floribundus* Spreng.	Abiotic	P				X
Euphorbiaceae	Sp. 16	-	-		X	X	
Fabaceae	*Dalbergia nigra* (Vell.) Allemão ex Benth.	Abiotic	P				X
Fabaceae	*Lonchocarpus sericeus* (Poir.) Kunth ex DC.	Abiotic	NP	X			
Fabaceae	*Machaerium fulvovenosum* H.C.Lima	Abiotic	NP				X
Fabaceae	*Machaerium hirtum* (Vell.) Stellfeld	Abiotic	P				X
Fabaceae	*Mimosa pudica* L.	Abiotic	NP	X	X	X	
Fabaceae	Sp. 14	-	-	X	X		
Fabaceae	Sp. 19	-	-			X	X
Fabaceae	Sp. 20	-	-		X		X
Fabaceae	*Myrocarpus frondosus* Allemão	Abiotic	NP	X	X		
Fabaceae	*Peltophorum dubium (Spreng.)* Taub.	Abiotic	P	X	X	X	X
Fabaceae	*Phyllocarpus riedelii* Tul.	-			X	X	X
Fabaceae	*Pterogyne nitens* Tul.	Abiotic	NP		X		X
Malpighiaceae	Morfo 26	-	-	X			
Poaceae	*Andropogon bicorni*s L.	Abiotic	Grass	X	X		X
Poaceae	*Cenchrus echinatus* L.	Biotic	Grass	X			X
Poaceae	*Paspalum maritimum* Trin.	Biotic / Abiotic	Grass	X	X		
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	Abiotic	Grass		X	X	X
Poaceae	*Setaria* sp.	Abiotic	Grass	X	X	X	
Poaceae	*Urochloa brizantha* (Hochst. ex A. Rich.) Stapf	Biotic	Grass	X	X		
Sapindaceae	*Cupania oblongifolia* Mart.	Biotic	P				X
Sapindaceae	*Serjania salzmanniana* Schltdl.	Abiotic					X
Trigoniaceae	*Trigonia* sp	Abiotic	NP	X	X		X
-	Sp. 35	-	-				X

When analyzing the composition of the species present in the seed rain, we observed that the composition varied between the study areas (Adonis, $F_{(3,44)} = 7.17$, P

<0.001). The NMDS ranking (Figure 2) showed a strong overlap in the composition of species present in the seed rain between the most recent forest restoration areas (5 and 10 years of restoration), which when compared pairwise did not differ statistically (Adonis, $F_{(3,44)} = 1.01$, $P = 0.42$). All other areas were statistically different (Adonis, $F_{(3,44)} = 7.17$, $P < 0.001$), despite overlap in the composition of species present in the seed rain between the reference area and the areas with 5, 10 and 20 years of forest restoration (Figure 2).

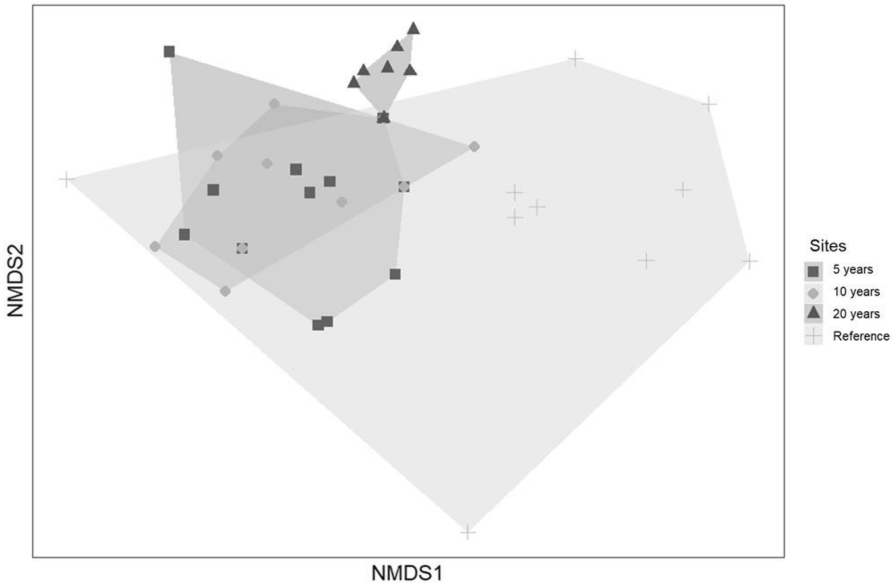


Figure 2. Non Metric Multidimensional Scaling (NMDS) with Bray-Curtis dissimilarity index for the composition of species present in the seed rain along the chonosequence of restoration of this study.

The density of seed rain (diaspores m^{-2} $months^{-1}$) varied significantly between the study areas ($F_{(3,236)} = 5.18$ $P < 0.001$; Figure 3A). Higher seed density was observed in areas with 5 and 10 years of restoration, which were statistically similar to each other (Figure 3A). About six times more seeds were deposited in the most recent areas of forest restoration (5 and 10 years of restoration), when compared than areas 20 years of restoration and reference. Areas with 20 years of restoration and reference did not show differences in seed density (Figure 3A). Species richness did not vary between areas ($F_{(3,236)}$ = 0.89 P> 0.05; Figure 3B).

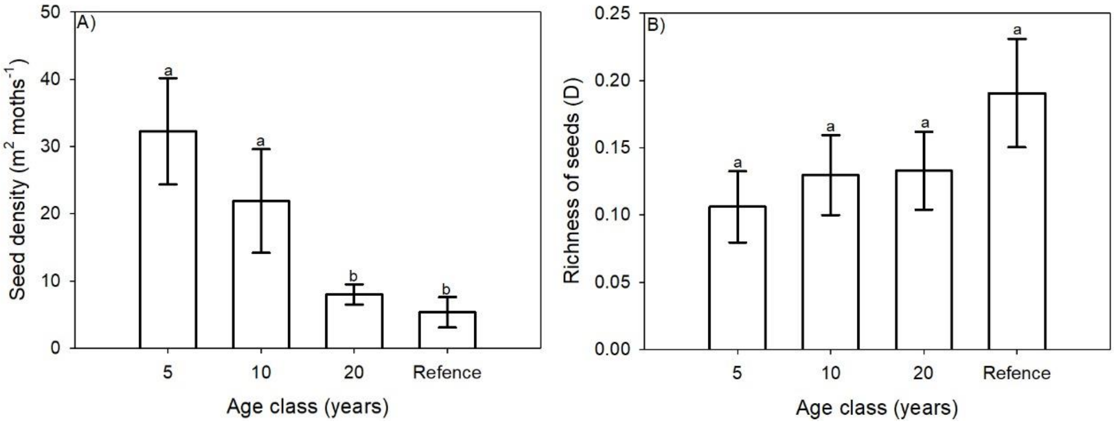


Figure 3. Assessment of month mean of seed density (A) and richness according to the Margalef Index - D (B) of species of seed rain over the chronosequence of restoration of this study. * Averages followed by the same letter do not differ between areas.

Differences in seed deposition were observed over the months ($F_{(11,228)}$= 2.59 P <0.001; Figure 3). The peak seed density varied over the restoration chronosequence of this study. Young areas showed peak seed density in the rainy season, while the old area and reference, the peak occurred in the dry season. The reference area showed a negative correlation with precipitation (r = -0.25; P <0.05, Supplementary Table 1), showing a greater deposition of seeds in the dry season (Figure 3D). In turn, the most recent forest restoration areas (5 and 10 years of restoration) showed a positive correlation with precipitation (r = 0.26; P <0.05 and r = 32; P <0.05, respectively for the 5 and 10 years of restoration, Supplementary Table 1), showing a greater deposition of seeds in the wet season (Figure 3A and B). Despite the variation over the months, the area with 20 years of restoration did not correlate with precipitation (r = -0.08; P> 0.05, Figure 3C). Species richness of seed rain also varied between months ($F_{(11,228)}$= 2.59; P <0.001), however within the areas there were no correlations with precipitation (Supplementary Table 1), except for the reference area, in which it was observed a negative correlation (r = -0.43; P <0.05).

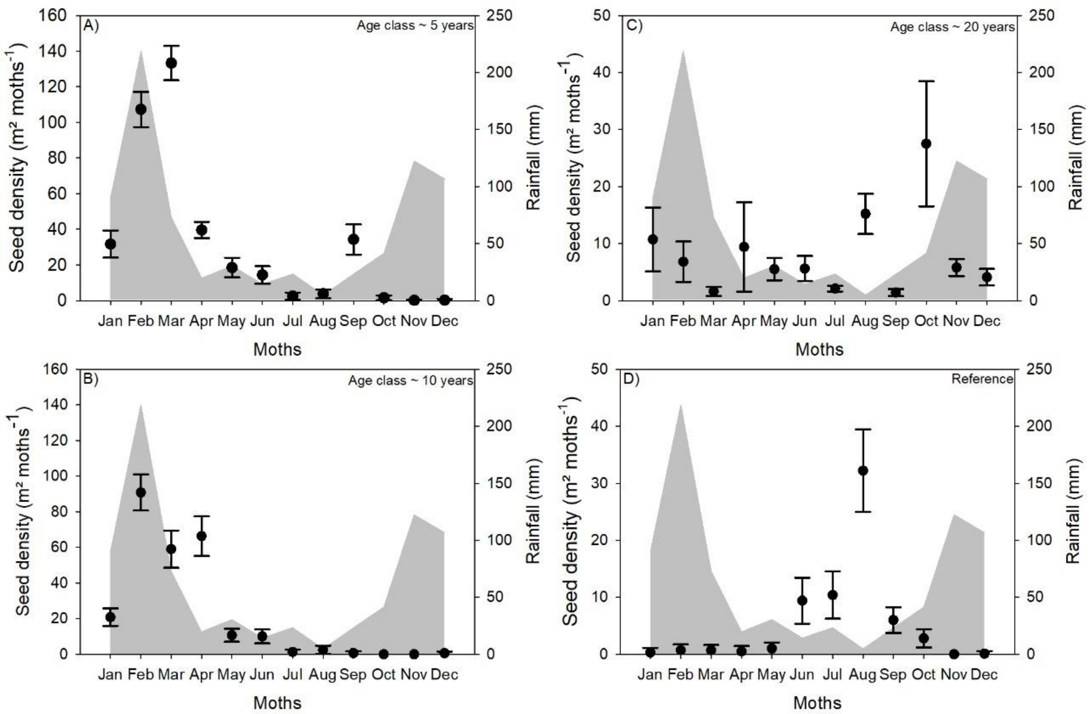


Figure 3. Absolute density of seed rain (●) over the months in the areas analyzed in this study.

The area under restoration for 20 years was the area where there was a smaller number of grasses (2) and, as similar with the reference area, there was no occurrence of *Urochloa brizantha* seeds. There was a greater deposition of grasses in the young areas under restoration, more than 30% of the total composition, but the woody species did not stand out, while in the area under restoration for 20 years and reference the amount of grasses was much lower when compared to the number of woody ones, being less than 20% of the total species composition. The deposition of seeds by ecological groups was statistically different (Figure 4). Areas with 5 and 10 years of forest restoration showed grass deposition (Figure 4A and B). In these areas the deposition of grass seeds corresponded to about 90% of the total seeds. An inverse pattern was observed in areas with 20 years of forest restoration and reference with greater deposition of pioneer and non-pioneer seeds (Figures 4C and D), about 95% of the total seeds.

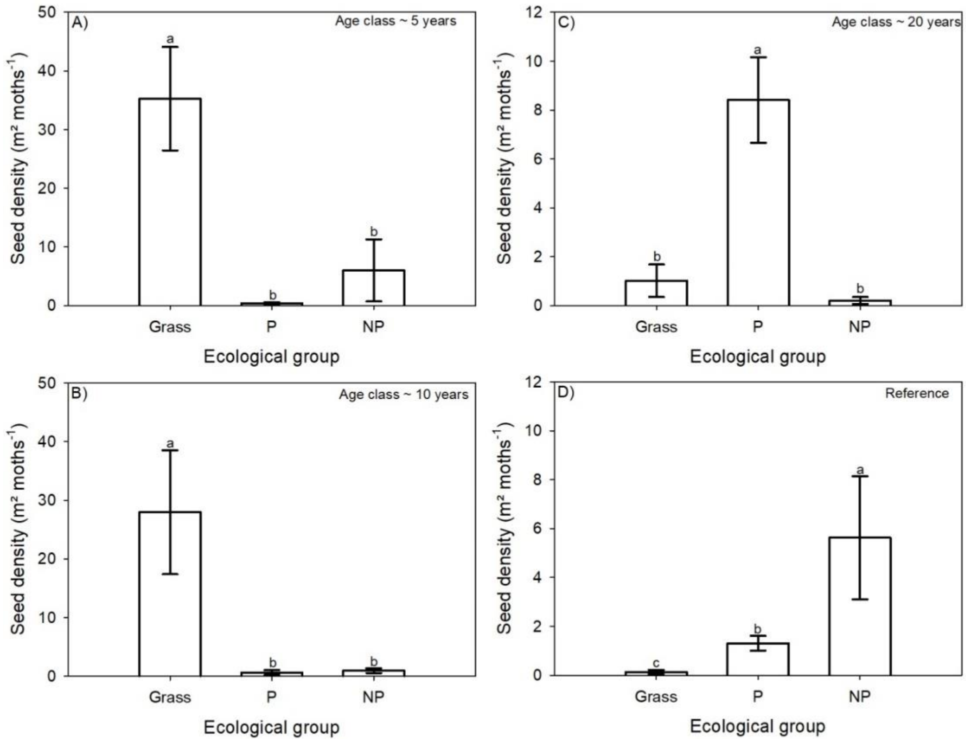


Figure 4: Comparison between the density of seeds and ecological groups along the chronosequence of its restoration, being: Grass = herbaceous and grass species; NP = not pioneer; P = pioneers. (a) area under restoration for 5 years; (b) area under restoration for 10 years; (c) area under restoration for 20 years; (d) reference area. * Averages followed by the same letter do not differ among ecological groups (assessment between ecological groups).

The characteristics of the soil and LAI varied between areas (Supplementary Table 2). The young areas under restoration presented a variation canopy according to the seasons.As expected, the reference area showed higher LAI values in the rainy and dry seasons. An area under restoration for 20 years, the canopy in the rainy season showed LAI values similar to the values in the reference area. In the dry season, all areas studied showed a drastic reduction in LAI.

Multiple regression analyzes indicated the leaf area index (LAI) in the rainy season as the variable that best explained the general seed density and by ecological group (Figure 5). The density of seeds including all ecological grups was negativelly associated with the LAI of the rainy season. This result was also found in relation to seeds of grass species but, a positive association was observed between density of seeds of pioner species and LAI. Multiple regression analyzes indicated that the leaf area index (LAI) in the rainy season, soil pH and organic matter are the variables that best explain the general seed density and by ecological group (Figure 5). The LAI of the rainy season negatively affected the density of total seeds and grasses (Figure 5A and C), while the relationship between soil pH and these variables was positive (Figure 5B and D). In turn, the LAI of the rainy season positively affected the density of pioneer seeds, whereas the organic matter in the soil negatively affected the density of pioneer seeds (Figure 5E and F).

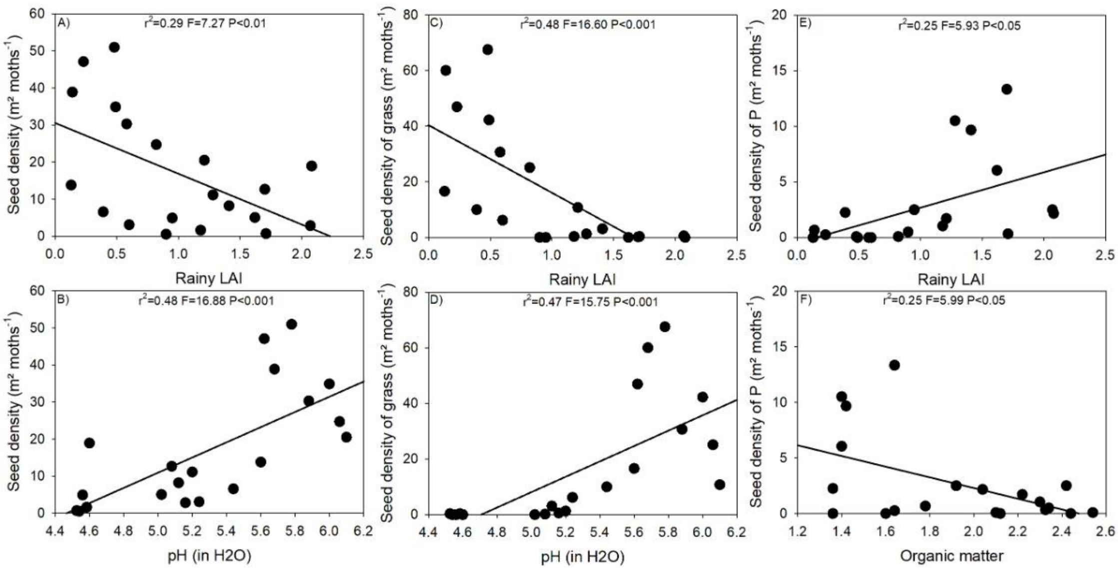


Figure 5. Results of the multiple regression analysis with variables that best explain the seed density by ecological group.

Discussion

According to our results, differences in species composition and density of seed rain were observed between areas previously used as pasture with different forest restoration times. There were no differences in the composition of the species of seed rain in the first 10 years of restoration. In areas under restoration for 5 and 10 years, there is an higher seed density of herbaceous species with a prevalence of the Poaceae family in the seed rain, with emphasis on the species *Andropogon bicornis* L., *Paspalum maritimum* Trin., *Setaria* sp., and *Urochloa brizantha* (Hochst. Ex A. Rich.) Stapf shared between the two areas. Fabaceae was the family with the largest number of species found in the seed rain in all the analyzed sites, this result is in line with several studies (see Leitão-Filho, 1987; Oliveira-Filho & Fontes, 2000; Oliveira-Filho et al., 2005) that describe the occurrence of this family as one of the richest in species in the Seasonal Semideciduous Forests under the Atlantic Forest domain in the south, southeast and midwest regions of Brazil. In all areas of this study, the presence of seeds of woody species was observed, both pioneers and advanced stages of succession, a condition that favors the process of forest regeneration in pasture areas, Chazdon (2014).

Peltophorum dubium (Spreng.) Taub. (Fabaceae), was the only seed species registered in all areas studied. This species is characterized by wide natural occurrence, belonging to the successional group of non-pioneer species (Durigan & Nogueira, 1990), but with characteristics of pioneer species (Marchiori, 1997), a fact that explains its occurrence throughout the entire chronossequence of restoration here studied. Grass seeds (Poaceae) occurred in the seed rain in all areas under restoration. In the area of Semideciduous Forest (reference), the occurrence of Poaceae species such as

Andropogon bicornis L., *Cenchrus echinatus* L. and *Setaria parviflora* (Poir.) Kerguélen was verified. These species have in common their plasticity, being characterized as ruderal species, commonly found in degraded and agricultural areas, close to roads or at the edges of fragments (Lorenzi, 2002). As the reference site is surrounded by pastures, the presence of these exotic species in the composition of the seed rain is justified, emphasizing the importance of monitoring the type of species that arrives in the fragment, as conserved areas tend to present strategies that minimize the impacts of invasive species, but areas that are undergoing restoration still show weakened resilience. Horacková et al. (2019) analyzed the seed bank in the soil in chronosequence and observed the presence of exotic / undesirable species in the seed bank regardless of the successional stage and restoration strategy, however, the similarity between the bank composition seeds and vegetation above the ground decreased throughout the succession, as the seeds of undesirable species may even arrive in the area, but are unable to establish themselves.

According to our hypothesis, greater density and richness in seed rain is to be expected in older restoration areas (greater canopy coverage) compared with recent areas (Piotto et al., 2019). However, in general, our results indicate greater seed deposition in the most recent forest restoration areas. Charles et al. (2016) worked on seed rain in abandoned tropical pastures and obtained results similar to this study, low values of forest species richness and higher density of grass seeds, although our work does not indicate differences in species richness between the studied areas. The increase in successional age can affect the taxonomic and functional composition of the species present in the seed rain, bringing these natural regeneration areas closer to the mature forest with time by reducing the density of grass seeds and increasing the presence of tree species, similar to the composition of mature forests (Nunez et al., 2019). In the chronosequence analyzed in this study, the areas in young restoration (5 and 10 years in restoration), showed greater deposition of seeds because, they are old pastures that are still dominated by exotic grasses, which have a high competitive capacity for available resources, rapid reproductive cycle and high seed production (D'antonio & Vitousek, 1992; Mack et al., 2000).

The significant occurrence of grasses justifies the high density of seeds in these areas. Charles et al. (2019) highlighted the role of landscape scale in the dispersion of seeds in isolated pastures, concluded that the plant composition around the area, directly influences the arrival of allochthonous seeds. The areas analyzed in this study were surrounded by pastures, including the fragment of Semideciduous Forest. However, as seen, there was no occurrence of *U. brizantha* seeds in the areas of advanced succession. The proximity of areas under restoration to conserved fragments does not always limit the arrival of seeds when the area presents adequate conditions for the installation of fauna, such as the presence of perches for fields and availability of attractive fruits in the forest remnants (La Mantia et al. 2019).

Therefore, limiting the arrival of native tree seeds in old pastures may be associated with the lack of available dispersers even in areas with ideal conditions for the installation of fauna. Boissier et al. (2020) stated that there is a limitation in the removal of seeds from the fragments due to the absence of these dispersers, according to the authors, anthropogenic actions such as hunting and logging influenced the ecosystem in such a way that, these are currently not available, compromising the diversity of tropical forests over time. In the present study, although the number of non-pioneer species has equaled that of grasses (seven and six species) in the restoration sites, the composition of the seed rain indicated a successional advance by reducing the density of grass seeds in the areas under old restoration (20 years in restoration) and area reference when compared to areas under youth restoration (5 and 10 years under restoration). Relevant evidence of successional advance was the non-occurrence of seeds of *Urochloa brizantha*, a recognized grass with a high invasive capacity (Meli & Dirzo, 2013; Kato-Noguchi et al., 2014), in the collectors both in the reference area and in the oldest area in restoration of this study.

The canopy cover (LAI) and soil characteristics affected the density of the seed rain, but the effects of these variables were different when assessing the seed density by ecological group. In general, areas with lower LAI values in the rainy season and with soil pH between 5.6 and 6, showed higher seed density determined maily by grasses seeds. Grasses represent 22% of all seeds sampled in this study. In more open canopy sites the understory light availability is a relevant filter in the selection of species that colonize a plant community (Liebsch et al., 2008; McClain et al., 2011; Suganuma & Durigan, 2014). The grasses have high seed production, their occurrence and biomass accumulation are closely related to the demand for light, therefore, areas of predominantly open canopy are favorable to the establishment of these species (Dias-Filho, 2000; Meli & Dirzo 2013). The greatest deposition of grass seeds occurred at the end of the rainy season (April), a period of fruiting and dispersion of the seeds as they remain retained in the inflorescences for a short period of time and their germination can occur in the soil surface, withstanding periods of drought and with the return of rains, has high growth capacity (Seiffert 1980). In addition, there are reports that liming and soil fertilization significantly increase the production of pasture biomass, contributing to their establishment and life cycle of these species, as observed in the most recent forest restoration areas (Paulino et al., 1994; Oliveira et al., 2003).

As for forest species, there was a tendency for the negative effect of soil organic matter on the seed density of pioneer species. The increase in organic matter in the soil increases the total negative charges and, consequently, increases the cation exchange capacity and, therefore, favors the nutritional status of the soil. There are studies showing higher levels of organic matter in soils in forests in a more advanced stage of succession, especially for Seasonal Semideciduous Forest, as in the case of this study, in which even in the early stages of succession, they have great potential in storing and stabilizing organic carbon in the ground (Machado et al., 2019).

For sites with a history of disturbance or degradation, Alba-García (2011) pointed out that, after three exclusions of anthropogenic disorders, it is possible to observe the development of the understory community, with greater recruitment of forest species, similar to reference sites. It is also predictable that, over a minimum of three years, seed rain will increase from the expansion of woody vegetation colonization (Martínez-Garza et al., 2011) and that the wealth of seed rain in subsequent succession areas (greater tree cover) is greater compared to early successional areas (Piotto et al., 2019). In an analysis of a a chronosequence of restoration (of 5, 9 and 10 years), Souza & Batista (2004) found that the arrival of seeds was insignificant, as seen in the present study in which the wealth remained predominantly low, the authors suggested that the absence of seeds would be associated with limiting the colonization of fauna in the restoration sites. However, with the increase in canopy coverage, resources attractive to fauna such as forage, perches and food are available, so the increases in leaf area index tends to gradually contribute to the seed rain as the succession process progresses (Holmes, 2020).

Conclusion

In conclusion, the results indicate that in a 20-year interval it is possible to observe successional progress through the seed rain in areas of Atlantic forest under restoration. As it is an old pasture, we observed the successional advance by reducing the presence of grasses (with the absence of *U. brizantha* seeds) and an increase in pioneer and non-pioneer species in the area under restoration and old reference, even though they are surrounded by pasture. However, considering old pastures areas, it takes more than 20 years to reestablish the full ecological functions of the seed rain. The low canopy cover (low LAI values) favors the production of exotic grass seeds in areas previously used as pasture, which can delay the forest restoration process. In addition, we do not indicate that they use only the seed density as an indicator of successional progress, especially in old pastures areas and that still suffer from the presence of grasses, we suggest in these cases the evaluation of seed rain considering the ecological groups of the species present in the seed rain.

References

Alba-García, L. (2011). Reclutamiento de especies leñosas en la selva seca de Sierra de Huautla, Morelos, Mexico. Bachelor´s degree. Biological Sciences. Universidad Autónoma del Estado de Morelos, Cuernavaca, Mexico, pp. 100.

Altman, J., Fibich, P., Leps, J., Uemurac, S., Hara T., Dolezal, J. (2016). Linking spatiotemporal disturbance history with tree regeneration and diversity in na old-growth forest in northern Japan. Perspectives in Plant Ecology, Evolution and Systematics, 21, 1-13. doi: 10.1016/j.ppees.2016.04.003.

Amaral, F. C. S. do., Santos, H. G dos., Agilo, M. L. D., Duarte, M. N., Pereira, N. R., Oliveira, R. P de., Carvalho, Jr. W. de. (2004). Mapeamento de solos e aptidão agrícola das terras do Estado de Minas Gerais (ed.). Rio de Janeiro, RJ: Embrapa Solos.

APG IV. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society, 181, 1–20. doi: 10.1111/boj.12385.

Araujo, M. M., Longhi, S. J., Barros, P. L. C., Brena, d. A. (2004). Caracterização da chuva de sementes, banco de sementes do solo e banco de plântulas em Floreta Estacional Decidual ripária Cachoeira do Sul, RS, Brasil, 66, 128-141.

Bellotto, A., Viani, R.A.G., Neves, A.G., Gandolfi, S., Rodrigues, R.R. (2009). Monitoramento das áreas restauradas como ferramenta para avaliação da efetividade das ações de restauração e para redefinição metodológica. p. 128-146. In: Rodrigues, R.R., Brancalion, P.H.S., & Isernhagen, I. (eds). Pacto pela restauração da mata atlântica:

referencial dos conceitos e ações de restauração florestal (ed.). São Paulo, SP: Instituto Bioatlântica.

Blackham, G. V., Thomas, A., Webb, E. L., Corlett, R. T. (2013). Seed rain into a degraded tropical peatland in Central Kalimantan, Indonesia. Biological Conservation,167, 215-223.

Boissier, O., Feer, F., Henry, P., Forget, P. (2020). Modifications of the rainforest frugivore community are associated with reduced seed removal at the community level. Ecological Applications. doi:10.1002/eap.2086

Brancalion, P. H. S., Isernhagen, I., Gandolfi, S., Rodrigues, R. R. Plantio de Árvores Nativas Brasileiras Fundamentada na Sucessão Florestal. In: BUISSON, E., DUTOIT, T., TORRE, F., ROMERNANN, C., POSCHLOD, P. The implications of seed rain and seed bank patterns for plant sucecssion at the edges of abandoned fields in Mediterranean landscapes. Agriculture, Ecosystems and Eviroment, 115, 6-14. 2009.

Buisson, E., Dutoit, T., Torre, F., Römermann, C., Poschlod, P. (2006). The implications of seed rain and seed bank patterns for plant succession at the edges of abandoned fields in Mediterranean landscapes. Agriculture, Ecosystems & Environment, 115, 6–14. doi:10.1016/j.agee.2005.12.003

Burnham, K. P., Anderson, D. R., & Huyvaert, K. P. (2011). Erratum to: AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology, 65, 415–415. doi:10.1007/s00265-010-1084-z.

Charles, L. S., Dwyer, J. M., Mayfield, M. M. (2016). Rainforest seed rain into abandoned tropical Australian pasture is dependent on adjacent rainforest structure and extent. Austral Ecology, 42, 238–249. doi:10.1111/aec.12426

Charles, L. S., Dwyer, J. M., Chapman, H. M., Yadok, B. G., & Mayfield, M. M. (2019). Landscape structure mediates zoochorous-dispersed seed rain under isolated pasture trees across distinct tropical regions. Landscape Ecology, 34, 1347–1362. doi:10.1007/s10980-019-00846-3.

Chazdon, R. L. (2014). Second Growth: The Promise of Tropical Forest Regeneration in an Age of Deforestation. Chicago, IL: University of Chicago Press. doi: 10.7208/Chicago/9780226118109.001.0001

Crawley, M. J. (2000). Statistical Computing: An Introduction to Data Analysis Using S-Plus. Gebundenes Buch. 772pp.

D'Antonio, C.M., & Vitousek, P.M. (1992). Biological invasions by exotic grasses, the grass/fire cycle, and blobal change. Annual Review of Ecology and Systematics, 23, 63-87. doi: 10.1146/annurev.ecolsys.23.1.63.

Dias-Filho, M. (2000). Growth and biomass allocation of the C4 grasses *Brachiaria brizantha* and *B. humidicola* under shade. Pesquisa Agropecuária Brasileira, 35, 2335-2341. doi: 10.1590/s0100-204x2000001200003.

Durigan, G., Nogueira, J. C. B. (1990) Recomposição de matas ciliares. São Paulo: Instituto Florestal, 14 p. (IF. Série Registros, 4).

Frazer, G.W., Canham, C.D., Lertzman, K.P. (1999). Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, user manual and program documentation. Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.

Hansen, M.C., Potapov, P.V., Moore, R. (2013). High-resolution global maps of 21st-century forest cover change. Science, 342, 850–853. doi:10.1126/science.1244693.

Holmes, M. A. (2020) Pasture trees contribute to structural heterogeneity and plant distributions in post-agricultural forests decades after canopy closure. Journal of Vegetation Science, IF 2.944 doi: 10.1111/jvs.12873

Horacková, M., Rehounková, K., Prach, K. (2019). Relationships between vegetation and seed bank in sand pits: effects of different restoration approaches and successional age. Applied Vegetation Science. doi:10.1111/avsc.12426

Howe, H.F., Smallwood, J. (1982) Ecology of seed dispersal. Annual Review of Ecology and Systematics, 390, 201–228.

Ingle, N.R. (2003). Seed dispersal by wind, birds, and bats between Philippine montane rainforest and sucessional vegetation. Oecologia, 134, 251–61. https://doi.org/10.1007/s00442-002-1081-7PMID: 12647166

Kato-Noguchia, H., Kobayashia, A., Ohnob, O., Kimuraa, F., & Fujii Y. (2014). Physiology Phytotoxic substances with allelopathic activity may be central to the strong invasive potential of *Brachiaria brizantha*. Journal of Plant Physiology, 171, 525–530. doi: 10.1016/j.jplph.2013.11.010.

La Mantia, T., Rühl, J., Massa, B., Pipitone, S., Lo Verde, G., Bueno, R. S. (2019). Vertebrate-mediated seed rain and artificial perches contribute to overcome seed dispersal limitation in a Mediterranean old field. Restoration Ecology, 27, 1393–1400. doi:10.1111/rec.13009

Li, B. Hao, Z.; Bin, Y.; Zhang, J.; Wang, M. (2012). Seed rain dynamics reveals strong dispersal limitation, different reproductive strategies and responses to climate in a temperate forest in northeast China. Journal of Vegetation Science, 23, 271–279.

Liebsch, D., Marques, M. C. C., Goldenberg, R. (2008). How long does the Atlantic Rain Forest take to recover after a disturbance? Changes in species composition and ecological features during secondary succession. Biological Conservation 141:1717–1725.

List of Species of Flora of Brazil. Jardim Botânico do Rio de Janeiro. (2018, January 20). Retrieved from http://floradobrasil.jbrj.gov.br.

Lorenzi, H. (2002). Plantas daninhas do Brasil: terrestres, aquáticas, parasitas e tóxicas. Nova Odessa: Instituto Plantarum, 425p.

Leitão-Filho, H. F. (1987). Considerações sobre a florística de florestas tropicais e sub-tropicais do Brasil. Revista do Instituto de Pesquisas Florestais-IPEF. 35, 41-46.

Machado, D. L., Pereira, M. G., Santos, L. L. dos, Diniz, A. R., & Guareschi, R. F. (2019). Organic matter and soil fertility in different successional stages of Seasonal Semidecidual Forest. Revista Caatinga, 32, 179–188. doi:10.1590/1983-21252019v32n118rc .

Mack, R. N., Simberloff, D., Lonsdale, W. M., Evans, H., Clout, M., Bazzaz, F.A. (2000). Technical report biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, 10, 689-710. doi: 10.2307/2641039.

Marchiori, J. N. C. (1997). Dendrologia das angiospermas: leguminosas. Santa Maria: Ed. da Universidade Federal de Santa Maria. 200p.

Martínez-Garza, C., Osorio-Beristain, M., Valenzuela-Galván, D., Nicolás-Medina, A. (2011). Intra and inter-annual variation in seed rain in a secondary dry tropical forest excluded from chronic disturbance. Forest Ecology and Management, 262, 2207–2218.

Maza-Villalobos, S., Balvanera, P., Martínez-Ramos, M. (2011). Early Regeneration of Tropical Dry Forest from Abandoned Pastures: Contrasting Chronosequence and Dynamic Approaches. Biotropica, 43, 666–675. doi:10.1111/j.1744-7429.2011.00755.x

McClain, C. D., Holl, K. D., Wood, D. M. (2011) Successional models as guides for restoration of riparian forest understory. Restoration Ecology, 19,280–289.

Meli, P., Dirzo, R. (2012). Effects of grasses on sapling establishment and the role of transplanted saplings on the light environment of pastures: implications for tropical forest restoration. Applied Vegetation Science, 16, 296-304.

Mittermeier, R. A., Gil, P. R., Hoffmann, M., Pilgrim, J., Brooks, J., Miitermeier, C. G., Lamourux, J., Fonseca, G. A. B. (2004). Hotspots revisited: earth’s biologically richest and most endangered terrestrial ecoregions. Washington, DC, USA: Cermex.

Niinemets, Ü., Keenan, T. F., Hallik, L. (2015). A worldwide analysis of within-canopy variations in leaf structural, chemical and physiological traits across plant functional types. New Phytologist, 205, 973–993. doi:10.1111/nph.13096.

Nunez, N. H., Chazdon, R. L., Russo, S. E. (2019). Determinism and stochasticity in seed dispersal-successional feedbacks, Journal of Ecology. doi: 10.1101/791988.

Oliveira-Filho, A. T., Fontes, M. A. (2000). Patterns of floristic differentiation among Atlantic Forests in southeastern Brazil and the influence of climate. Biotropica 32, 793-810.

Oliveira-Filho, A. T., Jarenkow, J. A., Rodal, M. J. N. (2005). Floristic relationships of seasonally dry forests of eastern South America base don tree species distribution patterns. p. 159-192. In: Pennington, R.F., Ratter, J.A., Lewis, G.P. (Eds.), Neotropical savannas and dry forests: Plant diversity, biogeography and conservation. CRC Press, Boca Raton.

Paulino, V. T., Costa, N. L., Lucena, M. A. C., Schammas, E. A., Ferrari Júnior, E (1994). Resposta de *Brachiaria brizantha* cv. Marandu a calagem e adubação fosfatada em um solo ácido. Pasturas Tropicales, 16, 23 - 33. doi: not available.

Pickett, S. T. A., McDonnell, M. J. (1989). Changing perspectives in community dynamics: a theory of successional forces. Trends in Ecology & Evolution, 4, 241-245.

Piotto, D., Craven, D., Montagnini, F., Ashton, M., Oliver, C., Thomas, W. W. (2019). Successional, spatial, and seasonal changes in seed rain in the Atlantic forest of southern Bahia, Brazil. Plos One, 14, 1-12. doi: e0226474. https://doi.org/10.1371/journal. pone.0226474

R Core Team. (2013). R: A Language and Environment for Statistical Computing. <https://www.R-project.org/>

Ribeiro, M. C., Metzger, J. P., Martensen, A.C., Ponzoni, F., Hirota, M. (2009). The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation, 142, 1141– 1153.

Richards, P. W. (1998). The tropical rain forest: an ecological study. Cambridge University Press. Cambridge, p. 115-116.

Rodrigues, R. R., Brancalion, P. H., Isernhagen, I (org.). Pacto pela restauração da mata atlântica: referencial dos conceitos e ações de restauração florestal. São Paulo: LERF/ESALQ: Instituto Bioatlântica, 2009. 256 pp.

Rodrigues, R. R., Gandolfi, S. (2004). Conceitos, tendências e ações para recuperação de florestas ciliares. Páginas 235-247. In: Rodrigues RR, Leitão-Filho HF. (eds.). Matas ciliares: conservação e recuperação. EDUSP, São Paulo, SP.

Santos-Silva, E. E., Almeida, W. R., Tabarelli, M., Peres, C. A. (2016) Habitat fragmentation and the future structure of tree assemblages in a fragmented Atlantic forest landscape. Plant Ecology, 217. 1129–1140.

Seiffert, N. F. (1980). Gramíneas forrageiras do gênero *Brachiaria*. Campo Grande MS: Embrapa-Centro Nacional de Pesquisa de Gado de Corte - CNPGC.

Shono, K., Cadaweng, E. A., Durst. P. B. (2007). Application of assisted natural regeneration to restore degraded tropical forestlands Restor. Ecology, 15, 620-626.

Silva, W., Ferreira, W. P. M., Soares, E., Souza, C. F. (2016). CLIMEP: Climatologia e Estudos da Paisagem, 9, 1-17.

Suganuma, M. S., Durigan, G. (2014). Indicators of restoration success in riparian tropical forests using multiple reference ecosystems. Restoration Ecology, 23, 238–251. doi:10.1111/rec.12168

Souza, F. M., Batista, J. L. F. (2004). Restoration of seasonal semideciduous forests in Brazil: influence of age and restoration design on forest structure. Forest Ecology and Management, 191, 185-200.

Souza, M. L., Duarte, A. A., Lovato, M. B., Fagundes, M., Valladares, F., Lemos-Filho, J. P. (2018). Climatic factors shaping intraspecific leaf trait variation of a Neotropical tree along a rainfall gradient. Plos One, 13, 1-20. doi: 10.1371/journal.pone.0208512.

Swaine, M. D., Whitmore, T. C. (1988). On the definition of ecological species groups in tropical rain forests. Plant Ecology, 75, 81-86. doi: 10.1007/BF00044629.

Teegalapalli, K., Hiremath, A. J., Jathanna, D. (2010). Patterns of seed rain and seedling regeneration in abandoned agricultural clearings in a seasonally dry tropical forest in India. Journal of Tropical Ecology, 26, 25–33.

Toscan, M. A. G. (2014). Análise da chuva de sementes de uma área reflorestada do corredor de biodiversidade Santa Maria, Paraná. Ambiência, 10, 217-230.

Veloso, H.P., Rangel Filho, A.L.R., Lima, J.C.A (1991). Classificação da vegetação brasileira adaptada a um sistema universal. Rio de Janeiro, RJ: Departamento de Recursos Naturais e Estudos Ambientais(IBGE).

Wolfe, B. T., Macchiavelli, R., Van Bloem, S. J. (2019). Seed rain along a gradient of degradation in Caribbean dry forest: effects of dispersal limitation on the trajectory of forest recovery. Applied Vegetation Science, 22:423–434. doi:10.1111/avsc.12444

Supplementary Material

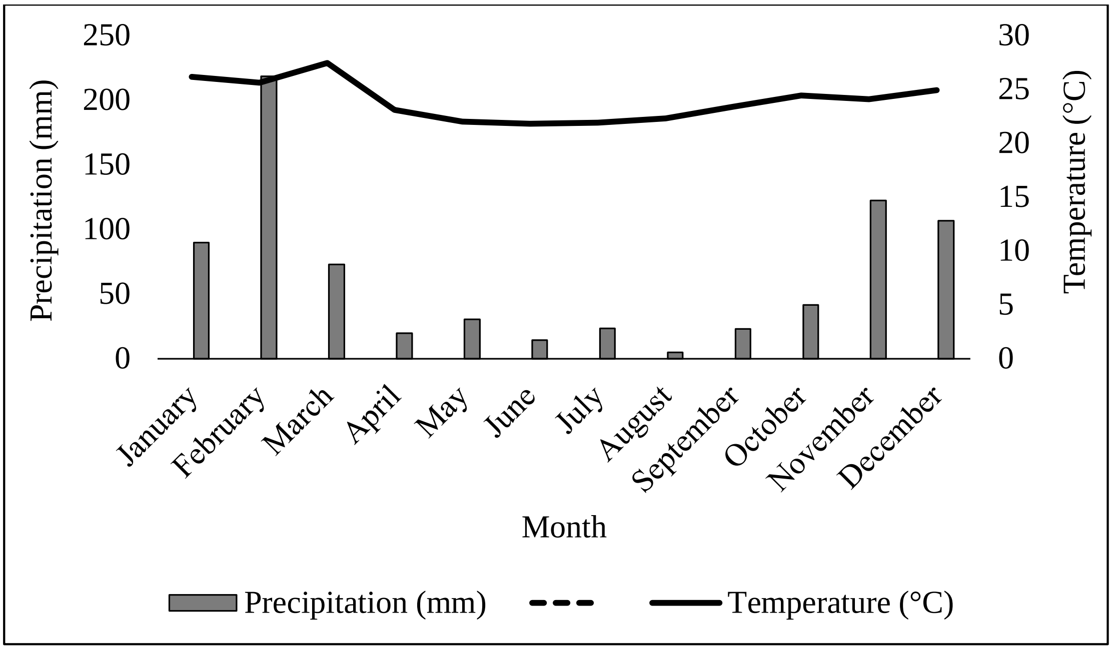


Figure 1. Precipitation (mm) and historical temperature (ºC) profile of the study period in the Seasonal Semideciduous Forest region, Aimoré, MG.

Table 1. Spearman's correlation between density and species richness of seed rain with monthly precipitation. *Significant difference at 5% probability of error.

SITES	Seed density (m² moths-1)		Richness of seeds (D)	
	Spearman	P	Spearman	P
5 years	0.32	<0.05	0.22	>0.05
10 years	-0.26	<0.05	-0.06	>0.05
20 years	0.08	<0.05	-0.03	>0.05
Reference	-0.25	<0.05	-0.43	<0.05

Table 2. Comparison between leaf area index and soil characterization variables along the restoration chronosequence of this study.

Sites	5 years	10 years	20 years	Reference
Soil				
Ph in H_2O	5.52 (0.31)b	5.96 (0.19)a	5.12 (0.17)c	4.56 (0.08)d

Al ($mmol_c.dm^{-3}$)	0.21 (0.17)c	0.00 (0.00)c	0.44 (0.14)b	1.24 (0.31)a
Ca ($mmol_c.dm^{-3}$)	1.12 (0.37)b	2.17 (0.76)a	0.74 (0.25)c	0.52 (0.12)c
Mg ($mmol_c.dm^{-3}$)	0.29 (0.11)b	0.52 (0.24)a	0.19 (0.06)c	0.11 (0.03)d
P ($mg.dm^{-3}$)	3.96 (2.81)a	4.24 (3.35)a	6.24 (6.04)a	4.20 (0.65)a
K ($mg.dm^{-3}$)	77.24 (27.52)b	95.36 (19.33)a	64.80 (12.86)c	40.40 (4.60)d
Na	31.32 (10.48)b	38.52 (8.08)a	28.00 (5.82)b	17.00 (0.00)c
Organic matter	1.55 (0.29)b	2.28 (0.51)a	1.56 (0.33)b	2.28 (0.34)a
V	40.33 (10.41)b	58.17 (9.37)a	28.09 (6.00)c	11.15 (1.31)d
Sand	442.08 (44.52)c	570.32 (69.88)a	491.12 (34.79)b	473.68 (52.84)b
Silte	101.12 (33.15)a	108.08 (58.36)a	92.84 (41.74)a	91.92 (46.86)a
Clay	456.80 (42.30)a	321.60 (65.30)c	416.00 (42.82)b	434.40 (50.17)a
LAI				
Rainy LAI	0.30 (0.20)c	0.91 (0.42)b	1.62 (0.30)a	1.36 (0.51)a
Drought LAI	0.22 (0.23)c	0.56 (0.48)b	0.56 (0.14)b	1.11 (0.33)a

Notes: V = base saturation. Mean values and standard deviation (in brackets) for soil variables and LAI are shown. Different letters after mean and standard deviation indicate significant differences among populations in contrast analysis in generalized linear models ($P < 0.05$).

CAPÍTULO III

EXOTIC GRASS IMPAIRS THE ATLANTIC FOREST RESTORATION IN SOUTHEAST BRAZIL

Submetido: Agriculture, Ecosystems & Environment

Abstract

Among the factors that impair the tropical forests restoration, exotic grasses by their high competitive capacity are particularly important, maily in areas previously used as pastures. In the present study we evaluated the density of recruits in an area previously occupied by *Urochloa brizantha* pasture undergoing forest restoration and in a secondary semideciduous forest to evaluate abiotic and biotic factors that impair the Atlantic Forest restoration. We evaluated the effect of the available light on the epigeal biomass of the exotic grass, and investigated associations of recruit density with soil variables and understory light availability. The seed rain in both areas was also evaluated in order to determine their limitation on recruit density. The biomass of *U. brizantha* was positively associated with available light and, a negative association was found between recruit density and available light when considering the two areas together. Compared with the semideciduous forest where there was no presence of the exotic grass, the area under restoration presented low density of recruits even showing more fertile soil. As a consequence of the low density of recruits in the restoration area, a negative association between recruit density and soil pH was found. These results suggested that the low soil fertility in the semideciduous forest aparently did not limit recruit density. The higher resources availability in the area under restoration favor the high productivity of grass that also result in high proportion of grass seeds in relation to the forest species in the seed rain. Althogether our results showed that light availability is determinant to favor the competitivity of the exotic *U. brizantha*, limiting the forest species recruitment and impairing the forest restoration in area previously used as pastures.

Keywords: Active restoration, *Brachiaria brizantha*, forest regeneration, light availability, seed rain, *Urochloa brizantha*.

Introduction

Forest restoration strategies range from low-cost spontaneous recovery of native species in abandoned sites to active processes that involve direct seeding and/ or sapling planting, the control of both invasive plants and fire, which increase the cost of restoration (Crouzeilles et al., 2017, Reid et al., 2018, Loft et al., 2019). If the recovery occurs either through a spontaneous or active process, invasion or the presence of exotic grasses, as in the case of areas previously used as pasture, can be a serious problem that affects forest restoration. The establishment and the dominance of exotic plants are often associated with low diversity of native species and the high competitive capacity of the exotic species in the utilization of available resources (Mack et al., 2000).

Abiotic factors as light and soil nutritional status can determine the competitivity of exotic species and thus interfer in the forest restoration. The opportunity to take advantage of available resources favors invasive exotic species in the process of competitive exclusion of native species (Davis et al., 2000). The competitive capacity of invasive species is commounsly favored under increased resouce availability as light and nutrients (Daehler, 2003, Dawson et al., 2012). The addition of nutrients results in an increase of biomass production of invasive species (Gross et al., 2005, Liu and Kleunen, 2017) favoring the growth of grasses already established, making it difficult to restore areas previously used as pasture.

The high light availability also frequently favors exotic species due to their higher capacity of light capture and use, which result in higher growth rate in sun or partial shade as compared with native species (Pattison et al., 1998). Thus, the low occurence of trees in areas previosly used as pastures favors a high light availability leveraging the competitive capacity of exotic grasses impacting the recruitment by forest species in areas under forest restoration. Besides having competitive advantages over native species in relation to light and water, exotic grasses can release compounds that impair or inhibit the growth of regenerating native plants in an allelopathic effect (Mack et al., 2000, Babu et al., 2008, Kato-Noguchia et al., 2014). The fast reproductive cycle and high seed production of exotic grasses facilitate their success and promote biodiversity loss (Baruch et al., 1985, Hughes et al., 1991, D'antonio and Vitousek, 1992).

In addition to abiotic factors that determine the higher competitivity of exotic than native species, the arrival of forest propagules is an important factor limiting forest restoration. The seed rain is a natural process that acts in the recruitment of individuals contributing to the richness and density of species in the community by providing propagules that will recolonize areas and consequently act in the process of ecological succession (Araujo et al., 2004, Auffret and Cousins, 2011, Piotto et al., 2019). However, only the arrival of propagules in the area is not enough for the establishment of the seedlings, especially in areas dominated by exotic grasses, because they tend to cover the soil with their biomass, preventing the arrival of light for germination or even due to competition for space (Meli and Dirzo, 2012, Kato-Noguchi et al., 2014).

Strategies that aim to adapt the environment to favor the establishment of native species in regeneration overcoming the competition with grasses and, consequently favoring the forest succession have been described (Sun and Dickson, 1996, Bellotto et al., 2009). Among these strategies, the planting of pioneer species (Aide et al., 2000) and direct seeding have been highlighted (Ceccon et al., 2016, Souza and Engel, 2018). Many native species, however, can overcome barriers and become established, even in pasture areas with few individuals remaining. In this case, shading tends to reduce the biomass of exotic grasses and contributes to successful forest succession (Zimmerman et al., 2000, Leitão et al., 2010). There is also the option of controlling invasive plant species with herbicides, although this option has been generally avoided as it could potentially harm the establishment of native regenerating species (McMannamen et al., 2018, Souza and Engel, 2018). The management of invasive grasses in revegetation areas, independent of the control methods applied, increases costs and can limit the effectiveness of restoration efforts, as allocated financial resources are limited (Silveira et al., 2013).

The African grass *Urochloa brizantha* (Hochst, Ex A. Rich.) RD Webster has been introduced in many tropical ecosystems to form pastures for cattle (McGregor et al., 1988). The species has been considered an aggressive invasive in hotspots of biodiversity such as the Cerrado (Barbosa et al., 2008), and causes difficulties for biotic recovery of tropical forests as the Atlantic Forest, particularlyy in areas previosly occupied by pastures (Holl, 1999, Fragoso et al., 2017). Comparative studies in restoration areas with high densities of exotic grasses and conserved areas of the Atlantic Forest can to lead a better understanding of the environmental filters that hinder the progress of forest restoration. In the present study we evaluate the density of forest recruits in a area under restoration dominated by *U. brizantha*, and in a semideciduous forest to verify limitant factors compromising forest restoration. We verify the effect of light availability on biomass production of the exotic grass and recruit density in the area under restoration and in the semideciduos forest. We also verify if compared to the semideciduous forest, the seed rain in areas previously used as pasture is predominantly dominated by seeds of the exotic grass. In addition, we assess if the low nutrient availability of the oligotrophic soil of the semideciduous forest can compromise recruitment. By meeting these objectives, we intend to collaborate by the understanding of the factors that impair the forest restoration in areas previously used as pastures.

Material and Methods

Study sites

The study was conducted at the Instituto Terra (www.institutoterra.org), Aimorés, state of Minas Gerais, Southeast Brazil (19° 53 ' S, 41° 09 ' W, Figure 1). The climate of the Instituto Terra is tropical altitude with average temperature varying between 18 and 29ºC; December is the wettest month and August the driest with average rainfall of 1772.7 and 97.7 mm, respectively (Köppen, 1948, INMET, 2018). The predominant soil in the region is classified as argisoil (Amaral et al., 2004). The Instituto Terra encompasses 710 ha, approximately 80% of which are in different stages of forest restoration. A significant portion of the area was previously used as cattle pasture. Forest restoration on the property began in 1999, with small fragments being restored annually by the planting of woody tree species.

Data were collected at two distinct areas. The first area, here referred to as forest restoration is in an area previously occupied by *U. brizantha* pastures and where attempts at forest restoration had been performed. This area encompasses more than 44 hectares, where native species were planted at a spacing of 2 x 2m in 2012. The preparation of the area for planting consisted of manual cutting around the pit, and fertilizing open pits with 200 grams of simple superphosphate. Twelve months after planting, the soil was fertilized with 100 grams of NPK 20-5-20 per plant, and ant management and manual weeding were performed around each plant. The area was enriched in 2015 with replanting of native species in the lines of the first planting. There is no current management intervention in the area that is dominated by *U. brizantha*. The second area is a fragment of semideciduous forest encompassing 125 hectares. This area has been undergoing natural regeneration for approximately 40 years, and was not invaded by *U. brizantha* (Figure 1). A list of the floristic elements of both sites is provided in Table Supplementary 1.

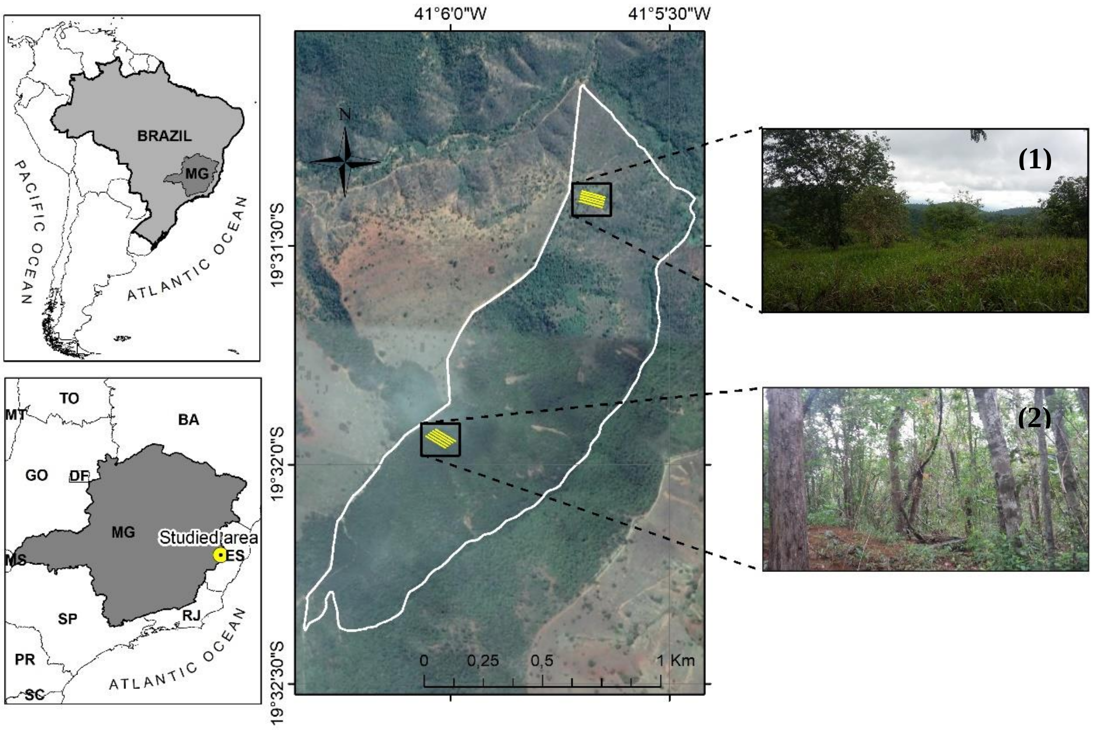


Figure 1 Location of study areas — Restoration Forest (1) and Semideciduous Forest Fragment (2) — in Terra Institute, located in the Southeast Region of Brazil.

Transmitted light, seed rain and biomass of *U. brizantha*

Five 2 x 110 m transects were installed at intervals of 10 m in each study areas. The transects were subdivided into 10 sampling points spaced at intervals of 10 meters. In each point, hemispheric photos taken with a Nikon Coolpix 5400 digital camera with a hemispherical fisheye-converted FC-59 lens, positioned level, facing the canopy and aligned to the north, at 1.5 m above the ground on a tripod. A total of 50 photos were taken in each area in July 2017, dry season. Photos were taken in the early hours of the day or late afternoon. The photos were analyzed to estimate the percentage of transmitted light using Gap Light Analyzer (GLA) software, version 2.0 (Frazer et al., 1999).

Five permanent 20x20m plots were installed in both study areas, which were subdivided into two subplots with a fixed collector (1x1m) in the center of each to measure seed rain. Material was collected monthly from January to December 2017, separated and quantified according to the ecological group (pioneer, non-pioneer, herbaceous or grass). The annual sum of seed density per m² per plot was used as a measure of seed rain.

The epigeal biomass of *U. brizantha* was sampled in July 2017 using a wood jig (0.5x0.5m). Sampling was performed randomly at 20 points at which hemisperical photos were taken along the previously installed transects in the area under restorarion. All material was cut close to the ground, oven dried for 72 hours at 65 °C, and weighed.

Natural regeneration

During the wet season (January 2017), the natural regeneration in the area under restoration and in the semideciduous forest was evaluated along the five transects previously installed for estimating transmitted light. The transects were subdivided into 10 plots of 2x2m spaced 10 m from each other, for a total of 200 m² sampled in each area. All regenerating saplings with heights between 10 cm and 2 m, and diameter at soil height (DSH) equal to or less than 5 cm, were included. The density of forest species saplings was calculated as the number of individuals per unit area (n/m²). Identification to family followed the classification system of the Angiosperm Phylogeny Group IV (APG IV, 2016). The species names and their respective authors followed the List of Species of Flora of Brazil (2018). The identified species were classified according to their ecological group — pioneer or climax/non-pioneer — following Swaine and Whitmore (1988).

Soil sampling

Soil samplings at a depth of 0 – 20 cm were performed in each plot demarcated along five the transects used to evaluate recruit density. The samples were joined in pairs to form composite samples, at a total of five locations per transect and twenty-five samples per area.The soil chemical and textural analyses followed the protocols described by Embrapa (1997). The variables analyzed were: phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), aluminun (Al), and sodium (Na), pH, organic matter, and sand, silt, and clay contents.

Statistical analyses

Generalized linear models (GLMs) were initially constructed to evaluate variation in density of recruits (natural regeneration) and soil characteristics between the studied areas. Density of recruits and soil textural and chemical characteristics were used as response variables while study areas (under restoration and semideciduous forest) was the explanatory variable. Separate models were created for each response variable and models were compared using ANOVA (Crawley, 2000). We also evaluated the average annual density of native seeds and *U. brizantha* per m² in seed rain of both studied areas by constructing models separately for each area.

Multiple regression analyses by GLM were used to investigate associations between density of recruits and soil variables and percentage of transmitted light through the canopy. Density of recruits was used as the response variable while percentage of light transmitted and soil characteristics were used as explanatory variables. Collinearity was evaluated separately between the soil predictor variables using Spearman's rank correlation coefficient ($r<0.6$) (Table Supplementary 2), and correlated variables were not used together in any of the elaborated models. To determine the most explanatory variables in the model we used second-order Akaike Information Criterion (AIC), where the best model is indicated by the lowest AIC value (Burnham et al., 2011; Niinemets, 2015; Souza et al., 2018). These analyses were performed using functions implemented in 'AICcmodavg' and ‘psych’ packages.

Multiple regression analyses by GLM were also used to verify the effect of percentage of transmitted light and soil characteristics (explanatory variables) on biomass of *U. brizantha* (response variable) initially using the same approach previously described to select the explanatory variables of the model (i.e., lowest AIC value). This was followed by analyzing the effect of biomass of *U. brizantha* (explanatory variable) on absolute density of recruits (response variable).

All data were analyzed using R v2.15.3 (R Core Team, 2013). All models were built using the appropriate error distribution considering the nature of each response variable, followed by model assessment. All generated models were compared to null models (Crawley, 2000).

Results

There was a significant difference (ANOVA, $F = 102.24$, $p < 0.001$) in saplings between the study areas, with 212 recruits sampled in the semideciduous forest and 26 in the area under restoration. The saplings were distributed among 12 botanical families, with 60% being non-pioneer species, in the two study areas (Table 1).

Table 1 Regenerating species followed by their respective botanical family, ecological group (P = pioneer; NP = non-pioneer), and total number of recruits in the sampled plots of the forest restoration area and of the semideciduous forest in Instituto Terra, Southeast Brazil.

Family	Species	Ecological Group	Number of Recruits	
			Restoration Forest	Semideciduous Forest
Acharieaceae	*Carpotroche brasiliensis*	NP		1
Anacardiaceae	*Astronium graveolens*	NP	1	14
Anacardiaceae	*Myracrodruon urundeuva*	NP	20	
Annonaceae	*Xylopia frutescens*	NP		9
Bignoniaceae	*Handroanthus serratifolius*	NP		4
Bignoniaceae	*Zeyheria tuberculosa*	NP	2	
Boraginaceae	*Cordia superba*	P	1	
Euphorbiaceae	*Joannesia princeps*	P		2
Fabaceae	*Anadenanthera colubrina*	P		1
Fabaceae	*Bauhinia forficata*	P		6
Fabaceae	*Dalbergia nigra*	P		66
Fabaceae	*Lonchocarpus cultratus*	NP		1
Fabaceae	*Machaerium fulvovenosum*	NP		6
Fabaceae	*Machaerium nyctitans*	P		40
Fabaceae	*Melanoxylon brauna*	NP		1
Fabaceae	*Myrocarpus fastigiatus*	NP		17
Fabaceae	*Peltophorum dubium*	P	2	14
Lecythidaceae	*Lecythis lanceolata*	NP		13
Moraceae	*Sorocea bonplandii*.	NP		2
Myrtaceae	*Plinia rivularis*	NP		1
Salicaceae	*Casearia sylvestris*	P		9
Sapindaceae	*Cupania oblongifolia*	NP		5
Total			26	212

We recorded 17 species in the seed rain in the area under restoration, 35% of them are grasses including the *U. brizantha* seeds (Table 2). Of the 23 species of the seed rain in the semideciduous area 13% are grasses, however in this area there is no seeds of *U. brizantha*. Species with abiotic dispersion syndromes dominated in both areas, 66% in the restoration area and 70% in the semideciduous forest. Despite the difference between the number of species in the seed rain being small between the two areas studied, there was a significant difference in the amount of seeds of native species and *U. brizantha* in the forest under restoration (51.0 ± 21.51 and 405.3 ± 105.74, P <0.001, respectively). *U. brizantha* seeds represented 88% of the total number of seeds that reached the collectors.

Table 2 Relationship of species present in the seed rain in the forest restoration area and in the semideciduous forest with the ecological group.

Family	Species	Ecological Group	Restoration Forest	Semideciduous Forest
Anacardiaceae	*Myracrodruon urundeuva* Allemão	NP	X	X
Asteraceae	*Bidens pilosa* L.	Herbaceous	X	
Bignoniaceae	Sp. 29	-		X
Bignoniaceae	*Zeyheria tuberculosa* (Vell.) Bureau ex Verl.	NP		X
Bignoniaceae	*Inga vera* Willd.	P	X	X
Ebenaceae	*Diospyros inconstans* Jacq.	NP	X	
Euphorbiaceae	*Croton floribundus* Spreng.	P		X
Fabaceae	Sp. 19	-		X
Fabaceae	Sp. 20	-		X
Fabaceae	Sp. 14	-	X	
Fabaceae	*Mimosa pigra L.*	NP		X
Fabaceae	*Machaerium fulvovenosum* H.C.Lima	NP		X
Fabaceae	*Pterogyne nitens* Tul.	NP		X
Fabaceae	*Myrocarpus frondosus* Allemão	NP	X	
Fabaceae	*Mimosa pudica* L.	NP	X	
Fabaceae	*Peltophorum dubium (Spreng.)* Taub.	P	X	X
Fabaceae	*Machaerium hirtum* (Vell.) Stellfeld	P		X

Fabaceae	*Dalbergia nigra* (Vell.) Allemão ex Benth.	P		X
Fabaceae	*Lonchocarpus sericeus* (Poir.) Kunth ex DC.	NP	X	
Fabaceae	*Phyllocarpus riedelii* Tul.			X
Malpighiaceae	Sp. 26	-	X	
Malvaceae	*Guazuma ulmifolia* Lam.	P	X	X
Poaceae	*Andropogon bicornis* L.	Grass	X	X
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	Grass		X
Poaceae	*Setaria* sp.	Grass	X	
Poaceae	*Cenchrus echinatus* L.	Grass	X	X
Poaceae	*Paspalum maritimum* Trin.	Grass	X	
Poaceae	*Urochloa brizantha* (Hochst. ex A. Rich.) Stapf	Grass	X	
Rutaceae	*Dictyoloma vandellianum* A.Juss.	NP		X
Sapindaceae	*Serjania salzmanniana* Schltdl.			X
Sapindaceae	*Cupania oblongifolia* Mart.	P		X
Trigoniaceae	*Trigonia* sp.	NP	X	X
-	Sp. 35	-		X

The texture of the soils of the two studied areas differed slightly with the soil of the area under restoration consisting of sandy clay loam while that of the semideciduous forest consisted of sandy clay (Table 3). The soil of the semideciduous forest are oligotrophyc with low pH, depleted in nutrients and rich in aluminum. In contrast the soil of the area in restoration present higher nutritional status, higher pH and no detectable aluminum (Table 3).

Table 3 Results of soil chemical and textural analysis (mean values and standard deviation along five transects) of the restoration forest area and semideciduous forest area at Instituto Terra, Southeast Brazil. ***, P < 0.001 in GLM.

Variables	Restoration Forest	Semideciduous Forest	*P*
P-Mehlich (mg/dm^3)	3.58± 0.64	4.16± 0.63	>0.05
K (mg/dm^3)	95.36± 19.13	40.56± 4.61	***
Ca (cmolc/dm^3)	2.17± 0.75	0.52± 0.12	***
Mg (cmolc/dm^3)	0.52± 0.24	0.11± 0.03	***
Al (cmolc/dm^3)	0.00± 0.00	1.26± 0.10	***

pH in H_2O	5.96±	0.18	4.56±	0.08	***
Organic matter (dag/kg^{-1})	2.28±	0.51	2.26±	0.34	>0.05
Na (cmolc/dm³)	38.52±	8.00	17.00±	0.00	***
Base saturation (%)	58.17±	9.28	11.09±	1.26	***
Sand (g/kg)	570.32±	69.16	471.84±	52.08	***
Silt (g/kg)	108.08±	57.76	92.96±	45.89	>0.05
Clay (g/kg)	321.60±	64.63	435.20±	49.91	***

Within of the analyzed variables, only P, organic matter and silt were not significantly correlated with pH, indicating that the higher the pH, the greater the nutrients available in the soil (Table Supplementary 2). Multiple regression analysis of both sites together detected variables that best explain the occurrence of recruits, namely the percentage of transmitted light and soil pH (Table 4 and Figure 2). A negative relationship between transmitted light and recruit density (Figure 2A) was found. Also, a negative association was found between soil pH and recruit density, with higher densities of recruits in the semideciduous forest where the soil is more acidic (pH ≤ 5.0) (Figure 2B).

Table 4 Results of multiple regression analyses for absolute density of recruits and total epigeal biomass of *U. brizantha* with light and soil variables. Recruits = absolute density of recruits; Qi/Qo = percent of transmitted light; pH = soil pH in H_2O; biomass of *U. brizantha*= total epigeal biomass of *U. brizantha*.

Regression	**N**	**AIC**	**R²**	**F**	**P**
Absolute density of recruits					
Recruits = 3.71 - 5.05^{-3} Qi/Qo - 0.54 pH	100	131.53	0.53	53.49	<0.001
Total epigeal biomass of U. brizantha					
Biomass of *U. brizantha* = $96.572e^{0.02\ Qi/Qo\ x}$	20	248.25	0.97	30.55	<0.001

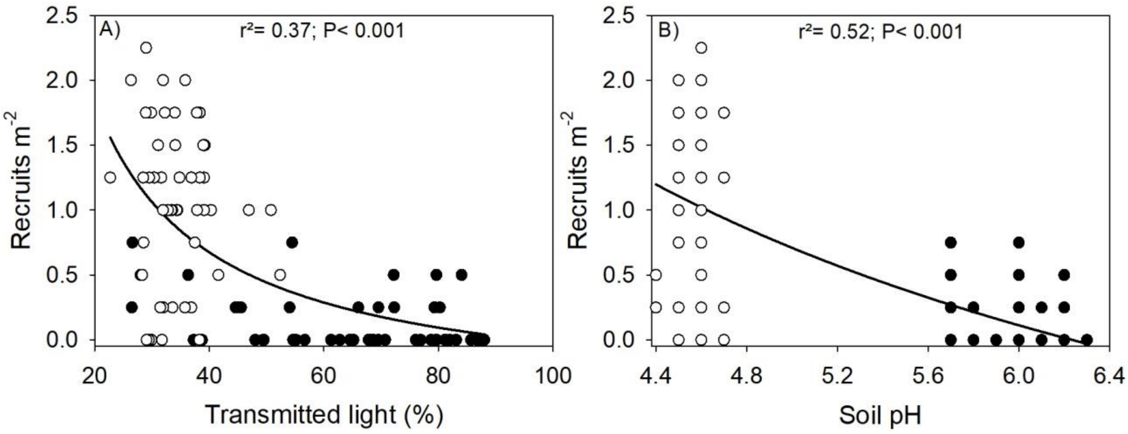


Figure 2 Relationship between percent of transmitted light and sapling density (A); and between soil pH and sapling density (B) in the Atlantic Forest Restoration area (●), and in the semideciduous forest (○) at Instituto Terra, Southeast Brazil.

Recruits of forest species were recorded in only 17 of the 50 plots evaluated in area under restoration, but recruits were recorded in most of the sampled plots of the semideciduous forest. Recruits of forest species were observed in a wide range of transmitted light levels (Figure 2A). In semidecidous forest, where *U. brizantha* was not observed, transmitted light values were always below 60% and most recruits occurred where transmited light ranged between 30 and 40% (Figure 2A).

Analysis focused only on the area dominated by *U brizantha* revealed a positive relationship between transmitted light and epigeal biomass of *U. brizantha* ($F = 30.55$, $p < 0.001$; Figure 3). No association was found between soil caracteristics and epigeal dry biomass of *U. brizantha*, or between recruit density and grass biomass ($F = 1.474$, $p = 0.24$).

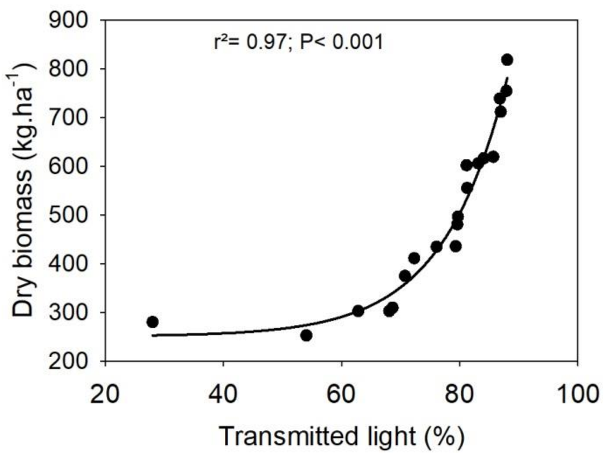


Figure 3 Effects of percent of transmitted light on total epigeal dry biomass of *U. brizantha* in the forest restoration area at Instituto Terra, Southeast Brazil.

Discussion

It is a great challenge to restore degraded areas, mainly old pastures, due to the persistence of exotic species. The difficulties of restoring tropical forests in areas previously used as pasture are also related to the great capacity of grasses to compete for resources (Cabin et al., 2002), and their production of toxins that inhibit or hinder the development of other species (Mack et al., 2000, Griscom et al., 2009). There are records of the production of allelopathic compounds by grasses in the genus *Urochloa*, which inhibit the germination and root growth of other species (Barbosa et al., 2008). The production of toxins by *U. brizantha* can also provide competitive advantages on account of its multiple effects, such as antimicrobial and anti-herbivore activities (Kato-Noguchia et al., 2014). Our results identified the high light availability as determinant for the expressive biomass production of *U. brizantha*. Thus it is plausible to assume that accompanying this great accumulation of biomass there is a great accumulation of allelopathic compounds impacting the success of seedlings from propagules that arrive in the area via seed rain.

The reduced density of recruits observed in the area under restoration may also be related to the limited seed bank of forest species in the area formerly occupied by pasture, and/or due to low seed deposition rates from adjacent forest fragments. The predominance of seeds of *U. brizantha* in the seed rain compared to seeds of native species as here quantified, certainly results in the maintenance of a large grass seed bank. This fact may explain the persistence of the grass even after weeding the area under restoration soon after planting the saplings of forest species. In disturbed environments, such as pasture areas, the planting of tree species can facilitate recolonization by native species by forming a canopy that provides shelter, perches and food for fauna that can contribute as seed source (Hansen et al. 2013, Suganuma and

Durigan, 2014). However, the observed low average seed density of native species in relation to *U. brizantha* suggests a paucity of forest seed sources near the study site, which would serve as primary seed source and support the process of ecological succession (White et al. 2004, Reid and Holl 2012). *U. brizantha* has as main characteristics the ease of vegetative propagation and high seed production, whose fruits are dry of the cariopse type (Moreira and Bragança 2010). Despite the high occurrence of *U. brizantha* seeds in the seed rain in the area under restoration, its absence in the reference area indicates how restricted the dispersion of the grass is.

Although seeds of forest species are present in the seed rain in the area under restoration, the establishment of seedlings in this area dominated by *U. brizantha* is limited as evidenced by the low density of recruits. The low success of the forest species seedlings in areas dominated by grasses has already been experimentally determined as in a study on direct seeding, which found low seedling survival in an area of seasonal tropical forest dominated by invasive alien grasses (Souza and Engel, 2018). High seed predation, low germination rate and competitive suppression by grasses that produce a dense layer of litter are determinant factors limiting the seedling stablisment success in areas of forest restoration dominated by grasses (Holl et al., 2000).

Our results indicated that the competitive advantage of *U. brizantha* is dependent on the availability of light. In sampling locations with around 60% transmitted light presented less than half the biomass of *U. brizantha* observed in more sunny locations. This result indicates that low light availability functions as a strong filter for *U. brizantha* biomass accumulation. This is in accordance with previous studies that found reductions between 60 and 75% in biomass accumulation of *U. brizantha* with a 70% reduction in incident light (Dias-Filho, 2000, Andrade et al., 2004). Since invasive grasses perform better in sites with direct light, they are able to successfully invade restoring areas of Atlantic Forest as soon as their seeds reach open environments. Small openings in the forest canopy may be more favorable for the establishment of forest seedlings (Corlett, 1992, Altman et al., 2016) while large openings would favor the invasion by exotic species. However, sites with continuous canopy cover can limit invasion success by shade intolerant species (Fine, 2002) as observed in the semideciduos forest in the present study. In addition to the greater canopy coverage limiting the understory light, the presence of *U. brizantha* seeds was not observed in the seed rain in the semidecidous forest. Both factors would explain the absence of exotic grass in this studied area.

It has often been reported that besides the frequency and intensity of disturbance the high resources availability favors exotic species over native species (Davis et al., 2000). Here, in addition to the negative relationship between the availability of light and the density of recruits, a negative relationship was also observed in relation to soil pH. In the restoration area dominated by *U. brizantha* beyond the higher light availability, a greater availability of nutrients was observed. There are studies that report that liming and fertilization significantly increase dry mass production of pastures of *U. brizantha* (Paulino et al., 1994, Oliveira et al., 2003), even in shaded stands (Paciullo et al., 2011). Evaluating the nutritional limitations of growth in secondary forests, Davidson et al. (2004) observed increased total biomass in plots that received fertilization. However, this increase was accompanied by the proliferation of remaining pastures and reduced biomass of herbaceous species. In the present study, the number and diversity of recruits were higher in the semideciduous forest where the soil was more acidic and poorer in bases compared to the area under restoration. This finding indicates that low soil fertility is not necessarily a limiting factor for forest species recruitment.

In both areas of this study, the largest number of recruit species were non-pioneer species that could tolerate shade and grow, albeit more slowly, under a closed canopy. However, the largest number of individuals were of pioneer species. Pioneer species may also grow in shaded environments, but only for a limited period of time due to their greater light demand for germination and development (Altman et al., 2016). Among the recorded forest species, saplings of *Myracrodruon urundeuva* Allem. (Anacardiaceae) and *Dalbergia nigra* (Vell.) Allemão ex Benth. (Fabaceae) had the highest number of regenerating individuals in the area under restoration and in the semideciduous forest, respectively. These species have some characteristics in common, such as capacity to germinate in the presence or absence of light and under a wide temperature range, which indicates that they can occur in both, open areas and areas under a more closed canopy (Ferraz-Grande and Takaki, 2001, Silva et al., 2002). These characteristics can explain the common occurrence of these in pasture areas or degraded forests. Thus, these species have high potential for forest recovering since they can even occur in soils with low nutritional status and are resistant to water deficit (Durigan et al., 1997).

Conclusion

In conclusion, the data obtained here indicate that greater availability of resources, notably light, favor the growth of exotic grass and therefore its competitive capacity. Under higher canopy cover, transmited light acts as a strong filter for the productivity of the studied exotic grass. The higher imput of grass seed in areas dominated by *U. brizantha* in proportion to the arrival of propagules of forest species is another factor that can limit the success of forest restoration. The low understory light and the absence of *U. brizantha* seeds in the seed rain explain the absence of the species in the semideciduous forest area. Considering that saplings in the semideciduous forest were present even under conditions of low light availability, procedures that limit light availability can weaken the competitiveness of the invading grass and favor recruitment. That would include the planting of saplings with a size larger than that reached by the grass, preferably pioneer species that would quickly develops a dense canopy or/and the use shading screens for reducing the impact of competition between grasses and seedlings, and promote forest restoration in sites previously used as pastures in the Atlantic Forest biome. Another result observed here was that the lower soil fertility of the semideciduous forest site aparently did not limit recruit density. This finding suggests that successful recruitment in areas dominated by tropical exotic grass is not necessarily related to higher soil fertility, and thus procedures such as liming and adding chemical fertilizers may be unnecessary and harmful to forest restoration, favoring invasive grasses. However, additional studies with a more adequate experimental design to test this hypothesis would be necessary.

References

Aide, T.M.; Zimmerman, J. K.; Pascarella, J. B.; Rivera, L. & Marcano-Veja, H. (2000). Forest regeneration in a chronosequence of tropical abandoned pastures: implications on restoration ecology. Restoration Ecology, 8, 328-338. doi: **1 0.1046/j.1526-100x.2000.80048.x**.

Altman, J., Fibich, P., Leps, J., Uemurac, S., Hara T., & Dolezal, J. (2016). Linking spatiotemporal disturbance history with tree regeneration and diversity in na old-growth forest in northern Japan. Perspectives in Plant Ecology, Evolution and Systematics, 21, 1-13. doi: **10.1016/j.ppees.2016.04.003**.

Amaral, F.C.S. do., Santos, H.G dos., Agilo, M.L.D., Duarte, M.N., Pereira, N.R., Oliveira, R.P de., & Carvalho, Jr. W. de. (2004). Mapeamento de solos e aptidão agrícola das terras do Estado de Minas Gerais (ed.). Rio de Janeiro, RJ: Embrapa Solos.

Andrade, C.M.S. de., Valentim, J.F., Carneiro, J. da C., & Vaz, F.A. (2004). Crescimento de gramíneas e leguminosas forrageiras tropicais sob sombreamento. Pesquisa Agropecuária Brasileira, 39, 262-270. doi: **10.1590/S0100-204X2004000300009**.

APG IV. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society, 181, 1–20. doi: **10.1111/boj.12385**.

Araujo, M. M.; longhi, s. J.; barros, P. L. C.; brena, d. A. (2004) Caracterização da chuva de sementes, banco de sementes do solo e banco de plântulas em Floreta

Estacional Decidual ripária Cachoeira do Sul, RS, Brasil. Scientia Forestalis. n. 66, 128-141.

Auffret, A. G.; Cousins, S. A. O. (2011) Past and present management influences the seed bank and seed rain in a rural landscape mosaic, (S.l). Journal of Applied Ecology, 48, 1278-1285.

Babu, C.M., Chakrabarti, R., & Sambasivarao, K.R.S. (2008). Enzymatic isolation of carotenoid–protein complex from shrimp head waste and its use as a source of carotenoids. LWT, 41, 227−235. doi: **10.1016/j.lwt.2007.03.006**.

Barbosa, E.G., Pivello, V.R., & Meirelles, S.T. (2008). Allelopathic evidence in *Brachiaria decumbens* and its potential to invade the brazilian cerrados. Brazilian Archives of Biology and Technology, 51, 825-831. doi: **10.1590/s1516-89132008000400021**.

Baruch, Z., Ludlo, M.M., & Davis, R. (1985). Photosynthetic responses of native and introduced C4 grasses from Venezuelan savannas. Oecologia, 67, 388-393. doi: **10.1007/bf00384945**.

Bellotto, A., Viani, R.A.G., Neves, A.G., Gandolfi, S., & Rodrigues, R.R. (2009). Monitoramento das áreas restauradas como ferramenta para avaliação da efetividade das ações de restauração e para redefinição metodológica. p. 128-146. In: Rodrigues, R.R., Brancalion, P.H.S., & Isernhagen, I. (eds). Pacto pela restauração da mata atlântica: referencial dos conceitos e ações de restauração florestal (ed.). São Paulo, SP: Instituto Bioatlântica.

Burnham, K. P., Anderson, D. R., & Huyvaert, K. P. (2011). Erratum to: AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology, 65, 415–415. doi:**10.1007/s00265-010-1084-z.**

Cabin, R.J., Weller, S.G., Lorence, D.H., Cordell, S., & Hadway, L.J. (2002). Effects of microsite, water, weeding, and direct seeding on the regeneration of native and alien species within a Hawaiian dry forest preserve. Biological Conservation, 104, 181-190. doi: **10.1016/s0006-3207(01)00163-x**.

Ceccon, E., González, E.J., & Martorell, C. (2016). Is Direct Seeding a Biologically Viable Strategy for Restoring Forest Ecosystems? Evidences from a Meta analysis. Land degradation and development, 27, 511-520. doi: **10.1002/ldr.2421**.

Corlett, R.T. (1992). The ecological transformation of Singapore. Journal of Biogeography, 19, 411-420. doi:**10.2307/2845569**.

Crawley, M. J. (2000). Statistical Computing: An Introduction to Data Analysis Using S-Plus. Gebundenes Buch. 772pp.

Crouzeilles, R., Ferreira, M. S., Chazdon, R. L., Lindenmayer, D. B., Sansevero, J. B. B., Monteiro, L., Strassburg, B. B. N. (2017). Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. Science Advances, 11, 01-07. doi:**10.1126/sciadv.1701345**.

Daehler, C. C. (2003). Performance Comparisons of Co-Occurring Native and Alien Invasive Plants: Implications for Conservation and Restoration. Annual Review of Ecology, Evolution, and Systematics, 34, 183–211. doi:**10.1146/annurev.ecolsys.34.011802.132403**

D'Antonio, C.M., & Vitousek, P.M. (1992). Biological invasions by exotic grasses, the grass/fire cycle, and blobal change. Annual Review of Ecology and Systematics, 23, 63-87. doi: **10.1146/annurev.ecolsys.23.1.63**.

Davidson, E.A., Carvalhos, C.J.R., Vieira, I.C.G., Figueiredo, R.O., Moutinho, P., Ishida, F.Y., Santos, M.T.P., Guerrero, J.B., Kalif, K., & Sabá, R.T. (2004). Nitrogen and Phosphorus Limitation of Biomass Growth in a Tropical Secondary Forest. Ecological Applications, 14, 150–163. doi: **10.1890/01-6006**.

Davis, M. A., Grime, J. P., & Thompson, K. (2000). Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology, 88, 528–534. doi:**10.1046/j.1365-2745.2000.00473.x**

Dawson, W., Rohr, R. P., van Kleunen, M., & Fischer, M. (2012). Alien plant species with a wider global distribution are better able to capitalize on increased resource availability. New Phytologist, 194, 859–867. doi:**10.1111/j.1469-8137.2012.04104.x**

Dias-Filho, M. (2000). Growth and biomass allocation of the C4 grasses *Brachiaria brizantha* and *B. humidicola* under shade. Pesquisa Agropecuária Brasileira, 35, 2335-2341. doi: **10.1590/s0100-204x2000001200003**.

Durigan, G.; Figllolla, M. B.; Kawabata, M.; Garrido, M. A. de O.; & Baitello, J.B. (1997) Sementes e mudas de árvores tropicais. São Paulo: Páginas & Letras. 65p.

EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. Sistema brasileiro de classificação de solos. (2018, January 20). Retrieved from http://www.cnps.embrapa.br/.

Ferraz-Grande, E.G.A., & Takaki M. (2001) Temperature dependente seed germination of *Dalbergia nigra* Allem (Leguminosae). Brazilian Archives of Biology and Technology, 44, 401-404. doi: **10.1590/s1516-89132001000400010**

Fine, P.V.A. (2002). The invasibility of tropical forests by exotic plants. Journal of Tropical Ecology, 18, 687–705. doi: **10.1017/s0266467402002456**.

Fragoso, R. de O., Carpanezzi, A. A., Ribas, K. C. Z.-, & Koehler, H. S. (2017). Forestry restoration in abandoned pastures of urochloa by different sizes of brushwood. Cerne, 23, 85–94. doi: **10.1590/01047760201723012276.**

Frazer, G.W., Trofymow, J.A., Lertzman, K.P. (1999). Canopy openness and leaf area index in chronosequences of coastal temperate rainforests. Can. J. For. Res. In Press.

Griscom, H.P., Griscom, B.W., & Ashton, M.S. (2009). Forest regeneration from pasture in the dry tropics of Panama: Effects of cattle, exotic grass, and forested riparia. Restoration Ecology, 17, 117–126. doi: **10.1111/j.1526-100X.2007.00342.x.**

Gross, K. L., Mittelbach, G. G., & Reynolds, H. L. (2005). Grassland invasibility and diversity: responses to nutrients, seed input, and disturbance. Ecology, 86, 476–486. doi:**10.1890/04-0122**

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., & Loveland, T. R. (2013) High-resolution global maps of 21st-century forest cover change. Science, 342, 850–853. doi: **10.1126/science.1244693.**

Holl, K.D. (1999). Factors limiting tropical rain forest regeneration in abandoned pasture: seed rain, seed germination, microclimate, and soil. Biotropica 31, 229–242. doi: **10.2307/2663786**.

Hughes, F., Vitousek, P.M., & Tunison, T. (1991). Alien grass invasion and fire in the seazonal submontane zone of Hawaii. Ecology, 72, 743-746. doi: **10.2307/2937215**.

Instituto Nacional de Meteorologia do Brasil – INMET. Normais Climatológicas (1972/2014). Brasília - DF, 2018. Taken from: < http://www.inmet.gov.br>

Kato-Noguchia, H., Kobayashia, A., Ohnob, O., Kimuraa, F., & Fujii Y. (2014). Physiology Phytotoxic substances with allelopathic activity may be central to the strong invasive potential of *Brachiaria brizantha*. Journal of Plant Physiology, 171, 525–530. doi: **10.1016/j.jplph.2013.11.010**.

Köppen, W. (1948). Climatologia: con un estudio de los climas de la tierra. México: Fondo de Cultura Econômica.

Leitão, F. H. M.; Marques, M. C. M.; & Ceccon, E. (2010. Young restored forests increase seedling recruitment in abandoned pastures in the Southern Atlantic rainforest. Revista de Biologia Tropical, 58, 1271-1282. doi: **10.15517/RBT.V58I4.5411.**

List of Species of Flora of Brazil. Jardim Botânico do Rio de Janeiro. (2018, January 20). Retrieved from http://floradobrasil.jbrj.gov.br.

Liu, Y., Kleunen, M. (2017). Responses of common and rare aliens and natives to nutrient availability and fluctuations. Journal of Ecology, 105, 1111–1122. doi:**10.1111/1365-2745.12733**

Loft, L., Gehrig, S.Le, D. N., & Rommel, J. (2019). Effectiveness and equity of Payments for Ecosystem Services: Real-effort experiments with Vietnamese land users. Land Use Policy, 86, 218–228. doi:**10.1016/j.landusepol.2019.05.010**.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M., & Bazzaz, F.A. (2000). Technical report biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, 10, 689-710. doi: **10.2307/2641039**.

McGregor, J.T., Smith, R.J., & Talbert, R.E. (1988). Broadleaf signalgrass (*Brachiaria platyphylla*) duration of interference in rice (*Oryza sativa*). Weed Science, 36, 747–750. doi: **10.1017 / S0043174500075767**.

McMannamen, C., Nelson, C.R.C., & Wagner, V. (2018). Timing of seeding after herbicide application influences rates of germination and seedling biomass of native plants used for grassland restoration. Restoration Ecology, 26, 1-12. doi: **10.1111/rec.12679**.

Meli P, Dirzo R (2012) Effects of grasses on sapling establishment and the role of transplanted saplings on the light environment of pastures: implications for tropical forest restoration. Applied Vegetation Science, 16, 296-304.

Moreira, H. J. da C., & Bragança, H. B. N. Manual de identificação de plantas infestantes: Cultivos de verão. Campinas, SP. 2010. 642p.

Niinemets, Ü., Keenan, T. F., & Hallik, L. (2015). A worldwide analysis of within-canopy variations in leaf structural, chemical and physiological traits across plant functional types. New Phytologist, 205, 973–993. doi:**10.1111/nph.13096.**

Oliveira, P.P.A., Boaretto, A.E., Trivelin, P.C.O., Oliveira, W.S de., & Corsi, M. (2003). Liming and fertilization to restore degraded *Brachiaria decumbens* pastures grown on an entisol. Scientia Agricola, 60, 25-131. doi: **10.1590/s0103-90162003000100019**.

Paciullo, D.S.C., Fernandes, P.B., Gomide, C.A.M., Castro, C.R.T. de., Sobrinho, F.S., & Carvalho, C.A.B de. (2011). The growth dynamics in *Brachiaria* species according to nitrogen dose and shade. Revista Brasileira de Zootecnia, 40, 270-276. doi: **10.1590/s1516-35982011000200006**.

Pattison, R. R., Goldstein, G., & Ares, A. (1998). Growth, biomass allocation and photosynthesis of invasive and native Hawaiian rainforest species. Oecologia, 117, 449–459. doi:**10.1007/s004420050680**

Paulino, V. T., Costa, N. L.; Lucena, M. A. C.; Schammas, E. A.; & Ferrari Júnior, E (1994). Resposta de *Brachiaria brizantha* cv. Marandu a calagem e adubação fosfatada em um solo ácido. Pasturas Tropicales, 16, 23 - 33. doi: not available.

Piotto, D., Craven, D., Montagnini, F., Ashton, M., Oliver, C., Thomas, W.W. (2019) Successional, spatial, and seasonal changes in seed rain in the Atlantic forest of southern Bahia, Brazil. Plos One, 14, 1-20. doi: **10.1371/journal.pone.0226474**

R Core Team (2013) R: A Language and Environment for Statistical Computing. <https://www.R-project.org/>

Reid, J. L., & Holl, K. D. (2012). Arrival ≠ Survival. Restoration Ecology, 21, 153–155. doi:**10.1111/j.1526-100x.2012.00922.x**.

Reid, J. L., Fagan, M. E., & Zahawi, R. A. (2018). Positive site selection bias in meta-analyses comparing natural regeneration to active forest restoration. Science Advances, 4, 01-03. doi:**10.1126/sciadv.aas9143**.

Rüger, N., Huth, A., Hubbell, S.P., & Condit, R. (2009). Response of recruitment to light availability across a tropical lowland rain forest community. Journal of Ecology, 97, 1360–1368. doi: **10.1111/j.1365-2745.2009.01552.x**.

Silva, L.M.M., Rodrigues, T.J.D., & Aguiar I.B. (2002) Efeito da luz da temperatura na germinação de sementes de aroeira (*Myracrodruon urundeuva* Alemão). *Revista* Árvore, 26, 691-697. doi: **10.1590/s0100-67622002000600006**.

Silveira, E.R. da., Melo, A.C.G. de., Contiéri, W.A., & Durigan, G. (2013). Controle de gramíneas exóticas em plantio de restauração do Cerrado. p. 05-09. In: Durigan, G., & Ramos, V.S. (2013). Manejo Adaptativo: primeiras experiências na Restauração de Ecossistemas. São Paulo, SP: Páginas & Letras Editora e Gráfica.

Souza, D.C. de., & Engel, V.L. (2018). Direct seeding reduces costs, but it is not promising for restoring tropical seasonal forests. Ecological Engeniring, 116, 35-44. doi: **10.1016/j.ecoleng.2018.02.019**.

Souza, M. L., Duarte, A. A., Lovato, M. B., Fagundes, M., Valladares, F. & Lemos-Filho, J. P. (2018). Climatic factors shaping intraspecific leaf trait variation of a Neotropical tree along a rainfall gradient. Plos One, 13, 1-20. doi: **10.1371/journal.pone.0208512.**

Suganuma, M. S., & Durigan, G. (2014).Indicators of restoration success in riparian tropical forests using multiple reference ecosystems. Restoration Ecology, 23, 238–251.doi:**10.1111/rec.12168**.

Sun, D., & Dickson, G.R. (1996). The competition effect of *Brachiaria decumbens* on the early growth of direct-seeded trees of Alphitonia petriei in tropical north Australia. Biotropica, 28, 272-276. doi: **10.2307/2389082**.

Swaine, M. D., & Whitmore, T. C. (1988). On the definition of ecological species groups in tropical rain forests. Plant Ecology, 75, 81-86. doi: **10.1007/BF00044629**.

Zimmerman, J.K.; Pascarella, J. B.; & Aide T. M. (2000). Barriers to forest regeneration in an abandoned pasture in Puerto Rico. Restoration Ecology, 8, 350–360. doi: **10.1046/j.1526-100x.2000.80050.x.**

White, E., Tucker, N., Meyers, N., & Wilson, J. (2004). Seed dispersal to revegetated isolated rainforest patches in North Queensland. Forest Ecology and Management, 192, 409–426. doi:**10.1016/j.foreco.2004.02.002.**

Supplementary Material

Table 1. List of tree species found in the forest restoration area and in the semideciduous forest area at Instituto Terra, Southeast Brazil.

Family	Species	Area	
		Restoration Forest	Semideciduous Forest
Acharieaceae	*Carpotroche brasiliensis* (Raddi) A Gray		x
Anacardiaceae	*Astronium graveolens* Jacq.		x
Anacardiaceae	*Myracrodruon urundeuva* Allem.	x	
Annonaceae	*Xylopia frutescens* Aubl.		x
Boraginaceae	*Cordia superba* Cham.	x	
Combretaceae	*Terminalia januariensis* DC.	x	x
Elaeocarpaceae	*Sloanea guianensis* (Aubl.) Benth.	x	
Fabaceae	*Anadenanthera peregrina* (Benth.) Altschul	x	
Fabaceae	*Andira fraxinifolia* Benth.	x	
Fabaceae	*Dalbergia nigra* (Vell.) Allemão ex Benth.		x
Fabaceae	*Hymenaea courbaril* L.	x	
Fabaceae	*Inga thibaudiana* DC.	x	
Fabaceae	*Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz	x	
Fabaceae	*Lonchocarpus cultratus* (Vell.) A.M.G.Azevedo & H.C.Lima	x	
Fabaceae	*Melanoxylon brauna* Schott		x
Fabaceae	*Myrocarpus fastigiatus* Allemão	x	x
Fabaceae	*Peltophorum dubium* (Spreng.) Taub.	x	x
Fabaceae	*Phyllocarpus riedelii* Tul.	x	
Lecythidaceae	*Lecythis lanceolata* Poir.		x
Malvaceae	*Luehea grandiflora* Mart. & Zucc.		x
Myrtaceae	*Plinia rivularis* (Cambess.) Rotman		x
Salicaceae	*Casearia sylvestris* Sw.		x
Sapindaceae	*Cupania oblongifolia* Mart.	x	x
Sapindaceae	*Cupania vernalis* Cambess.		x
Sapotaceae	*Manilkara zapota* (L.) P.Royen		x

Table 2. Spearman's correlation for soil chemical and physical variables of the forest restoration area and semideciduous forestarea at Instituto Terra, Southeast Brazil.

Variables	P	K	Ca	Mg	Al	pH	OM	Na	V	Sand	Silt	Clay
P-Mehlich (mg/dm³)	1,00	-	-	-	-	-	-	-	-	-	-	-
K (mg/dm³)	0,05	1,00	-	-	-	-	-	-	-	-	-	-
Ca (cmolc/dm³)	-0,02	0, 80*	1,00	-	-	-	-	-	-	-	-	-
Mg (cmolc/dm³)	-0,07	0,70*	0,93*	1,00	-	-	-	-	-	-	-	-
Al (cmolc/dm³)	0,01	-0,85*	-0,80*	-0,73*	1,00	-	-	-	-	-	-	-
pH in H_2O	0,02	0,88*	0,90*	0,84*	-0,94*	1,00	-	-	-	-	-	-
Organic matter (dag/kg^{-1})	-0,01	0,02	0,28*	0,28*	-0,03	0,10	1,00	-	-	-	-	-
Na (cmolc/dm³)	0,06	0,99*	0,80*	0,70*	-0,84*	0,88*	0,04	1,00	-	-	-	-
Base saturation (%)	0,02	0,88*	0,94*	0,88*	-0,91*	0,99*	0,14	0,88*	1,00	-	-	-
Sand (g/kg)	0,20*	0,54*	0,49*	0,40*	-0,56*	0,59*	-0,03	0,54*	0,59*	1,00	-	-
Silt (g/kg)	-0,09	-0,05	0,16	0,20*	-0,19	0,02	0,34*	-0,04	0,18	-0,29*	1,00	-
Clay (g/kg)	-0,14	-0,50	-0,58*	-0,52*	0,67*	-0,70*	-0,20*	-0,50*	-0,68*	-0,78*	-0,37*	1,00

***** $p < 0.05$

CONSIDERAÇÕES FINAIS

Nesta tese padrões da dinâmica florestal em ambientes em restauração foram examinados sob diferentes aspectos. Buscamos caracterizar e mapear as dificuldades encontradas na implementação de projetos de restauração, especificamente em ambientes de antigas pastagens, associando dados climáticos, edáficos e cobertura do dossel como variáveis que também merecem atenção na elaboração desses projetos. Além disso, também analisamos dados com base no senso comum na busca pelo confronto entre o conhecimento formal e tradicional sobre o conhecimento das espécies e ecossistemas tomados como referência para o sucesso da restauração. Destacamos que é preciso atenção ao estabelecer critérios que definem um ecossistema referência, em especial aqueles que serão base para o planejamento de projetos de restauração, espécies presentes em listas publicadas de áreas conservadas destoam das listas obtidas pelo conhecimento comum adquirido ao longo dos anos por pessoas que vivenciaram na prática, e por vezes, participaram do processo de desmatamento. A integração do conhecimento tradicional ofertado pelos idosos locais, aliada aos inventários florísticos, embasaria melhores estratégias para projetos de restauração de áreas degradadas. Nosso estudo em cronossequência de restauração se torna uma ferramenta para os projetos de restauração e embasa novas pesquisas. Foi possível notar avanço sucessional com base na composição da chuva de sementes, área referência e em restauração há 20 anos, mesmo sendo áreas circundadas por pastagem, não apresentaram presença da gramínea *Urochloa brizantha* na chuva de sementes, diferentesmente das áreas em restauração há 5 e 10 anos, que apresentaram elevados valores de densidade de sementes justamente pela presença da exótica. A ocorrência de *U. brizantha* pode limitar o sucesso da restauração, sabendo que sua produtividade é ainda maior em áreas cujo dossel é predominantemente aberto, logo, procedimentos que limitam a disponibilidade de luz, como o uso de telas de sombreamento, poderiam ser testados como um método economicamente viável para reduzir o impacto da competição entre gramíneas e recrutas nativos. Outro achado interessante neste estudo foi que, a menor fertilidade do solo da área não limitou a densidade de regenerantes nativos. Esse achado sugere que o recrutamento bem-sucedido em áreas previamente utilizadas como pastagens não está necessariamente relacionado à maior fertilidade do solo e, portanto, procedimentos como calagem e adição de fertilizantes químicos podem ser desnecessários. Mais que o solo, a luz pode ser um filtro para a restauração florestal de antigas pastagens, pois contribui com o acúmulo de biomassa seca de gramínea exótica como *U. brizantha*. Os dados gerados no presente estudo podem contribuir para a elaboração de projetos de restauração, estratégias de manejo e conservação da biodiversidade. Esta tese deixa questões em aberto e sugerimos que durante a elaboração dos projetos de restauração o gestor questione se o modelo de projeto de restauração florestal utilizado está de fato tendo como presmissa a restauração do ecossistema ou estão trabalhando apenas com a revegetação.

REFERÊNCIAS BIBLIOGRÁFICAS

ALMEIDA, A. F. de. Interdependência das florestas plantas com a fauna silvestre. Série Técnica IPEF, Piracicaba, v.10, n.29, p.36 – 44, 1996.

BARRETT, S. C. H. The evolution of plant reproductive systems: how often are transitions irreversible? Toronto, Canadá. Proceedings of the royal society, n. 280. 2013.

BAKER, H. G. Some Aspects of the Natural History of Seed Banks. In: LECK, M.A.; PARKER, T. V.; SIMPSON. R. L. eds Ecology of Soil Seed Banks. New York: Academic Press, 1989. p. 9-21

BALAGUER, L.; ESCUDERO, A.; MARTIN-DUQUE, J.F.; MOLA, I.; ARONSON, J. The historical reference in restoration ecology: re-defining a cornerstone concept. Biology Conservation, n. 17, p. 12–20, 2014. doi:10.1016/j.biocon.2014.05.007.

BARBOSA, J. M; EISENLOHR, P. V; RODRIGUES, M. A; BARBOSA, K. C. Ecologia da dispersão de sementes em florestas tropicais. In: MARTINS, S. V. Ecologia de florestas tropicais do Brasil. Viçosa-MG: UFV, p. 85-106, 2012.

BRASIL. Conselho Nacional de Meio Ambiente. Resolução nº 02 de 18 de março de 1994.

BUDOWSKY, G. Distribution of tropical American rain forest species in the light of sucessional process. Turrialba, v.15, n.1, p.40-43, 1965.

BUDOWSKY, G. The distinction between old secondary and climax species in tropical Central American lowland forests. Tropical Ecology, n. 11, p. 44-48, 1970.

CAMPOS, É. P. de.; VIEIRA, M. F.; SILVA, A. F.; MARTINS, S. V.; CARMO, F. M. DA S.; MOURA, V. M.; RIBEIRO, A. S. Chuva de sementes em floresta estacional semidecidual em Viçosa, MG, Brasil. Acta Botânica Brasilica, São Paulo, v. 23, n. 2, p. 451-458, 2009.

D’ANTONIO, C. M.; VITOUSEK, P. M. Biological invasions by exotic grasses, the grass/fire cycle, and blobal change. Annual Review of Ecology and Systematics, 23, 63-87, 1992. doi: 10.1146/annurev.ecolsys.23.1.63.

DURIGAN, G.; FRANCO, G. A. D. C.; SAITO, M.; BAITELLO, J. B. Estrutura e diversidade do componente arbóreo da floresta na Estação Ecológica de Caetetus, Gália, SP. Revista Brasileira de Botânica, São Paulo, v. 23, n. 4, p. 371-383, 2000.

EWEL, J. Tropical Sucession: mainfold routes to maturity. Biotropica, v. 59, n. 2, p. 2-7, 1980.

FENNER, M. Seed ecology. London, Chapman and Hall, 1985.

GANDOLFI, S.; LEITÃO-FILHO, H. F.; BEZERRA, C. L. F. Levantamenti florístico e carater sucessional das espécies arbustivo-arbóreas de uma Floresta Mesófila Semidecídua no município de Guarulhos, SP. Revista Brasileira de Biologia, v. 55, n. 4, p. 753-767, 1995.

GONÇALVES, J.L.M.; NOGUEIRA JÚNIOR, L.R.; DUCATTI, F. Recuperação de solos degradados. In: KAGEYAMA, P.Y.; OLIVEIRA, R.E.; MORAES, L.F.D.; ENGEL, V.L.; GANDARA, F.B. Restauração ecológica de ecossistemas naturais. Botucatu: Fundação de Estudos e Pesquisas Agrícolas e Florestais, 2003. p.111-163.

HALLETT, M. L.; DIVER, S.; EITZEL, M. V.; OLSON, J. J.; RAMAGE, B. S.; SARDINAS, H.; STATMAN-WEIL, Z.; SUDING, K. N. Do we practice what we preach? Goal setting for ecological restoration. Restorarion Ecology, n. 21, p. 312–319, 2013. doi:10.1111/rec.12007.

HARPER, J. L. Population biology of plants. New York: Academic Press, 1977. 892 p.

HOBBS, R. J.; NORTON, D. A. Towards a conceptual framework for restoration ecology. Restoration Ecology, Tucson, v. 4, n. 2, p. 93-110, 1996.

HOWE, H. F.; SMALLWOOD, J. Ecology of seed dispersal. Annual Review of Ecology and Systematics, n. 13, p. 201-228, 1983.

HUGHES, F.; VITOUSEK, P.M.; TUNISON, T. Alien grass invasion and fire in the seazonal submontane zone of Hawaii. Ecology, 72, 743-746, 1991. doi: 10.2307/2937215.

JACKSON, S.T.; HOBBS, R.J. Ecological restoration in the light of ecological history. Science, n. 325, p. 567–569, 2009. doi:10.1126/science.1172977.

KATO-NOGUCHIA, H.; KOBAYASHIA, A.; OHNOB, O.; KIMURAA, F.; FUJII Y. Physiology Phytotoxic substances with allelopathic activity may be central to the strong invasive potential of *Brachiaria brizantha*. Journal of Plant Physiology, n. 171, p. 525–530, 2014. doi: 10.1016/j.jplph.2013.11.010.

LAMB, D.; ERSKINE, P. D.; PARROTTA, J. A. Restoration of degraded tropical forest landscapes. Science, v. 310, n. 5754, p. 1628-1632, 2005.

LI, B.; Hao, Z.; Bin, Y.; Zhang, J.; Wang, M. Seed rain dynamics reveals strong dispersal limitation, different reproductive strategies and responses to climate in a temperate forest in northeast China. Journal of Vegetation Science, v. 23, p. 271–279, 2012. doi:10.1111/j.1654-1103.2011.01344.x

LIEBSCH, D.; ACRA, A. L. Síndromes de dispersão de diásporos de um fragmento de floresta ombrófila Mista em Tijucas do sul, PR. Revista Acadêmica, v. 5, n. 2, p. 167-175, 2007.

MACK, R. N.; SIMBERLOFF, D.; LONSDALE, W. M.; EVANS, H.; CLOUT, M.; BAZZAZ, F. A. Technical report biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, n. 10, p. 689-710, 2000. doi: 10.2307/2641039.

MARTINEZ-RAMOS, M.; SOTO-CASTRO, A. Seed rain and advanced regeneration in a tropical rain forest. Vegetatio, The Hague, v. 107, n. 1, p. 299-318, 1993.

MAZA-VILLALOBOS, S.; LEMUS-HERRERA, C.; MARTÍNEZ-RAMOS, M. Successional trends in soil seed banks of abandoned pastures of a Neotropical dry region. Journal of Tropical Ecology, v. 27, p. 35-49, 2011.

MIKICH, S. B.; SILVA, S. M. Composição florística e fenologia das espécies zoocóricas de remanescentes de Floresta Estacional Semidecidual no centro-oeste do Paraná, Brasil. Acta Botanica Brasilica, Rio de Janeiro, v. 15, n. 1, p. 89-113, 2001.

PICKETT, S. T. A.; MCDONNELL, M. J. Changing perspectives in community dynamics: a theory of successional forces. Trends in Ecology & Evolution, London, v. 4, n.8, p. 241-245, 1989.

REFORD, K. H. The empty forest. BioScience, Washington, DC, v. 42, n. 6, p. 412-422, 1992.

RODRIGUES, R. R.; GANDOLFI, S. Recomposição de florestas nativas: princípios gerais e subsídios para uma definição metodológica. Revista Brasileira de Horticultura Ornamental, v. 2, n. 1, p. 4-15, 1996.

RODRIGUES, R.R.; GANDOLFI, S. Restauração de florestas tropicais: subsídios para uma definição metodológica e indicadores de avaliação e monitoramento. In: DIAS, L. E.; MELLO, J. W. V. de (eds.). Recuperação de áreas degradadas. Viçosa: UFV, 1998. p. 203-215.

RODRIGUES, R. R.; BRANCALION, P. H.; ISERNHAGEN, I (org.). Pacto pela restauração da mata atlântica: referencial dos conceitos e ações de restauração florestal. Lerf/Esalq: Instituto Bioatlântica, 2009.

SERI (Society for Ecological Restoration International Science and Policy Working Group). 2004. The SER International Primer on Ecological Restoration. Society for Ecological Restoration International, Tuscon, Ariz. [Online.] Available from www.ser.org.

SHACKELFORD, N.; HOBBS, R. J.; BURGAR, J. M.; ERICKSON, T. E.; FONTAINE, J. B.; LALIBERTE, E.; RAMALHO, C. E.; PERRING, M. P.; STANDISH, R. J. Primed for change: Developing ecological restoration for the 21st century. Restoration Ecology, n. 21, p. 297–304, 2013. doi:10.1111/rec.12012.

SHONO, K.; CADAWENG, E. A.; DURST. P. B. Application of assisted natural regeneration to restore degraded tropical forestlands Restor. Ecology, v. 15, n. 4, p. 620-626, 2007.

STANTURF, J. A.; PALIK, B; J.; DUMROESE, R. K. Contemporary forest restoration: A review emphasizing function. Forest Ecology and Management, v. 331, n. 1, p. 292–323, 2014.

TABARELLI, M.; SANTOS, B.; ARROYO-RODRÍGUEZ, V.; MELO, F. Secondary forests as biodiversity repositories in human-modified landscapes: insights from the Neotropics, Belém, PA. Ciência Nature, v. 7, n. 3, p. 319-328. 2014.

TOSCAN, M. A. G. Análise da chuva de sementes de uma área reflorestada do corredor de biodiversidade Santa Maria, Paraná. Ambiência, v.10, p. 217-230, 2014.

VAN DER PIJL, L. Principles of dispersal in higher plants. 3. ed. New York: SpringerVerlag, 1982. 215 p.

YANG, D.; KANAE, S.; OKI, T.; KOIKE, T.; MUSIAKE, K. Global potential soil erosion with reference to land use and climate changes. Hydrol. Process, v. 17, p. 2913–2928, 2003.

WHITE, P. S., WALKER, J. L. Approximating nature’s variation: selecting and using reference information in restoration ecology. Restoration Ecology, n. 5, v. 4, p. 338–349, 1997. doi:10.1046/j.1526-100X.1997.00547.x.