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"*Em princípio, o que quero dizer é que cada pessoa escolhe se vai sair do torno triturada ou com um polimento brilhante".*

Elisabeth Kübler Ross, M.D.

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Resumo

O cenário global político ambiental e o comprometimento do Brasil em restaurar extensas áreas aumenta a preocupação com o fornecimento de materiais para implementação desses projetos. Para conhecer a situação da produção de sementes e mudas no Amazonas, fizemos um levantamento dos produtores do estado com visitas aos locais de produção e aplicação de formulário. Os dados obtidos foram analisados a partir de estatística descritiva. A produção de sementes e mudas no estado do Amazonas ainda é incipiente quando comparada com a necessidade de provisionamento para compromissos de restauração assumidos pelo Brasil. Para atingir essa finalidade, uma base de dados atualizada e consistente se torna necessária, que pode se originar de informações do Renasem. A quantidade produzida ainda não é significativa, porém pode ser aumentada usando a mesma infraestrutura e número de produtores. Uma mudança do enfoque de produção de espécies nativas com potencial de restauração será necessária para que seja essa a principal destinação do material de plantio. Dessa maneira, o setor econômico produtivo de sementes e mudas precisa ser expandido, porém ainda depende de incentivos externos para operação, principalmente no quesito financeiro.

Palavras chave: Amazônia, propagação vegetativa, cadeia produtiva da restauração, Renasem, produtores de sementes e mudas

Abstract

The global environmental policy scenario and Brazil's commitment to restore extensive areas increases the concern about provision of material for implementation of these projects. To understand the situation of the production of seeds and seedlings in Amazonas state, we did a survey of producers in the state with visits to places of production and application of form. The data obtained were analyzed based on descriptive statistics. Seed and seedling production in the state of Amazonas is still incipient compared to provisioning need for restoration commitments in Brazil. To this end, a data base updated and consistent is required, that could stem from Renasem's record information. The quantity produced is not yet sufficient to re-establish floral richness of the Amazon. A shift to focus on production native species with restoration potential will be needed for this to be the major destinations of planting material. Thus, economic, production-related sector of seed and seedling needs to be extended, however seems to depend on external incentives for operation, specially regarding financial performance.

Key words: Amazon, plant propagation, productive chain of restoration, Renasem, seed and seedling producers

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Introdução

A exploração mais significativa do território Amazônico se iniciou após a colonização dos europeus, com o ciclo da borracha, o extrativismo de "drogas do sertão" e outras espécies de interesse econômico, por exemplo o Pau-rosa (Pontes Filho 2011). O desenvolvimento da região seguiu com projetos governamentais desenvolvimentistas que tinham a intenção de ocupar o território e assim promover crescimento econômico (Pontes Filho 2011).

O processo de desmatamento mais expressivo começou com a abertura da Rodovia Transamazônica a partir da década de 70 (Fearnside 2005). Desde então, a degradação da floresta Amazônica passou a ser mais intensa e acelerada (Fearnside 2005) e as taxas de desmatamento da Amazônia Legal apresentam uma tendência de aumento na maior parte dos anos, principalmente a partir de 1991 (INPE 2019).

A principal consequência imediata do desmatamento é a perda de biodiversidade e, à longo prazo, as mudanças climáticas e diminuição na provisão de serviços ambientais (Fearnside 2005). A restauração ecológica é apontada como uma possível solução para a perda de serviços ambientais causada pelo desmatamento (Hobbs e Harris 2001; Chazdon 2008).

A restauração ecológica pode ser definida como "processo de auxiliar a recuperação de um ecossistema que foi degradado, danificado ou destruído" (SER 2004). A restauração busca alterar o ecossistema para que este restaure as relações ecológicas anteriormente estabelecidas e pode ser conduzida de forma ativa e/ou passiva (DellaSala *et al.* 2003). A estratégia pode consistir em combinar mais de uma técnica de restauração, como restauração ativa por plantio de mudas de espécies pioneiras associado com semeadura direta de espécies não pioneiras e de sementes grandes (Camargo *et al.* 2002; Souza e Engel 2018). O plantio direto pode ser efetuado pelo método da muvuca de sementes, que adiciona diversificadas espécies nativas plantadas manual ou mecanicamente (Schmidt *et al.* 2018).

Uma definição enfatizando o processo da restauração como um todo, ao invés de apenas o objetivo final de revegetação, engloba os contextos históricos, culturais, sociais, políticos, morais e estéticos (Higgs 1997). Dessa forma, a restauração ecológica deve abordar propósitos políticos, sociais e ecológicos com objetivos claros, principalmente para iniciativas em larga escala (Mansourian *et al.* 2017).

Diversos países estão buscando trabalhar com politicas publicas para a conservação dos recursos naturais. Exemplos de políticas públicas visando a conservação de recursos naturais de escopo mais abrangente podem ser citadas no Brasil e no âmbito mundial, como o Bonn Challenge e a iniciativa 20x20, em 2014, que foram incorporadas como Contribuição Nacionalmente Determinadas no Brasil no Acordo de Paris em 2015 (UN 2019, WRI 2019). O comprometimento do Brasil nesse acordo foi de restaurar mais de 12 Mha até 2030. O Decreto Nº 8.972/2017, que trata sobre a Política Nacional de Recuperação da Vegetação Nativa – Proveg, objetiva aproximar e proporcionar políticas, programas e ações nacionais que impulsionem a restauração da vegetação nativa nos termos da lei, por meio do Plano Nacional da Vegetação Nativa – Planaveg, promulgado através de Portaria Interministerial Nº 230 em novembro de 2017. O Sistema de Cadastro Ambiental Rural – Sicar, os instrumentos do Plano de Regularização Ambiental – PRA e as linhas de ação e apoio e incentivo à conservação do meio ambiente da Lei de Proteção da Vegetação Nativa são exemplos de outros mecanimos da legislação no qual o Planaveg se baseia.

A Lei Nº 12.651/2012, a Lei de Proteção da Vegetação Nativa (LPVN), apesar de diminuir as áreas protegidas em propriedades rurais e dar anistia a desmatamentos anteriores a julho de 2008, instituiu o Cadastro Ambiental Rural – CAR. A partir desse, pretende-se regularizar áreas protegidas na propriedade, como Áreas de Proteção Permanente - APP e Reserva Legal - RL, utilizando para isso os Programas de Regularização Ambiental – PRA nos estados. Esses mecanismos da LPVN podem ampliar os esforços para restauração da vegetação suprimida de propriedades rurais, que somam 21 ± 1 Mha de área irregular (Soares-Filho *et al.* 2014). Outro mecanismo dessa Legislação é a Cota de Reserva Ambiental - CRA, que permite a comercialização de áreas de floresta nativa não protegida por lei para proprietários rurais irregulares. Esse mercado pode suprir 56% de RL não preservadas (Soares-Filho *et al.* 2014).

Diante deste cenário de necessidade de restauração florestal de extensas áreas, a produção de sementes e mudas é indispensável. Essa atividade organiza a cadeia produtiva da restauração ecológica, além de proporcionar oportunidades de desenvolvimento socioeconômico. Para regulamentar essa atividade a Lei Nº 10.711/2003 e o Decreto Nº 5.153/2004 estabeleceram o Sistema Nacional de Sementes e Mudas. A legislação define o produtor de sementes ou mudas como “pessoa física ou jurídica que, assistida por responsável técnico, produza a semente/muda destinada a comercialização”. Todos os produtores precisam ter seus cadastros no Registro Nacional de Sementes e Mudas - Renasem. Nesse registro, devem especificar um responsável técnico e listar as espécies que pretendem produzir cadastradas no Registro Nacional de Cultivares - RNC. A Instrução Normativa do Ministério da Agricultura, Pecuária e Abastecimento - MAPA nº 56/2011 foi substituída posteriormente pela IN nº 19/2017, que regulamenta a produção, comercialização e utilização de espécies florestais. A principal alteração da referida IN é dispensar das obrigações dispostas na Lei nº 10.711/2003 e IN do MAPA Nº 17/2017 os produtores com produção anual inferior a 10.000 mudas de espécies nativas.

Em 2006, estimou-se uma demanda de 56,5 milhões de mudas para a Amazônia, mais de 91,5 milhões para todo o Brasil (Moreira 2006). Baseado nesse número foi estimado um déficit de 43,9 milhões de mudas para atender a demanda de todo o país. A demanda de sementes estimada para cenários com maior ou menor utilização de sementes para plantio direto e produção de mudas varia de 809 a 2.991 ton/ha (Freire *et al.* 2017). No entanto, a área que deve ser restaurada é possivelmente menor (58% inferior ao previsto anteriormente), devido às mudanças da Lei de Proteção a Vegetação Nativa, em que RLs ou APPs desmatadas ilegalmente antes de 2008 deixam de ser irregulares (Soares-Filho *et al.* 2014). Essa redução de áreas a serem restauradas, provavelmente, reduziu a demanda por mudas. Mesmo considerando menores áreas de restauração com plantio de mudas, supõe-se que a provisão de sementes e mudas pode retardar ou prejudicar esforços de restauração em larga escala (Moreira da Silva *et al.* 2017). Números mais acurados só estarão disponíveis após a conclusão e divulgação do CAR nos estados.

Um levantamento das espécies florestais de interesse econômico e do cenário de produção de sementes e mudas foi feito recentemente na Amazônia Ocidental por Calvi e Ferraz (2014). Apesar da riqueza de espécies das florestas tropicais da Amazônia ser estimada em 14.003 espécies (Cardoso *et al.* 2017), na Amazônia Ocidental foram levantadas apenas 788 espécies de relevância econômica com usos madeireiro, alimentício, medicinal, ornamental e artesanal (Calvi e Ferraz 2014; Ferraz e Calvi 2015). Baseado nos registros do Renasem, os autores verificaram que o número de produtores de sementes e mudas florestais cadastrados nos estados da Amazônia Ocidental ainda é pequeno (Acre = 19, Amazonas = 60, Rondônia = 64, Roraima = 6; totalizando 149 cadastros). A maior parte de sementes (79 – 84%) e mudas (50 – 67%) registrados no Renasem na Amazônia Ocidental foram nativas do bioma, enquanto que espécies nativas de outros biomas ou exóticas foram destinadas principalmente à ornamentação e alimentação, no entanto, nesse estudo não foi verificada a quantidade e número de espécies realmente produzidas, além disso, não menciona a destinação de mudas para restauração florestal (Calvi e Ferraz 2014).

É importante ressaltar que o número de espécies listadas no registro junto ao Renasem provavelmente é superestimado uma vez que é vantajoso para o produtor declarar um número maior de espécies produzidas para não precisar alterar os registros e se submeter a novas taxas (Calvi e Ferraz 2014). Para muitas dessas espécies ainda faltam conhecimentos científicos: apenas um terço das espécies listadas no levantamento possuem normas para avaliação da qualidade das sementes e menos da metade dispõe de classificação quanto ao comportamento da semente no armazenamento (Calvi e Ferraz 2014). Conhecer a classificação da semente quanto ao armazenamento (ortodoxa, recalcitrante ou intermediária) (Roberts 1973; Ellis *et al.* 1990) é indispensável para manejar e comercializar sementes pois informam quanto à possibilidade de armazenamento a longo prazo das mesmas sem perder o poder germinativo.

Diante do compromisso brasileiro em restaurar 12 Mha de vegetação nativa brasileira, um dos grandes desafios é a produção de sementes e mudas. Para isto, no estado do AM é preciso realizar um trabalho mais acurado sobre os produtores de sementes e mudas, considerando os aspectos sociais, políticos, econômicos e de conhecimento técnico para o avanço do setor florestal e, assim, contribuir no processo de restauração. Portanto, o intuito deste trabalho é verificar a situação atual da produção de sementes e mudas florestais nativas além dos dados registrados para o estado do Amazonas. Desse modo, os dados obtidos serão úteis para embasar pesquisas na área de tecnologia de sementes florestais e direcionar políticas públicas de desenvolvimento socioeconômico e de restauração florestal. A produção de sementes e mudas desponta como uma oportunidade de valorização e conscientização da importância da floresta e demais formações vegetais brasileiras, incluindo o desenvolvimento econômico e social.

Apresentamos no primeiro capítulo uma visão geral da quantidade, perfil socioeconômico, capacidade produtiva, dificuldades técnicas dos produtores de sementes e mudas com o intuito de reconhecer as possíveis restrições para restauração ecológica no Amazonas. No segundo capítulo, as espécies produzidas são listadas com sua origem e usos descritos. Estabelecemos relações de uso e potencial de conservação das espécies produzidas, além de levantar lacunas de conhecimento das espécies consideradas prioritárias para os produtores do estado. A capacidade produtiva de espécies nativas no Amazonas e a aplicabilidade dessas para restauração afetam os resultados das iniciativas de restauração, contexto em que se insere este trabalho.

Objetivos

Geral

Caracterizar o potencial de produção de sementes e mudas nativas para restauração florestal e apontar os gargalos desse setor no estado do Amazonas.

Específicos

- Verificar a confiabilidade dos dados oficias de registro de sementes e mudas no estado do Amazonas;
- Caracterizar o perfil dos produtores e da produção de sementes e mudas no estado do Amazonas;
- Analisar o potencial produtivo do setor de sementes e mudas do estado do Amazonas;
- Compreender as principais dificuldades enfrentadas para produção de sementes e mudas no estado do Amazonas;
- Descrever os usos e origem de ocorrência natural das espécies produzidas no estado do Amazonas;
- Especificar quais são as espécies de maior interesse comercial no estado do Amazonas

Capítulo 1

Marques, M. C., Calvi, G. P., Arruda, Y. M. B. C., Ferraz, I.D.K., 2019. Behind the forest restoration scene: a social, economic and scientific setting in Amazonas, Brazil. Manuscrito em preparação para publicação na revista *Restoration Ecology*.

Abstract

Brazilian Legal Amazon forest conservation is a global concern, and Amazonas is the largest state in this politically designated area. Amazonas stands out for its great area, with over 91% of forest cover. This study comprises a detailed survey of the 35 native seed and seedling producers in Amazonas, through open and closed questions and descriptive statistical analyses. We also researched the main bottlenecks for production from the producers' point of view. This field data obtained indicates that official Brazilian Ministry of Agriculture data needs improvements so that it can be better used for habitat restoration planning. Producers are mainly privately-owned family businesses and medium-sized operations (25,000 – 250,000 seedlings/year). Seed production could be expanded more than five times, whereas seedling production could be nearly eight times the amount produced in 2018. Amazonas production is principally focused on species (including exotics) for food production (48% of seeds and 74% of seedlings). In most cases, problems cited by producers were in areas outside their production knowledge, e.g., trade, legislation, and logistics. Low demand for species was the most noteworthy constraint for seed and seedling production, followed by problems in transportation, and bureaucracy. All possible efforts done by the federal government to improve quality and monitor commercialization of seeds and seedlings is a kickstart to improve the sector. But it is time to invest in enhancing financial sustainability, and in knowledge bases to achieve adequate quality standards.

Key words: Amazon, plant propagation, rainforest restoration, Renasem, seed and seedling producers

Introduction

Decreasing forest cover is a global issue, and 12% of world's forested area is located in Brazil (FAO 2015). Excluding the possibility of making good use of resources and ecosystem services impairs conservation effectiveness (Diegues 2001). Forest biodiversity use is restricted to few commercial species, though there is potential of diversifying economic utilization (Schmidt 2007). Timber is the most usable forest product, engaging in a broader use of forest, but resources (ecosystem goods and services) is urged to conserve this ecosystem (Myers 1988).

Ecological restoration is "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004), and has been a part of world's agenda for biodiversity conservation (Aronson & Alexander 2013). International public policy such as the Bonn Challenge, 20x20 Initiative and the Paris Agreement are examples of international agreements for that purpose (WRI 2019; UN 2019). Socio-economic aspects must be incorporated in restoration, as reported Atlantic Forest initiatives with profit generation for private land-owners and other stakeholders (Mesquita et al. 2010; Melo et al. 2013).

Some of the restoration techniques require seed, and/or seedling, planting. Therefore, seedling supply could constrain large-scale restoration in Brazil since its supply chains rely on seed and seedling production and other intricate processes (Moreira da Silva et al. 2017). Planting material supply in terms of quantity, species diversity and quality concerns directly affect ecologically sound restoration projects (Ladouceur et al. 2018). The structure in seed supply would involve formal and informal sectors of production, context of public policies, and actors associated with related tasks (Lillesø 2006). A well-functioning seed system should have research and practioner actors tightly connected, legislation requiring only minimum guidelines and quality control (Schmidt

2007). In Brazil, political and administrative organization of seed and seedling production is with the Ministry of Agriculture, Livestock and Food Supply (MAPA). Federal law no. 10.711/2003 introduced a national system of production of seeds and seedlings. Only eight years later specific rules for native and exotic tree species were regulated, posteriorly revoked in 2017. Renasem is the Portuguese acronym for National Registry of Seeds and Seedlings in which private and corporate businesses have to be accredited.

The invisibility of seed suppliers in Brazil is underscored by Urzedo et al. (2019). Accordingly, a research verified that a majority are private nurseries, followed by governmental nurseries and a smaller number of association/cooperatively owned ones in Brazil (Moreira da Silva et al. 2017). The same study pointed to a scarcity of Amazon region nurseries, however, they did not provide details on their distribution (Moreira da Silva et al. 2017). The Legal Amazon comprises nine states and more than half of the country's land area. Amazonas, one of the states within the Legal Amazon, is Brazil's largest state with 62 municipalities and approximately 4 million inhabitants (IBGE 2019). Population literacy rate is around 88%, and regional economy has an estimated *per capita* income is below minimum wage, and the (IBGE 2019).

Recent global restoration researches are assessing the capability of seed and seedling provision. The estimated demand for provisioning of native seeds in restoration situations established a percentage-based area to be planted in each restoration technique which varies from 809 – 2,991 ton/ha (Freire et al. 2017). There are often several estimated amounts of seedlings, however we verified in the field, the information detailed on production and producers in Amazonas.

This paper provides a current appraisal of the quantity and provision capability of native seed and seedling producers in Amazonas. Here we present results of field data about seed and seedling production in the state, focusing on economic, public policy and social issues. We compare official Brazilian government data with producers' self-declared information. We also investigate production capacity under current scenario and the possibility of market extension, as well as examining socio-economics, planting material destination, and technical difficulties. Results provide a diagnosis of the state's production and points to gaps where public policy and private investment can act to achieve restoration baselines.

Methods

Seed and seedling producers' survey

Seed and seedling producers in the nine states of the Brazilian Legal Amazon were appraised in November 2018 at the official website of Ministry of Agriculture (MAPA 2018).

In Amazonas state, we verified the number of producers with at least native species combined with exotic species and active production. Therefore, we filtered them by production, leaving only 35 producers in the study. Producers without registration in MAPA were estimated using the snowball method (Goodman 1961), where a known group of individuals were asked to indicate other producers in the survey. No interviews were done with these producers without registration.

A detailed study was done with Amazonas producers who had declared to work with native species. Production sites were visited and compared to official registrations. In the Manaus metropolitan area: Manaus, Iranduba, Rio Preto da Eva, Presidente Figueiredo, Careiro; Itacoatiara, and farther away: Maués, Parintins, Apuí, Humaitá, and Manicoré, a total of 30 seedling and 5 seed producers were interviewed (Figure 1).

Interviews were performed during visits to production and points of sales, with open and closed questions (Supporting Information 1). The half-structuralized questionnaire was arranged in five sections: socio-economic profile of seed suppliers and nursery owners; their economic arrangements; production quantification of average annual production and self-declared maximum production capacity; final destination of planting material; and bottlenecks of seed and seedling production. All responses to questionnaires were self-declared and not systematically verified.

The identification of the bottlenecks in seed and seedling production was accessed throughout the questionnaire and with one specific question partly driven to technical, scientific, logistical and commercial obstacles. We classified problems and difficulties with seed and seedling production into biological, economic and political aspects, each with several categories (Figure 2).

Data analyses

Data obtained by closed questions were tabulated and each producer received a number in decreasing order of maximum production capacity (being 1 the seed supplier with highest production capacity, and 5 the one with the lowest production capacity; 1 the nursery owner with the highest production capacity, and 30 the one with lowest production capacity). Descriptive statistics – frequencies, percentages, means and cross tabulations among variables – allowed us to analyze data obtained in the questionnaire sections.

To analyze results of open questions we considered the number of citations, where one producer could cite several items in each bottleneck.

Results

Seed suppliers and nurseries based on the official site in nine states of the Legal Amazon compared with field visits in Amazonas state

A total of 299 seed suppliers and 499 nurseries were registered in the nine states of the Legal Amazon at MAPA (Table 1).

During our visits we checked the numbers in Amazonas state. Of the nine registered seed suppliers three had closed and one was registered twice, resulting in five seed suppliers in 2018 (Table 1). Of the 74 nurseries, 24 (32%) had stopped production. The snowball method revealed another 54 nurseries which were not listed on the official site, in a total of 42% representing the invisibility of producers (Table 1).

Seed suppliers and nurseries were distributed in 11 municipalities, most of them (68.6%) in the Manaus Metropolitan Area (Figure 1).

Details of Amazonas state's producers and production

Seed suppliers and nursery owners (n = 34) were primarily (88%) private enterprises, with ages between 41 and 65 years (57%) and male (70%) (Figure 3). A University degree or even post-graduate degrees had been obtained by 51%, in Agronomy (6), Business and Administration (4), Forestry (3), and other producers with miscellaneous degrees.

Functioning of seed suppliers (n = 5) varied from 4 – 25 years, whereas nurseries (n = 30) ranged from months of operation to 37 years, as of 2018. Workforce which included family members occurred in 21 (70%) of the nurseries and one (20%) of the seed suppliers.

The major production of seeds (48%) and seedlings (74%) was food for plantations for human consumption, such as fruit trees (*Citrus* spp. - Rutaceae), Brazil-nut tree (*Bertholletia excelsa* - Lecythidaceae) and other native fruit species in smaller proportions; palm trees (*Euterpe oleraceae)* and guarana (*Paullinia cupana* - Sapindaceae).

Other important uses for seeds were in ecological restoration (35%), scientific research (15%) and on a smaller scale, urban trees planting (2%) (Figure 4). Seedlings were also produced for ecological restoration (8%), landscaping (5%), urban trees plantation (8%), and other destinations (5%) (Figure 4).

Based on the information from either the owner (22) or the production manager (13) we show data from 30 nurseries with native plant seedling production and 5 seed producers in Amazonas. Annual seed and seedling production was below maximum capacity (Figures 5 and 6). Seed supplier (Se 3) with the current largest production was not the same as the one with the highest potential to increase production capacity (Se 1) (Figure 5). Over one million seedlings, almost four tons of seeds comprise the average currently produced; and 9.7 million seedlings (~ sevenfold), and 21.8 tons of seeds (~ fivefold) would be the maximum production capacity (Figures 5 and 6).

We observed three sizes of nurseries based on maximum capacity: below 25,000 seedlings/year (n = 7), between 25,000 and 250,000 seedlings/year (n = 16), and above 250,000 seedlings/year (n = 7). Based on registered annual production, estimated seedling production was 413,600 seedlings/year in Amazonas (M. M. Pereira 2019, MAPA, Manaus, AM, personal communication).

Regardless of the size of production, none of the producers calculated or documented their credits and expenses in detail. Production costs and profits were based on producers’ estimates. Small-sized nursery profits ranged from 46 to 83%, whereas medium and large-sized varied from 25 to 90%. However, 57% of the small nurseries (<25,000 seedlings/year) could not even estimate their production costs, emphasizing the informality of the enterprise. Even larger nurseries (> 250,000 seedlings/year) had two of seven producers who could not estimate costs. Seed suppliers and nurseries generated jobs for 201 people in 2018. The percentage of temporary workers was 60% in seed supply and 80% in nurseries.

The only nurseries (n = 2) which had equal or greater demand than production are medium or large-sized. The nursery (no. 18) with superior demand produces mainly *Citrus* spp. Commercial demand was considered small in relation to capacity by most nurseries (83%), independent of business size. Although all small producers considered demand smaller than production capacity, 29% of them were not interested in promoting their enterprise.

Bottlenecks of Seed and Seedling Production

Bottlenecks were diverse, here classified in 10 categories (SI 2). The difficulties were essentially related to Business and Trade, Logistics, and seed and seedling Legislation. Demand below producers' capacity for forest species was the most conspicuous difficulty, as fruit trees and ornamentals had higher demand. We can establish interconnections between low demand and other bottlenecks within Business and Trade, such as business management flaws and deficiencies in financial resources; and with other categories such as difficulties in transportation (in Logistics), deficiency in government technical support (in Public Policy), and non-stock material of seedlings (in Seedling Production). An overview of the difficulties cited for seed supply and seedling production is shown in Figure 7. In the first category, Business and Trade, besides the largest bottleneck "low demand for forest species", there followed “volatile demand”, “financial resources”, “informality of the business”, “management”, “quality *vs.* price”, “access to consumers”, “association/cooperative”, “trade competition” were cited with similar importance (3 – 7 citations each).

The second most-cited bottleneck was transportation, caused by the size of the state (Table 1), or even lack of road access and dependence on river transportation (Figure 1).

The third most-cited item was Legislation, with bureaucracy to comply with legislation, e.g., each species produced has to be registered with many details, and there are registration taxes. Another bottleneck cited in this category was that a technical supervisor with a university degree is required, increasing costs and not always providing technical assistance. Auditing of irregular producers was cited and respondents implied that non-registered producers may be more competitive, as operational costs are lower. Our findings corroborate this, as 42% of all producers were not registered (Table 1), however we do not know their degree of competitiveness as their production was not assessed. Regular producers can only commercialize species listed in the Cultivars National Registry (RNC in Portuguese). RNC may hinder production, as it fails to address all species, regional variations of popular names, and updates in taxonomy for native species. Access to legal orientation was considered a difficulty, as laws may be difficult to understand plus tracking updates in legislation. Of the interviewed producers, 49% did not understand the seed and seedling legislation. Reports on why they do not understand it include: technical language and excessive details. Legislation updates were not followed by 54% of producers; they cited lack of interest and reliance on the technical supervisor for updates. The need for registration of seed collection areas or individual parent trees hampers production, as paperwork is needed with a GPS fix, which was not accessible for four producers. Based on geographic and historical situations in the Amazon region, landholding is not always with legal title, which was a difficulty for two nurseries.

The need for technical knowledge came up only after political-economic obstacles (Business and Trade, Logistics and Legislation). Nurseries cited Seed Supply, with seed availability as the major bottleneck, while seed suppliers indicated collection and storage. Reduced seed availability was cited considering low fruiting synchronization between trees and low densities of desired species in natural habitats. The whole process of seed collection is a labor-intensive activity and may risk workers' safety when collecting in tree crowns in tropical forests. A high percentage of desiccation-sensitive seeds in Amazonian species and the need for of dry- and wet-storage facilities were noted as storage difficulties.

Biotic and abiotic bottlenecks were related to pest and disease control, more intense in the tropical climate, climatic peculiarities in the tropics, and botanical identification of species in a highly diverse, sometimes undescribed flora.

Seedling Production had bottlenecks in the following order of mention: seedling propagation techniques, production planning, seed prices, germination/dormancy, and non-stock material. Plant diversity creates the need for awareness of species-specific technical expertise to germinate seeds and produce seedlings. In addition, native species may not show uniformity in germination. Seedlings under tropical conditions have increased growth rates and cannot be maintained in the nursery for a long time; therefore, unsold products have to be discarded. Orders take place by the rainy season, so producers have to plan and align seed availability, and time for seedling growth so as to be ready by planting season.

Effectiveness of public policies, priority for local production, support for seed and seedling production, development of the primary sector, and technical assistance were cited in the Public Policy category. Amazonas state producers felt the need to recognize the limitations of forest resources, and the possibility of plantation of native species of economic interest.

Human Resources, Knowledge Sharing, and Vegetative Propagation matters were the three least-cited categories. These categories were specifically listed by 8 – 1 producers without necessarily meaning they are less important.

Discussion

Seed suppliers and nurseries based on the official site in nine states of the Legal Amazon compared with field visits in Amazonas state

Our field visit results demonstrate the invisibility of seed suppliers and nurseries. Our quantification of Amazonas state producers is higher than what was found in another survey via telephone calls for the Amazon biome (Moreira da Silva et al. 2017, 2015). Legal Amazon official data would total 499 nurseries and 299 seed producers. However, likewise Amazonas, other states probably have producers in MAPA's database which are not producing anymore. Accordingly, if we considered the same proportion of closed nurseries and seed suppliers in Amazonas, the other states of Legal Amazon, would comprise 337 (67.6%) nurseries and 166 (55.6%) seed suppliers. In addition, there would be invisible Legal Amazonas producers uncomprised in the database.

The number of Amazonas seed suppliers and nurseries could be explained by the deforestation rate in this state. Outside the Legal Amazon, São Paulo state has a structure of 209 nurseries producing 37 million seedlings/year, with most of the nurseries (30%) in the 100,000 to 499,999 seedlings/year category and maximum production capacity above 77 million seedlings/years (Barbosa et al. 2018). Amazonas state is much larger in area, still, maximum production capacity is almost eight times smaller probably explained by greater area of forest cover and, legislation compliance for protection of vegetation in Amazonas. Hence, Amazonas would require less seeds and seedlings for restoration, and seed suppliers and nurseries in the state would produce for a different share of the market.

The number of nurseries and seed suppliers is reasonable as a much smaller number was reported for Amazon biome (Moreira da Silva et al. 2017). However, 68.6% are concentrated in Manaus metropolitan area (Figure 1). Since Amazonas is the largest state in Brazil, a well-distributed seed and seedling network is desirable to accomplish ecologically sound restoration by matching species composition with planting material provenance.

We can only speculate that the closed nurseries were unable to survive in the market; conceivable reasons could be insufficient sales, lack of knowledge, or preparation. Non-registered seedling producers were not verified in terms of economic activity or production. However, depite their invisibility, they feed the informal economy. Even in São Paulo, a state with longer experience and greater development of the sector, there is still a large number (80.4%) of non-registered seedling producers (Piña-Rodrigues et al. 2018). This study did not elucidate details on non-registered producers, therefore a national study is needed to undercover investigation and detail this information.

We highlight the invisibility of Brazilian seed and seedling production as is not yet fully on government record. For example, the numbers of registered nurseries do not correspond to reality. Once registered, the producer remains in the database irrespective of registration renewal. MAPA also requires six-month reports on seeds and seedlings produced, however, most registered producers do not adhere to this condition and MAPA staff is reduced to assure enforcement of this term (M. M. Pereira 2019, MAPA, Manaus, AM, personal communication). Additionally, there are: non-commercial operations or production smaller than 10,000 seedlings/year, which are not part of MAPA's official registry.

Details of Amazonas state's producers and production

We found the majority of producers being by private initiative, corresponding to the results obtained for a study at the national level in Brazil (Moreira da Silva et al. 2015). Associations show potential success for business implementations, specially for small-scale nurseries (Frost & Muriuki 2006). The only association ownership reported here was a seed supplier, although there were associations for promoting sales of ornamental plants. Additionally, working in associations makes possible higher amount of seed provision, fulfilling large-scale demands (Frost & Muriuki 2006).

NGOs, private companies and government agency subsidies were pointed as a downside for the development of private initiative small-scale nurseries in Africa and Asia (Nyoka et al. 2015). In Amazonas, NGOs and government agencies is inconspicuous and there are three nurseries providing seedlings free of charge. Letting the market work is the business-as-usual procedure for economic enterprises, this way producers would have to be able to survive in the market with its own management skills. However, government intervention is necessary when it is a public policy, such as is applied for ecological restoration in private land regularization with the LPVN, and Bonn the Challenge international agreement. As reduced economic resources is a common drawback for producers in developing countries, government assistance might be necessary to develop a strong sector providing good quality material (Harrison et al. 2008).

More than a third of the producers did not have higher education and this would be a concern, as it would be harder for them to examine and put into practice scientific and technical publications. In these cases, the technical supervisor is supposed to provide guidelines and solve possible production difficulties.

The deforestation rate in Amazonas is among the lowest when compared to other states in the Legal Amazon (INPE 2019), hence the area to be restored is much smaller, a more likely reason for food production being the main objective. Seed and seedling producers have to wait for the restoration market to grow and mean while reach out to the markets of food production, landscaping and urban reforestation to remain in business. Still, demand for native species destined for restoration projects is to be expected with the program of environmental regularization enforcement from the LPVN.

Seed transport is easier and lower-cost than for seedlings, which could explain the higher proportion of seeds than seedlings for restoration. Therefore, seeds can be sold to bording states with higher deforestation rates, whereas seedlings would be restricted to short-distance transportation. Urban trees destination was more prominent in seedling than in seed production as seedlings are mostly used for such purposes. This also explains the absence of landscaping plants in the seed supply.

Without any infrastructure or increase in number of suppliers, it is possible to augment seed and seedling production. Widely discussed restoration techniques and strategies to lower time and cost required, while still yield ecosystem services, can diminish number of seedlings demand as opposed to the total area planting method (Lamb et al. 2005; Chazdon 2008; Rodrigues et al. 2009). Taking the native tree planting in the total area at a planting distance of 3x2 meters, 1,667 seedlings per hectare would be needed. The maximum capacity of Amazonas would fulfill 11.6% of the total deforested area in the state. Therefore, to rectify environmental passives production would have to be greatly increased.

Restoration projects represent a possibility to provide social enhancement (Melo et al. 2013). In this study, legally contracted labor equaled 201 and most businesses hired temporary workers. This corroborates with another study that demonstrates that seed and seedling production plays a part in socio-economic growth in Brazil (Moreira da Silva et al. 2017). Additionally, a study case in 2012 shows that seed collection can yield over four times the Brazilian minimum wage if collectors efforts were dedicated full-time work in this activity (Brancalion et al. 2012).

Analyzing each category of producers, large producers had lower profits probably because they cut prices to sell larger quantities. Whereas small producers have greater profitability as they sell smaller quantities, so they can have higher prices.

Producers did not track costs in detailed spreadsheets, no costs separated by species, nor did they have any interest in marketing techniques to increase sales. Consequences of not handling gross margin per seedling could be operating in debt when costs were considered per species (Frost & Muriuki 2006). Besides the cost of production included in variable costs, it is important that the producers estimate their depreciation costs, legally contracted labor, insurance, fees, taxes, rental, among others (Farias et al. 2018). Part of our concern is that producers have the capacity to expand output with existing infrastructure but might be unprepared to manage financial resources and labor in major upgrades.

Market surveys are crucial to assess allocation of demand for new and functioning seed producers as customers' expectations vary on size, quantity, and species list varies with destination of planting material (Turchetto et al. 2018; Schmidt 2007).

Additionally, marketing strategies enhance trade possibilities, e.g. providing catalogues with basic information for each species (Schmidt 2007).

In other regions of Brazil, the production sector is also exceedingly informal (Moreira da Silva et al. 2017) and other countries' experiences of advanced native seed and seedling provision are connected to restoration initiatives (Smith et al. 2007; Broadhurst et al. 2008; Merritt & Dixon 2011; Oldfield & Olwell 2015; Ladouceur et al. 2018; White et al. 2018).

Bottlenecks of Seed and Seedling Production

In other parts of the world, seed and seedling production also experience difficulties. General limitations include seed availability and low-quality seedlings (Frost & Muriuki 2006). Seed availability was a common problem for producers in Amazonas, however low seedling quality was only vaguely assessed in the seed origin bottleneck. However, we disagree that this is absent or irrelevant in the region. Seed and seedling production is such an undeveloped practice that producers are not yet concerned about quality.

Southeast and East Asia's lack of structural, economic, human and information resources are the leading bottlenecks (Ahmed et al. 2008; Harrison et al. 2008). African and Asian countries have complications with germplasm origin tracking, quality control policies, and availability of production statistics (Nyoka et al. 2015). Their producers cite: absence of market, deficiency of scientific data and technical capability, and limited access to quality material (Nyoka et al. 2015). Similarly, lack of demand for forest species was the most pressing problem in this study. A government role is essential in appraising technical production and aiding of the production chain (Nyoka et al. 2015).

In Brazil, a study on seedling production found lack of seed supply, difficulties in seedling commercialization, and lack of trained labor as the main difficulties (Moreira da Silva et al. 2017). These would compare to seed availability, multiple topics in business and trade, and skilled labor, whereas in our case trending topics were lack of demand, bureaucracy and transportation problems. Different results are expected since we appraised producers' difficulties, whereas Moreira da Silva et al. (2017) investigated general problems throughout the country. In the Legal Amazon, complications are expected to be distinct from other regions of Brazil. Academy professionals at a meeting of the Amazon Seed Network listed difficulties regarding seed supply, including seed collection and availability, identification of species, and storage (Ferraz 2007). In this study, we encompassed a larger scope as we included political and economic obstacles for seed and seedling supply. Besides, the main topics listed by Ferraz (2007) were cited at least once in our study. Some of them were not as prominent due to the low-level education of a third of the producers in this study. In addition, bottlenecks linkage between Business and Trade and Public Policy was not stablished for many producers, e.g. low demand for forest species was the most cited bottleneck, but effectiveness of public policy did not have such an expressive referenced.

Planting material trade can be hampered by failure to produce high-demand species and lack of transportation (Harrison et al. 2008). Corresponding with our findings, limited consumer market was also cited as an important problem for nurseries in developing countries (Harrison et al. 2008).

Volatile demand is one of the reasons for exotic species production to maintain the enterprise's financial stability (Moreira da Silva et al. 2017). Generally, market is the main regulator of demand, however government intervention is recommended when it refers to a common affair (Harrison et al. 2008) as it is for restoration in Brazil. Public policy can enhance demand either by setting regulations and controls, setting economic incentives, or subsidizing any step of the production chain. In developed countries, seed and seedling supply for restoration is a concern in terms of provision (Oldfield & Olwell 2015; Ladouceur et al. 2018) capacity due to these countries' policies framework for restoration and assigned resources for this purpose. A common scenario in developing countries is diminished economic resources for this activity, and low and sparse demand (Schmidt 2007). Amazonas state's economy depends on extraction of forest resources and tree planting is not a well-established source of economic income.

Working with community-based enterprises may result in management, human relations and economic sustainability difficulties (Mesquita et al. 2010). In this study, we had 6 citations on this problem and 3 producers in this category, which means each producer had multiple problems with the cooperative or association. However, association- or cooperative-owned enterprises were only 3% of whole.

Distance from Manaus results in long transport times and cost, adding to the fact that biological material is sensitive to rough environmental conditions often occurring in transport. The consumer market should be taken to account in planning the enterprise so that logistics would not restrain the business or escalate prices (Turchetto et al. 2018). Brazilian transport is focused on roads, and in Amazonas, terrestrial access is limited most municipalities are restricted to air or river transport. This entails longer and/or more expensive logistics.

Seed and seedling Legislation was the third in noteworthiness. There are a few aspects of the legislation that are unenforceable in Amazon biome region. In Amazon region there is only one accredited seed-testing laboratory in an area comprising more than

60% of Brazilian territory. Recent changes of seed and seedling legislation (MAPA normative instruction no. 17, amended by no. 19/2017) relaxed the rules and made it easier to sell seeds and seedlings. One of the modifications allowed a three-year gap for non-registered laboratories to perform analyses.

In short, seed and seedling production legislation have much to be developed (Freire et al. 2017), however it can be considered the beginning of a plan of action to certify quality in seed and seedling supply (Moreira da Silva et al. 2017). Combining tree seed production with ornamental and agricultural production standardizes very distinct techniques, which are inserted in different economic political context (Schmidt 2007). Additionally, legislation on seed and seedling production should prioritize seed and seedling quality (Harrison et al. 2008; Moreira da Silva et al. 2017). However the Ministry is still struggling to enforce the guidelines and paperwork requirements of the registry.

Another alteration is exemption of small producers (less than 10,000 seedlings/year) from registration. Producers who were in accordance with requirements told of being at a trade disadvantage because of fees and paperwork demanded. In the US, 90% of online commerce did not comply with endangered species permits (Shirey et al. 2013). These authors theorize the main driver of non-compliance is due to fees and bureaucracy. Indeed, seedling producers (18) interviewed in this paper indicated dissatisfaction with excessive bureaucracy of Brazilian seed and seedling legislation.

Seed collection is the first step in the seed production chain and is critical to all other courses of action as it will determine quality (Schmidt 2007). Collection recommendations are scarce and should focus more on gathering genetic diversity rather than restricting to local seed sources (Broadhurst et al. 2008). Having a collection team is economically advantageous since producers avoid market prices and add value to the seed by selling seedlings (Calvi & Ferraz 2014). Specifically for seed production, deficiencies similar to the ones found in this study were pointed out by Merritt & Dixon (2011). In Colorado, U.S. restoration industry companies were highly qualified and able to analyze genetic sources of plant material (Smith et al. 2007) which is different from how Amazonas producers deal with seed technology. Although storage was not a major concern for producers, advantages of storing seeds include: year-round seed provisioning, reducing seed collection costs, and storing rare species (Schmidt 2007). However, storage feasibility depends on seeds' physiological behavior during storage (Gasparin et al. 2018). A common characteristic of Amazon species' seeds is sensitivity to desiccation, as noted for 63% of timber species in Central Amazonia (Ferraz et al. 2004), 75% of fruit tree species (Carvalho et al. 2001), and 46.6% of evergreen rainforest species (Tweddle et al. 2003). For Amazonas producers this is a challenge since the majority of seed and seedling destination is for food production. Commercial-scale seed management, especially storage, requires infrastructure such as drying equipment or extensive areas for a natural drying process (Gasparin et al. 2018), economically unfeasible for most of the producers in Amazonas. Methods such as gene and seed banks are pointed out as an option for scaling up restoration efforts (Schmidt 2007; Merritt & Dixon 2011). However, using advanced biotechnologies like cryo-conservation and infrastructure requirements for landscape-scale seed banks in Brazil would require substantial funding.

Environmental management alone does not guarantee public policies effectiveness and better compliance unless associated with economic development, e.g., regional profit-making activities such as ecotourism (Tallis et al. 2008). Agreeing with this idea, nursery number 30 listed rural farm tourism as a way to increase visibility the of the enterprise and enhance sales.

In essence, legal systems' shift to economic instruments instead of command and control measures is necessary to assure social and the state interests are necessary to secure restoration performance (Aronson et al. 2011). Incentive regularizations foster good practices and to merit them, producers must demonstrate their compliance (Schmidt 2007). Therefore, it can reduce government's law enforcement efforts and encourage good practices. Additionally, bottom-up approach for restoration proposals are more likely to be effective, with national level proposals adjusted to local and regional levels (Meli et al. 2017).

Development of the primary sector in Amazonas is still inconsistent. Forest use depends mainly on timber extraction, and non-timber forest products are not fully documented by federal statistics (IBGE 2019). Lack of knowledge reduces effectiveness of public policies and the whole network involved in creating public policies to encourage multiple uses of the forest.

Research and training are important for successful seed and seedling supply (Kindt et al. 2006; Harrison et al. 2008). Accordingly, skilled labor was, in reality, the most cited problem within the Human Resources category.

Scientific research and further divulgation on native species are important to assist biodiverse seed and seedling production and consequently restoration (Moreira da Silva et al. 2017). However, native seed supply comes up against challenges in dialogue between academics, producers and decision-making actors (Piña-Rodrigues et al. 2018) and, in some cases, academy and practioners disagree in technical knowledge (Smith et al. 2007). Therefore, establishing constant contact among practioners, academics, entrepreneurs is crucial to providing advice (Meli et al. 2017). Absence of scientific knowledge, absence of scientific publications of empirical knowledge, and lack of accessible publications to less qualified readers are usual problems in knowledge transfer (Meli et al. 2017). The Amazon Seed Network (RSA in Portuguese), created in 2001, is suitable mechanism to ally interdisciplinary actors in seed structure, promote scientific research and divulgation, technical training, and advise on formal laws and regulations. Therefore, RSA has a crucial role in generating and providing knowledge for producers.

It was our expectation to generate issues to research according to the problems identified by producers. However, producers indicated bottlenecks in economic and political aspects. This indicates that the obstacles are outside their expertise. These bottlenecks consequently must be resolved through public policy and other actors on restoration (NGOs, private initiative), as opposed to producers themselves, scientists, or academics.

Further studies to resolve problems in seed production (collection, processing, storage, germination, testing) and nursery techniques management (plant germination and emergence, growth, rustification) are necessary to understand the real root of the problems listed by producers.

Correlated Public Policies

With LPVN, Initiative 20x20, and the Bonn Challenge, a boost in seed and seedling production is expected, however 59% of seedling producers in Brazil have not noticed difference since 2012 (Moreira da Silva et al. 2017). In Amazonas, most of the producers perceived a decrease on seed or seedling demand. LPVN’s instrument to monitor land use on rural properties, named Environmental Rural Registry (CAR), deadline has been postponed for the last five years. This fact added to the amnesty given to rural producers that did not comply with this law until August 2008 reinforces the idea of impunity to environmental regulations (Soares-Filho et al. 2014). This explains why the effectiveness of LPVN has not yet been experienced in practice (Brancalion et al. 2016).

National initiatives interconnecting multidisciplinary professionals to achieve restoration outcomes can be cited throughout Brazil. The Brazilian Network for Ecological Restoration is a nationwide example that aims to establish public policies, instructions and studies on the theme (Isernhagen et al. 2017). The Atlantic Forest Restoration Pact is a coalition of government agencies, NGOs, scientific community and private industries, property owners aiming to restore 15 million hectares by 2050 in the 17 Brazilian states where the Atlantic Forest biome occurs (Melo et al. 2013). Connecting multiple actors of seed and seedling production can improve restoration projects achievements (Ladouceur et al. 2018). Indeed, to deliver landscape-scale restoration goals, the powers that be should work closely with other interested parties to set explicit targets while addressing ecological and social issues (Mansourian et al. 2017). To effectively enhance this sector, specific public policy on habitat restoration should be created (Brancalion et al. 2010). In Brazil, Sao Paulo state is a success case of restoration legislation in exhaustive detail of methods and recommendations developed since 2000 with involvement of stakeholders (Aronson et al. 2011). Lack of in-depth legislation on restoration guidelines, aims and inspection, such as the Amazonas state example, hampers quality of projects (Aronson et al. 2011; Chaves et al. 2015).

To get around the lack of interest in private land conservation, economics and funding tools can enhance interest in restoration by having positive stimuli for environmental sound practices. Restoration ecology legislation requiring biodiversity and origin of seed and seedling can be a driver to encourage native production (Ladouceur et al. 2018), resulting in better success in restoration ecology projects. The US example shows that government agencies have the potential to be the main consumer of native seed and seedlings for habitat restoration (Oldfield & Olwell 2015).

Payment for ecosystem services programs is an option to jointly serve conservation and socio-economic goals and is established in the LPVN. However, the majority of success cases are associated with freshwater supply (Tallis et al. 2008). Due to the abundance of water in the Amazon region and the fact that it is one of the largest freshwater reservoirs in the world, paying for provision of water is far from our reality. The ecosystem service at issue in the Amazon is CO_2 absorption. Besides, scientific elucidation of use, economic evaluation and offsetting among other ecosystem services is a key issue to improve success of the initiative (Tallis et al. 2008).

Because large-area restoration is a crucial matter in Brazil, public policy should comprise enhancement of seed and seedling activity. This could be achieved with government working in partnership with the private sector to progress economic and administration (Harrison et al. 2008; Moreira da Silva et al. 2017). The government could provide some of the conservation priority species to ensure biodiversity in restoration projects (Harrison et al. 2008). In developing countries, restoration projects and nurseries count on government funding or external financial resources (Harrison et al. 2008; Murcia et al. 2016). Likewise, research funding also relies on government or NGO investments, therefore studies on seed and seedling technology should be encouraged by public investiment (Harrison et al. 2008).

Seed documentation provides minimum quality criteria to safeguard consumers, additionally it can provide a database for decision-makers in restoration, tree farming, and urban forestry (Schmidt 2007). In Brazil, legislation regarding seed and seedling production is relatively recent, as it was first published in 2003. However, in Brazil registration and data sharing is protracted hence all documentation stages are dependent on paper-work. Computerized procedures could facilitate speed up seed documentation (Schmidt 2007). In Amazonas state, MAPA's inspectors are not enough to supervise the whole state, therefore, requirements are limited to informing seed origin, a six-month report of species and quantity produced, and minimum phytosanitary infrastructure.

Seed quality has been debated (Sebbenn 2002; Broadhurst et al. 2008), however, public policy still has to advance in this matter to ensure good genetic quality (Barbosa et al. 2018; Perrando et al. 2018). Besides all these challenges, climate change adaptation should be among the planning strategies in seed and seedling production for ecological restoration (Tepe & Meretsky 2011; Broadhurst et al. 2015). Further ahead, certification and tracking of all handling procedures of propagation material could be a strategy to encourage high quality (Schmidt 2007).

The US National Seed Strategy, a government, non-government organizations, scientific academy coalition, exemplifies an approach to improve public policy effectiveness and support for seed and seedling production (Oldfield & Olwell 2015). In 2001, we had a similar endeavor with national edicts for the organization of seed networks in Brazil (Piña-Rodrigues et al. 2015). At the time, eight seed networks were created, but very few of them remain active due to discontinuation of funding (Freire et al. 2017). Though we emphasize the weight of seed networks, continuous effort is necessary for success.

Implications for practice

Official registration of seed suppliers and nurseries should be used with restrictions since we detected closed (32%) and non-registered producers (42%).

Maximum production capacity is five- to seven-fold higher than the current scenario, which is primarily allocated for food plantations. A shift for restoration purposes is possible, as maximum production capacity would permit the restoration of 11.6% in the state of Amazonas.

Amazonas state producers could assume an important role in seed supply to bording states. Feasibility may be restricted to desiccation tolerant seeds.

The bottlenecks registered by producers are mostly related to low demand, transportation and bureaucracy, and not technical difficulties.

Enforcement of existing environmental legislation is the pivotal step to increasing seed and seedling demand for habitat restoration.

Ethics Committee Approval

The project was approved by Human Research Ethics Committee (CEP) of National Institute for Amazonian Research (INPA), accredited by the National Commission of Ethics in Research, Ethical Review Certificate of Appreciation no. 80225317.6.0000.0006 in December 2017.

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Figures and Table

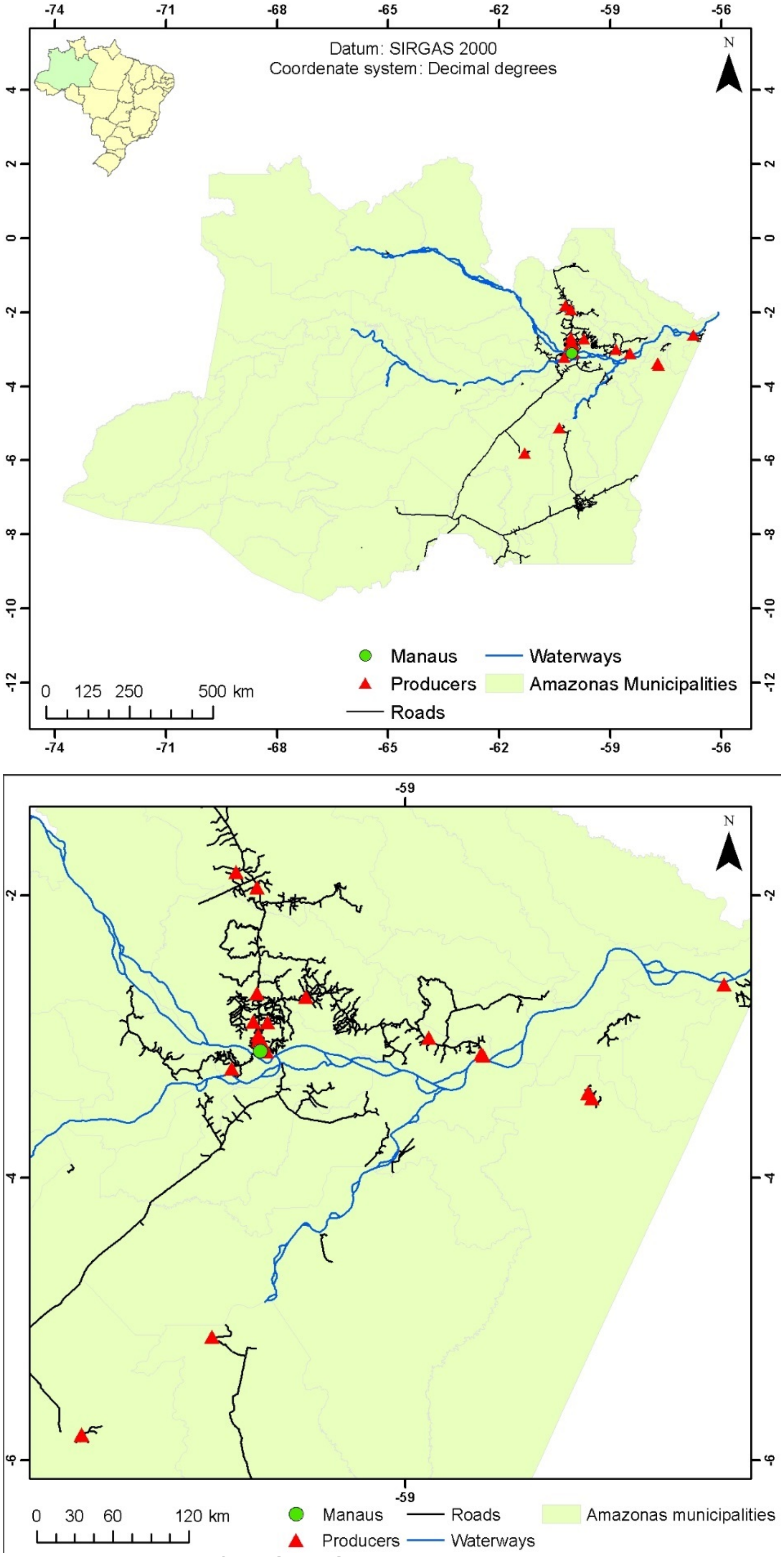

Figure 1: Location of the Seed Suppliers and Nurseries registered at Ministry of Agriculture, Livestock and Food Supply (MAPA) in Amazonas state.

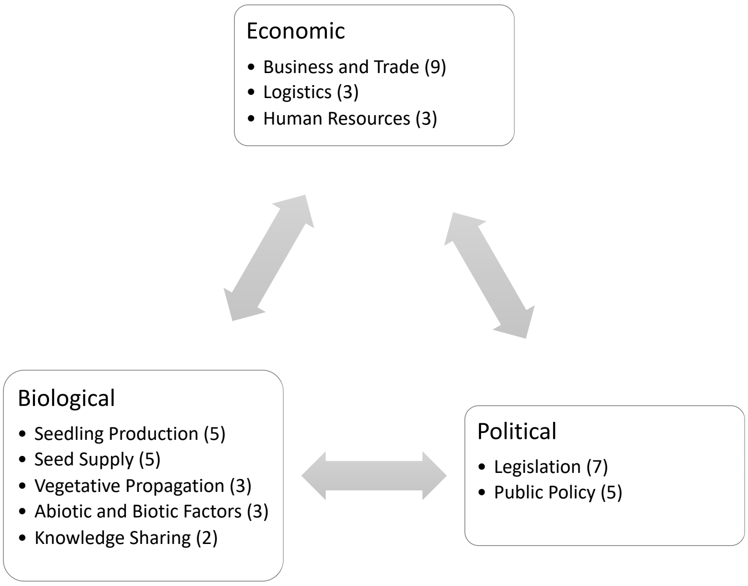

Figure 2: Number of bottlenecks (in parentheses) allocated in ten major categories listed by seed suppliers and nurseries in the state of Amazonas, considering biological, economic and political aspects (See Figure and SI 2 for detailed information).

Table 1: Legal Amazon states areas and deforestation, number of seed and seedling producers based on official data with detailed data obtained in the field in Amazonas. Verified: producers with active production verified in the field; Non-registered: producers without registration at the Renasem database, obtained by snowball sampling. [a] (IBGE 2019); [b] (INPE 2019).

	Seed	Seedling	Area[a] (x10^3 km^2)	Deforested area[b] (x10^3 km^2)	Population[a]	Population density[a]
Acre	1	23	164.1	1.57	869,265	4.47
Amapá	0	2	142.8	0.08	829,494	4.69
Amazonas	9	74	1,559.0	4.16	4,080,611	2.23
Verified	5	50				
Non-registered	0	54				
Maranhão	22	14	333.9	1.19	7,035,055	19.81
Mato Grosso	183	51	903.2	7.01	2,441,998	3.36
Pará	38	133	1,248.0	11.95	8,531,497	6.07
Rondônia	6	163	237.8	5.37	1,757,589	6.58
Roraima	7	12	224.3	0.77	576,568	2.01
Tocantins	33	27	277.7	0.20	1,555,229	4.98
Total	299	499	5,090.8	32.29	27,677,306	54.20

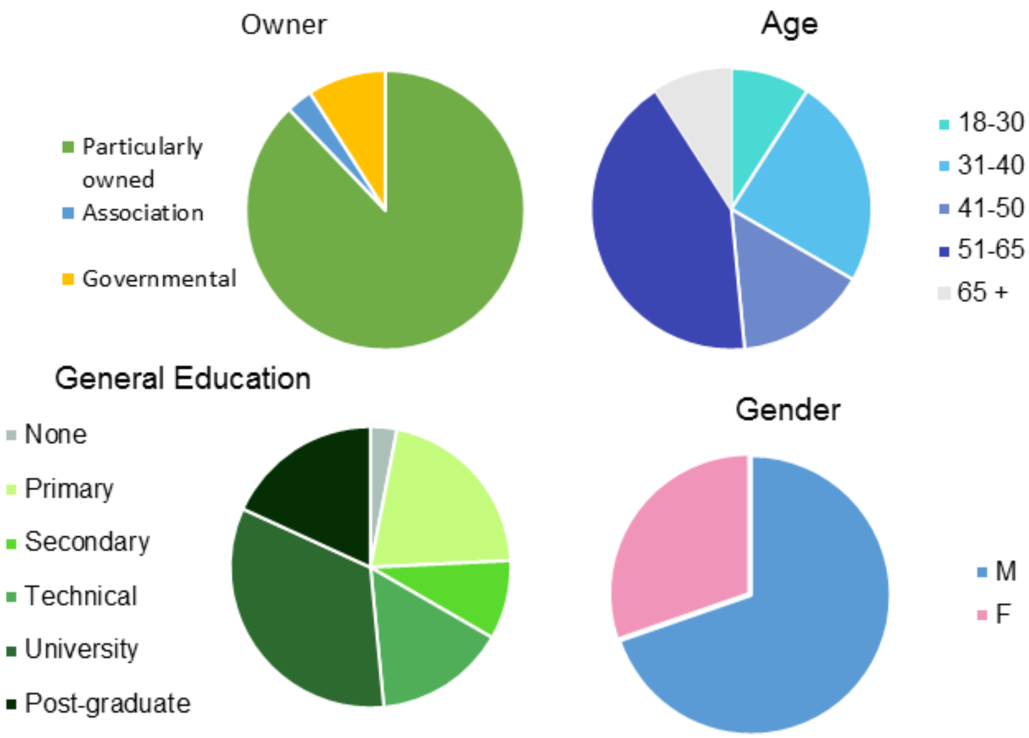

Figure 3: Socioeconomic profile of seed suppliers and nursery owners (n = 35) in Amazonas state in 2018.

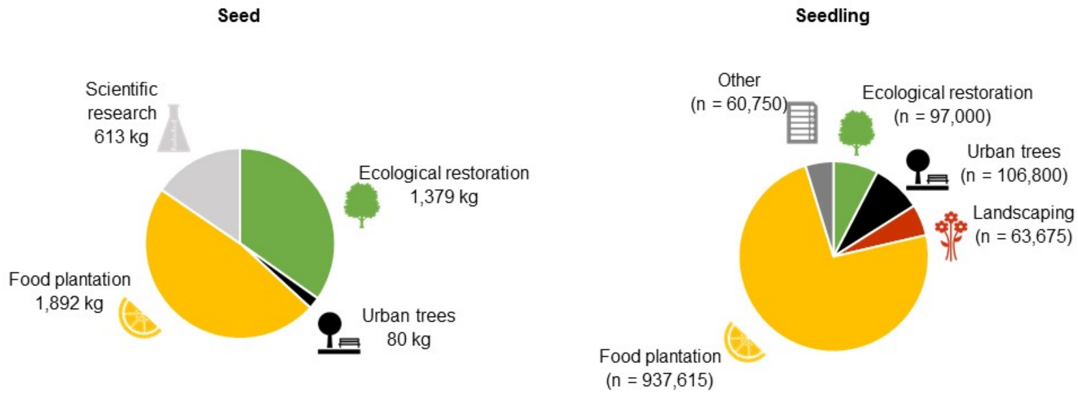

Figure 4: Final destination of produced seeds and seedling in Amazonas state in 2018.

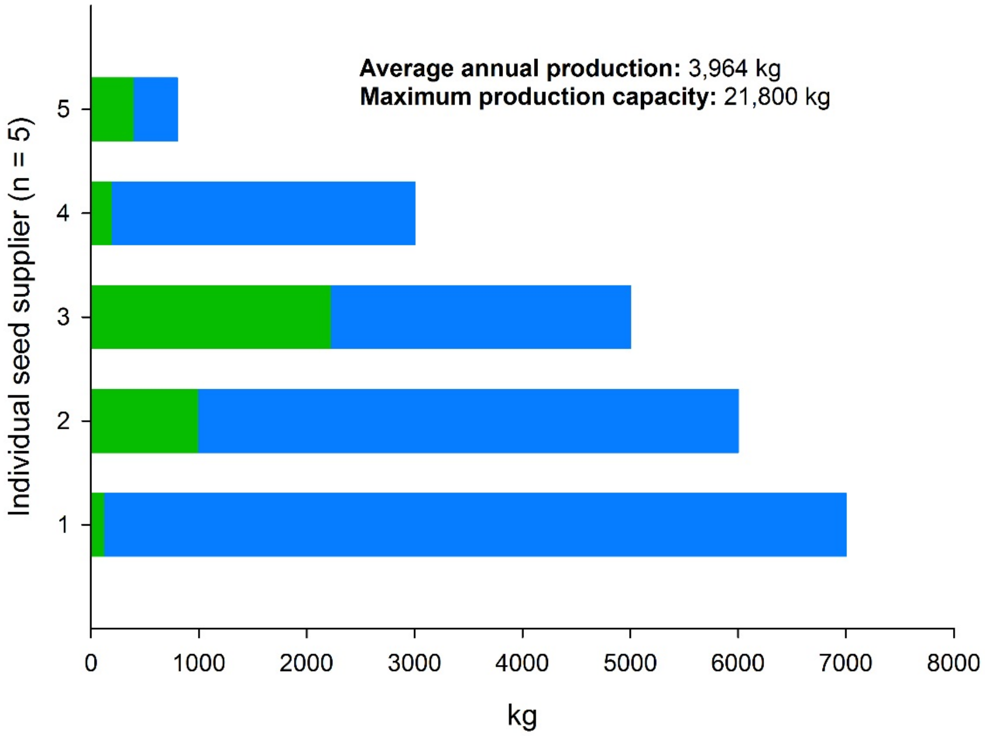

Figure 5: Average annual seed production (green) and maximum production capacity (blue) as estimated by individual seed suppliers in Amazonas.

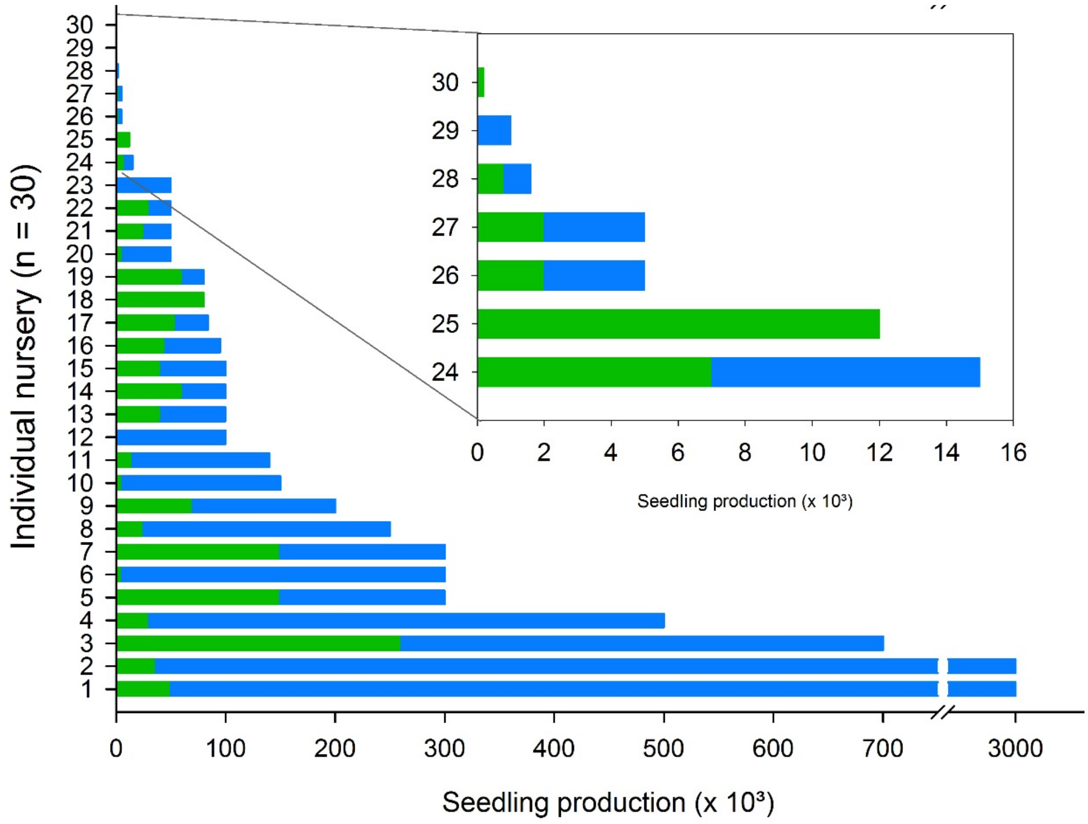

Figure 6: Average annual seedling production (green) and maximum production capacity (blue) as estimated by individual nursery owners in Amazonas state.

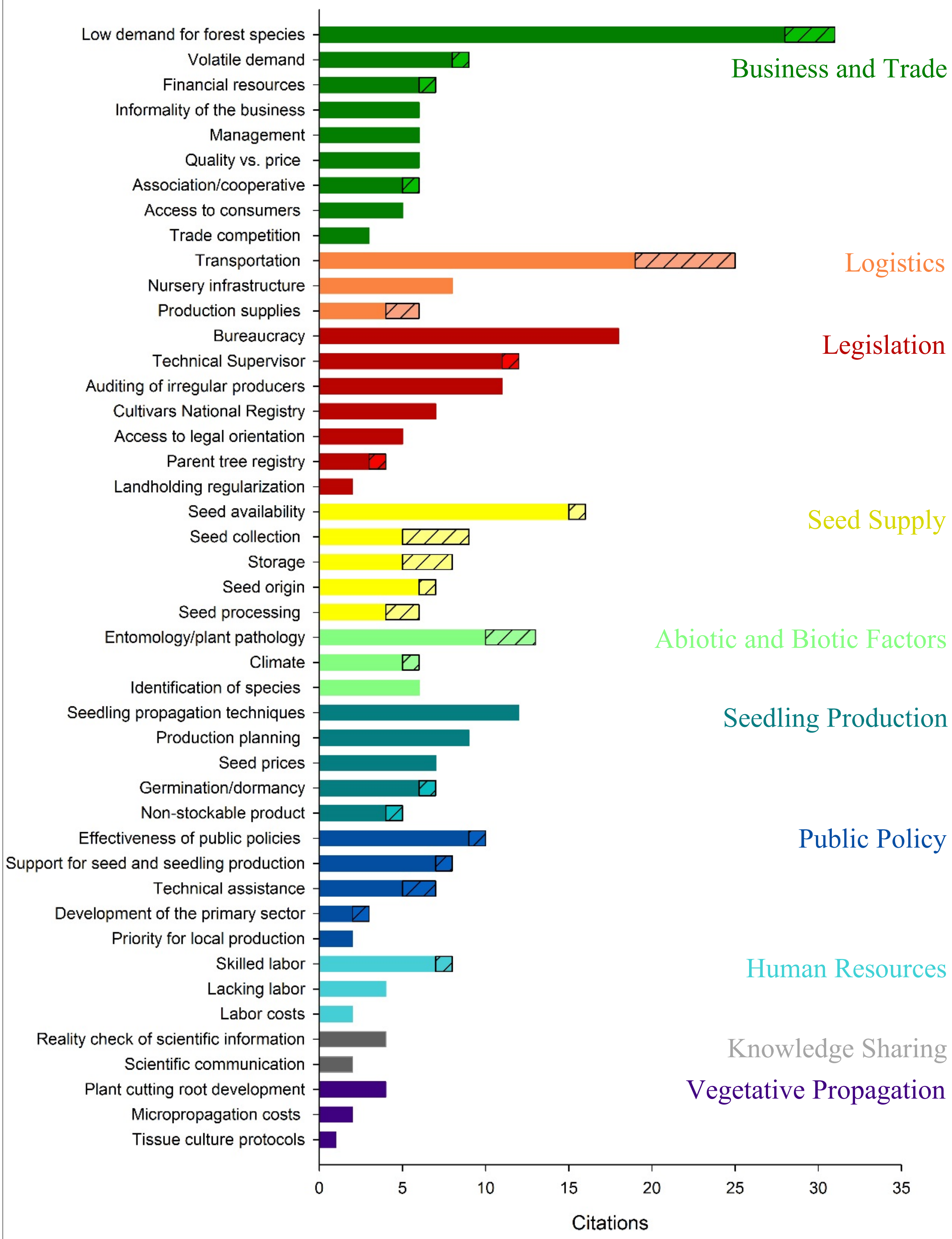

Figure 7: Bottlenecks based on number of citations and arranged in ten major categories; shaded segments represent seed supplier, other nursery owner; producer could cite several difficulties in the same bottlenecks(see SI 2 for list of difficulties within each bottleneck).

Supplementary Information 1

Questionnaire

Interviewers: ____

Date: ___/___/_____ Hour: ____:____

Producer: ( ) Seed ( ) Seedling

Municipality: _____________________________________ Geographical coordinate: _______________________

Name of interviewee: ____Gender: ( ) M ( ) F

Owner classification: ( ) Particular ( ) NGO, Association, Co-op ( ) Governmental

RENASEM Registry: ____

Address:____

Tel: ____ E-mail: ___________________________________

Nursery production: ( ) Tree species ____% ( ) Fruit trees ____% ( ) Ornamental plants ____ %

Estimated annual production: ____

Which are the most produced and their selling price? (Ask for species and price list)

Among the species listed, which are the most produced/commercialized?____________________________________

____

____

____

How long have been working as a seedling/seed supplier? ____

Are other family members involved? ____

How many full-time employees? ____

Is there temporaries recruitment? ( ) Yes When? __________________ ( ) No

Material produced is allocated to: ( ) Forest restoration ____% ( ) Urban forestation ____%

( ) Landscaping ____% ( ) Food plantations ____% ( ) Others ____% Which? ________________________________

Does the business have a spreadsheet with costs for production of seeds/seedling? ( ) Yes ( ) No

Estimated average production cost R$ _____ Estimated average marketing price R$ _____

Current demand is: ( ) Smaller ( ) Equal ( ) Higher than maximum production capacity

Maximum production capacity ____________________

Advertisement? ____

Intention to advertise? ____

Does the nursery have a spreadsheet with seed/seedling production costs? ( ) Y ( ) N

Average cost of production R$ __________

Average selling price R$ __________

Which are the main technical, scientific, logistical and commercial difficulties faced? (List in order of importance)____
____
____
____
____

Are you aware of the changes of the seed and seedling legislation? ( ) Yes ( ) No

Do you have difficulty to undestanding the law of seed and seedling? ( ) Yes ( ) No

Supplementary Information 2

Meaning of the bottlenecks

Economic aspect

Business and Trade

Low demand for forest species: producers can produce more but demand is low; other species (fruit trees, ornamental) are easier to sell than native tree species.

Volatile demand: sales depend on demand for restoration purpose, demand is not constant; species preference changes over time.

Informality of the business: orders have no contract, consumers order and do not purchase.

Quality vs. Price: consumers are not always willing to pay more for higher seed and/or seedling quality; to have competitive prices, product quality has to be reduced.

Financial resources: high initial investment to start business; lack of financial resources prevent business improvement.

Management: insufficient management ability to maintain business; lack of marketing strategies.

Association/cooperative: problems in human relations when working in an association; association does not cover individual business interest.

Trade competition: competition in local market; non-local production has more competitive prices.

Access to consumers: lack of marketplace where producers and consumers can trade; no access to mobile phone or internet in rural areas.

Human resources

Labor costs: wage costs are high.

Lacking labor: hard to find workers; seed supply and nurseries require high human labor input.

Skilled labor: hard to find competent workers to maintain production quality.

Logistics

Production supplies: hard to find good quality supplies in the Amazon region; some supplies have to be sent from other states or countries.

Transportation: transport difficulties prevent sales; size of the state area augments costs; lack of road access and necessity of boat transport;

Nursery infrastructure: satisfactory nursery area and location for seedling production.

Political aspect

Legislation

Bureaucracy: excessive requirements to comply with legislation; each species produced has to be registered with many details; taxes of registration process.

Cultivar National Registry (RNC in Portuguese): some species are absent in the RNC and cannot be produced; trade is based on popular names, however not all regional variations of popular names are comprised in RNC; recent changes in scientific names are not updated in RNC.

Auditing of irregular producers: lack of inspection of producers and legislation requirements permits irregular producers with lower operational costs.

Parent tree registry: producers have to provide the GPS fix to register seed collection area or even individual trees, however good equipment which works under dense forest canopy and in areas without mobile range is expensive; parent tree registry requires paperwork.

Technical Supervisor: need of a Technical Supervisor with a university degree, increasing costs; Technical Supervisors only sign as responsible, but many do not provide technical assistance.

Landholding regularization: based on geographical and historical situations in the Amazon region, landholding is not always with legal title.

Access to legal orientation: laws are difficult to understand; legislation updates are difficult to follow.

Public policy

Effectiveness of public policies: ineffective law enforcement in environmental policies; Law of Native Vegetation Protection (LPVN in Brazil) is not enforced, which would increase seed and seedling demand.

Priority for local production: government apparently does not prioritize acquisition of local products.

Support for seed and seedling production: lack of public support (e.g. credits) to enhance business.

Development of the primary sector: necessity to recognize the limitations of forest resources, and the possibility of plantations of native species of economic interest is fundamental.

Technical assistance: assistance for training and knowledge transfer to improve production.

Biological aspect

Seedling production

Seedling propagation techniques: plant diversity may require species-specific techniques.

Non-stockable product: seedlings under tropical conditions have increased growth rates and cannot be maintained in the nursery for a long time; unsold products have to be disposed.

Production on demand: production depends on orders and have to be aligned with demand; production has to be ready by the planting season (rainy season).

Germination/dormancy: native species may not show uniformity in germination; dormancy breaking treatments and adequate substrates are not known for all species.

Seed prices: seed prices are considered high by the producers; higher prices for certain species.

Seed supply

Seed origin: finding good quality seeds is difficult as it requires several mother trees to form a seed lot.

Seed availability: fruiting is not synchronized within the same species; species density may be low in highly diverse tropical forest; seed availability is reduced in large-seeded species and animal consumption in the forest may be high; native seed trade is limited.

Seed collection: whole process of seed collection is difficult; labor intensive, risky (collecting in tree crowns) and needs security equipment.

Seed processing: knowledge in seed morphology is desired for proper processing.

Storage: a high percentage of desiccation-sensitive seeds; need for dry- and wet-storage facilities.

Vegetative propagation

Tissue Culture Protocols: knowledge of species-specific protocols is desired.

Plant cuttings root development: species-specific treatments to stimulate root growth may be necessary.

Micropropagation costs: up-front investment for micropropagation is high; fixed costs for micropropagation are high, requiring large regular production, which sales are not guaranteed.

Abiotic and biotic factors

Climate: the tropical climate in Amazon region hampers adaptation of species from other biomes which would have demand.

Entomology/plant pathology: pest and disease control is difficult in the tropical climate; seed and seedling production is subjected to insect and disease infestation.

Identification of species: botanical identification is not an easy task, as the flora is highly diverse, not fully described, and still new tree species are described.

Knowledge sharing

Reality check of scientific information: there may be difference between scientific results and field practice; focused view of a specialist may not comprise the bigger picture.

Scientific communication: language of scientific communication may not be understandable for the lay public.

Capítulo 2

Marques, M. C., Calvi, G. P., Arruda, Y. M. B. C , Ferraz, I.D.K., 2019. Does seed and seedling species pool meet large scale restoration goals in the Amazon. Manuscrito em preparação para a publicação na revista Acta Amazonica.

Abstract

Large scale restoration initiatives are part of global policies and multiple countries commitments. Arising with this concern, the necessity for seed and seedling supply is growing. In the state of Amazonas an assessment of seed supply and nurseries was performed to relate the resources with possible use for restoration. Of the 421 species almost 50% were exotics not native to Brazil. For restoration purposes, there were only 133 native species available. However, for 75 priority species listed by the producers, basic scientific data on germination, storage was deficient.

Key-words: restoration, seed supply, Amazonas state, nursery

Introduction

Amazonas is Brazil's largest state, with a total area of 1.6 million km² and 62 municipalities (IBGE 2019). The state surpasses the areas of France, Spain, Sweden and Greece combined. Non-occupied areas total 94.7% of Amazonas, with protected by law forest cover in conservation units or indigenous lands (INPE 2019).

Overall, Amazon plant diversity is still not fully known by botanical collection (Schulman *et al.* 2007; dos Santos *et al.* 2015) with an estimate of more than 14,000 plant species (Cardoso *et al.* 2017). America's outstanding biodiversity of tropical tree species holds most of the worlds' carbon stock, and tropical forest contribution is over 80% (Baccini *et al.* 2012; Slik *et al.* 2015). This emphasizes the importance of the Amazon forest to climate change mitigation. Brazilian Amazon deforestation has become more intense since the 1970s (Fearnside 2005), and has especially increased in the last six years (INPE 2019). Consequences of deforestation occur on the local level through reduction of precipitation, evapotranspiration, and cloudiness and changes of a much larger region rainfall pattern (Werth and Avissar 2002).

Public policies along with supply chain interventions are strategies for biological conservation. *In situ* conservation efforts are mainly related to creation of protected areas, and restoration aiming at species, genetic or ecosystem conservation. Restoration ecology has gained remarkable attention in the scientific community in the last decade, seen by increasing number of publications and the creation of specialized graduate programs (Suding 2011).

Restoration ecology strategies are a key component in recent conservation biology meetings (Aronson and Alexander 2013), which have resulted in multilateral agreements handling bold attempts concerning climate change coping and adaptation, e.g. Aichi Biodiversity Target 15, Initiative 20x20, Bonn Challenge, Paris Agreement (CBD 2019; UN 2019; WRI 2019).

Brazil took part in these agreements, committing to restore 12 million hectares by 2030. These agreements are regulated by Law of Native Vegetation Protection – LPVN (Federal Law no. 12,651/2012) and National Policy of Native Vegetation Restoration (Planaveg in Portuguese) (Federal Decree no. 8,972/2017).

Various criteria can be used to define species pool for conservation purposes, some conservation ecologists suggest to include red-list species (e.g.: Flather *et al.* 1998; Mazziotta *et al.* 2014; ter Steege *et al.* 2015). Among conservation strategies, large scale ecological restoration requires a well-structured supply chain, including planting material provision in quantity and quality. Species pooling for restoration can contain desirable characteristics for restoring the environment and allowing natural regeneration. Increasing the number of species used in restoration plans can not only increase alfa-diversity but also beta-diversity (Grman and Brudvig 2014). Other studies also highlight the importance of selecting species to meet functional diversity (Giannini *et al.* 2017; Brancalion *et al.* 2018; Guimarães *et al.* 2018). Seed size and dispersal method are relevant traits for pooling species in restoration projects (Brancalion *et al.* 2018).

However, does the species pool indicated by conservationists meet with commercial availability? In the United States, a research included about 25,000 vascular plants, of which 26% was sold by the plant industry (White *et al.* 2018). Yet, this study concentrates in an assessment of a few states commercializing vascular plants in which there is a high endemism rate (White *et al.* 2018). In Europe, of the 1,122 grassland species pool for restoration 39% were available and only 49% had information on seed data (Ladouceur *et al.* 2018).

In Brazil, large scale seedling production (above 1 million *per* year) is achieved by 3% of the nurseries and most of them produce a broad number of species (Moreira da Silva *et al.* 2017). However, these nurseries are clustered in Atlantic Forest biome and Southeast region (Moreira da Silva *et al.* 2017). Actual commercial availability of native species is unknown.

National commercial seed and seedling production is regulated by the Ministry of Agriculture, Livestock and Food Supply (MAPA in Portuguese). Nurseries with annual production above 10,000 seedlings/year or producing non-native species are required to enroll and accredit within MAPA's service named National Registry of Seed and Seedling (Renasem in Portuguese). In these terms, seed and seedling producers are defined as "the individual or legal entity that, assisted by a technical manager, produces seed/seedling for commercial purposes" (Federal Law no. 10.711/2003). Upon registration, producers are instructed to provide a list of species they intend to produce.

Studies on restoration supply chain are rising with the necessity of larger areas to be restored but are mostly based on unverified data available on the internet or non-personal interviews. Here, we offer field data gathered with all legal producers in the state of Amazonas, Brazil. This paper provides an assessment of Renasem registered species, listing actual production in Amazonas state, their uses, origin, and inclusion ~~in~~ on the red-list. Priority species for production were assessed to ~~point~~ show gaps in scientific information on seed quality assurance or basic seed traits such as weight, germination, dormancy and storage capacity.

Methods

Producers survey - We accessed all seed and seedling producers of Amazonas state registered at Renasem's website and received their contacts and species list of possible production directly from MAPA's office in Manaus, Amazonas state. Between February and September 2018, we contacted the producers and detected three seed suppliers without active production and one with a duplicate entry, 24 closed nurseries and another four nurseries with owners who refused to participate in the study. Thus, a sum of 51 production sites were visited on field, comprising 46 nurseries and five seed suppliers.

Travel by car, boat and airplane was necessary to reach the producers in the municipalities in Manaus Metropolitan region: Manaus, Iranduba (car, 40 km from Manaus), Rio Preto da Eva (car, 80 km), Presidente Figueiredo (car, 119 km), Careiro (car, 124 km), Itacoatiara (car, 282 km); and more distant municipalities: Maués (boat, 280 km), Parintins (boat, 445 km), Apuí (airplane, 454 km), Humaitá (airplane, 592 km), Manicoré (boat, 611 km).

Species produced - Actual produced species list was compared with the production registered at Renasem of the 51 producers. As most producers used only common names, the botanical names were deduced from literature including common names (; Lorenzi 1992; Lorenzi and Souza 1995; Lorenzi 2003; Lorenzi and Matos 2003; Carrero *et al.* 2014) and actual scientific name was verified in Brazilian Flora (LEFB 2019) and International Plant Names Index (IPNI 2019).

Species were classified by origin (native Amazonian, native other Brazilian biomes, exotic, hybrid based on Brazilian Flora (LEFB 2019), and possible use categorized as: forestry, food, ornamental, medicinal, craft (Lorenzi 1992; Lorenzi and Souza 1995; Cordero and Boshier 2003; Harri and Abreu 2008; Campos Filho 2009; Lorenzi 2009a; Lorenzi 2009b; Matos and Queiroz 2009; Rabelo 2012; Calvi and Ferraz 2014;

Mendonça *et al.* 2014; Wallace 2014). Priority species for trade were determined according to citation frequency (number of times producers mentioned each species as a priority), permitting an unlimited number of citations.

Scientific data of native priority species - The information was grouped in: 1,000 seed weight, germination, oil content, predation, protein content, salt tolerance, seed dispersal, seed morphology, surveyed in Rules for Seed Testing (RAS - Brasil 2009), Instruction to Forest Seeds Analysis (Brasil 2013), Seed Information Database (Kew 2019), and Baskin and Baskin (2014). Seed desiccation tolerance and possibility of seed storage verified in Calvi and Ferraz (2014) and Kew database (Kew 2019). Availability of seeds and seedlings in the nurseries was checked against endangered species (Ministry of the Environment Normative Instruction No. 06/2008).

Data analysis - The data was organized in Excel spreadsheets. Descriptive statistics – frequencies, percentages, means and cross tabulations among variables allowed characterization of origin, uses, and scientific data available of the species.

Results

Species produced

Between February and September 2018, a total of 421 species produced in the nurseries or available for seed supply, their origin and possible uses can be found in Supporting Information (SI 1), together with the number of suppliers. Mainly species native of Brazil (55.6%) were produced, Amazonian species made up the major part of these (74.8% of native species). Exotic and hybrid species represented 42.7% and 1.7%, respectively (Figure 1).

Species’ use could fill in more than one category, including timber and non-timber forest products, and more than half (65.8%) of the species were used for ornamental purposes (277), 185 species (44%) were used for forestry. Multiple uses were found for a total of 106 species (25.2%) with more than three uses (Figure 2), and 13 species (3%) comprised all uses: ornamental, forest, food, medicinal and artisanal. Native Amazonian species had the highest rate in forestry and artisanal, and uses listed included exotic species (Figure 3).

Several families and genera stand out as particularly important in terms of species diversity in production. Fabaceae is noticeable and in particular *Inga* with 13 species, and Arecaceae, particularly *Oenocarpus* with four species. *Euterpe oleraceae* (Arecaceae) is indicated as most commercialized species by producers; other native priority species are listed in SI 2.

Four producers (7.8%) completely complied with their species list registered, whereas 44 (86.3%) had more species registered than in actual production during the period of visits. Four species produced were among the endangered species in the Normative Instruction No. 6/2008: *Euterpe edulis, Aniba rosiodora, Bertholletia excelsa, Swietenia macrophylla.*

Available scientific data for native species

Priority native species enumerated by producers consisted of 74 species (SI 2). Storage capacity was the most common information (48.6%), however 38 species (51.4%) had no classification of sensitivity to desiccation. Species with orthodox seeds represented 52.8% (n = 19) of classified species, and 47.2% of the species (n = 17) had recalcitrant seeds. Germination was between the most available scientific topics, and 52.7% of the species had no protocols for seed quality in RAS or Instruction to Forest Seeds Analysis (Figure 4). Among the priorities, 33.8% species were without any scientific seed information. (Figure 4).

Discussion

Listed species

Compliance level on the registered species lists was low and overestimated. Database establishment facilitates access to information and improves resource use effectiveness (Broadhurst *et al.* 2015). Still, MAPA government officials encourage adding the maximum number of species intended to produce as it is advantageous for producers since a fee is charged at each subsequent change in the record (Calvi and Ferraz 2014). Therefore, the overestimated official list hinders its use as a reliable database for restoration practitioners and decision-makers.

Consuming market does not acknowledge good quality material and prefers to pay lower prices more than concern for quality (Barbosa *et al.* 2018). One way to overcome this problem is by regulating public policy to assure good quality material, then all producers would have competitive costs (Barbosa *et al.* 2018).

Tropical forests high diversity is an obstacle to seed provision, especially for restoration purposes (Schmidt 2007). From the 250 native Amazonian species listed on Renasem by Amazonas producers (Calvi and Ferraz 2014), 175 are in fact commercially available. This number is minimal compared to 11,842 species cataloged in the Brazilian Flora project (LEFB 2019). Seed and seedling supply can bias species pooling and jeopardize original plant community restoration and provision of ecosystem services (Broadhurst *et al.* 2015; Brancalion *et al.* 2018), consequently species pool in Amazonas would not achieve this objective. Seeds cooperatives work as a cost-effective option for seed supply and increasing species richness (Schmidt et al. 2018). Additionally, public policies initiatives should discourage the additional stocking of large-seeded and animal dispersed species, seeing that their recolonization process is restricted in areas disturbed by man and carbon stock is significant (Osuri and Sankaran 2016; Brancalion *et al.* 2018).

São Paulo state has a successful example of seed and seedling production short-period response to public policy: the number of species produced went from 277 to 800 (Barbosa *et al.* 2018), and the number of nurseries more than doubled (Brancalion *et al.* 2010). A single large-scale nursery in Sao Paulo produces 344 native species (Brancalion *et al.* 2012), which is higher than the species richness of all 35 nurseries and seed suppliers in Amazonas.

Uses and origin classification

The species shall be selected mostly based on its ecological grouping, however looking outward to examine such characteristics as the ability of the species to provide food and habitat for fauna, besides representing the floristic composition of the region to be restored (Reis and Wiesbauer 2006). Seed size and dispersal method are other factors that should be taken into consideration, which influence seed prices (Brancalion *et al.* 2018). In the same manner, the parent-tree should be selected considering nearness to area to be restored and genetic base diversification (Lorza *et al.* 2006).

Most significant uses found in this study corroborate with a 788 economic interest species list in Western Amazonia (Calvi and Ferraz 2014). Although federal and state legislation is still poor in supporting silvicultural operations (Calvi and Ferraz 2014), which means forestry use could surpass ornamental utilization.

Here we comprise commercially available species, and not all of them have restoration uses. In European grasslands, species with higher economic interest were more commonly accessible commercially (Ladouceur *et al.* 2018). Despite the strong points for commercialization of exotic timber species for commercial purposes (Harrison *et al.*

2008), native species production is preferred for restoration objectives. Besides that, Brazilian Law of Protection of Native Vegetation allows restoration with plantations intermingled with native occurring species. Therefore, the exotic and hybrid species could enter protected areas in private properties. However, this has several conservations constraints for restorations projects as it can hinder natural environment due to possible invasion of foreign species (Mooney and Cleland 2001). This is not an expected outcome in Amazonas as the possible uses of exotic species were mostly ornamental, food and medicinal. In any case, public policy aid for native species production are necessary to stimulate those species' supply and demand and avoid pooling exotic species for restoration projects (Moreira da Silva *et al.* 2017).

Commercial trade of threatened species cuts both ways, as it can be a strategy for species conservation or it could cause major hazards such as hybridization, genetic exchange with other species, and phytosanitary contamination (Shirey *et al.* 2013). In this study, threatened species production rate was insignificant. Accordingly, protected species in European grasslands were less likely to be sold or in scientific research content (Ladouceur *et al.* 2018).

Scientific data available

Piña-Rodrigues *et al.* (2018) showed the most researched topics in a broader range of seed technology: genetic, biochemistry and general production. We analyzed topics within germination and found storage and germination studies were the most easily available. Germination and dispersal data are listed as the main traits used to filter species to local ecological restoration because of its functional significance in climate adaptation, colonization capacity, seed vigor and viability (Jiménez-Alfaro *et al.* 2016). Dispersal data was available for only 27% of the priority commercial species.

Calvi and Ferraz (2014) discussed that classification of storage and quality analysis procedure are base level information that should be available for seed trade. This information was not fully available even for the most commercialized species. We support the idea that scientific information fosters higher species diversity production, however this might not have been the main reason for indication of the species as a priority. Marques *et al.* (in prep) found problems on seed and seedling applied knowledge, seed technology and seedling production, which may also be a result of absence of technical information.

There seems to be a relation between seed data and species' commercial availability (Ladouceur *et al.* 2018). In this study, a third of the priority species did not have any of the scientific information explored. Further investigation would be necessary to show a relation, but for ~ 75% of priority species there is at least one of the topics researched. We might establish connections between the absence of information and availability or even low quality of material. Additionally, seed and seedling quality is not yet a concern for Amazonas producers, which may restrain restoration plans success. Seeds with wide genetic variability enhances survival, adaptation, and reproduction strategies of the plants they will become (Sebbenn 2002; Broadhurst *et al.* 2008). Therefore, without genetic quality of planting material, restoration projects may not have long-term effectiveness.

On the other hand, provenance of seeds should take into consideration not only local sourcing but also genetic quality of the source material, especially in large scale restoration plans (Broadhurst *et al.* 2008). Such as national and international policies of restoring 12 Mha, which 40% will take place in the Amazon (Planaveg).

Eastern Amazonia in addition to researches on species phenology, seed technology and pathology, and seedling production, also implemented 6 seed collection areas

(Leão *et al.* 2015). As far as we know, Amazonas is the state in Brazilian Western Amazonia more advanced in these initiatives, with five established seed collection areas, three of them with forest management plan. As a future project, we recommend seed orchards on key species pointed by producers that are protected by federal and state legislation: *Aniba rosiodora, Carapa guianensis, Paullinia cupana* var. *sorbilis, Swietenia macrophyla, Bertholletia excelsa, Hevea brasiliensis, Copaifera duckei*.

While seed collection areas or orchards are not available, there are stepping stones available till we get to this point. In regions with vast forest extension, such as Central Amazonia, seed production cooperatives are a great chance to thrive diverse species for restoration projects (Schmidt et al. 2018).

Seedling production shortcomings also affects tree development. Seedlings with root development problems possibly cause deficiency in tree ground support (Harrison *et al.* 2008). Other problems in inferior quality seedlings such as slow growth, weak seedlings, seedling condition leading to poor performance on outplanting can be caused by diverse mismanagement on production (Harrison *et al.* 2008). Many known causes of deficient quality of seedlings were observed in visit to producers: unknown and unimproved genotype seeds or wildlings available, collection of seed from inferior mother trees, containers placed on ground rather than raised shelves, using pots without root trainers (e.g. polybags, jam tins), collection of wildlings, especially advanced ones, pest or disease damage, lack of sun hardening, deformed or severed roots, failure to discard weak or overgrown seedlings. Additionally, seedling with higher quality guidelines indicate better survival and colonization chances, e.g. in Brazilian savanna, species with higher growth rate transited faster to reproductive phase (Pilon and Durigan 2017).

Conclusion

Due to serious gaps on mismatch of official data, and recent urge on restoration requiring a robust seed and seedling supply system, state and federal policy should embrace the restoration cause. We found that several hundred species are produced, not all of them native. Higher species richness would be necessary to satisfactorily represent the Amazon flora. However, it is practically impossible to imagine that without proper technical know-how and minimum quality standards. We found 3 endangered species among the 74 priority species. Proper technical know-how and minimum quality standards was surprisingly unavailable for the priority species. In spite of the lack of knowledge on seed storage behavior, the available data permit to indicate that recalcitrant seeds represent a high percentage of the species. In front of the Amazon flora diversity, this survey indicated the species that are the priority species for production, in this way, indicates key scientific studies needed to enhance nurseries and seed suppliers' activity, and facilitate large scale restoration plans. As for now, Amazonas producers may not be ready to emerge as large-scale restoration suppliers. Quality control to assure survival of the plants in the fields and wide genetic variability are most likely the next steps to fulfil restoration goals such as the Bonn Challenge and Planaveg's 12.5 Mha.

Ethics Committee Approval - The project was approved by Human Research Ethics Committee (CEP) of National Institute for Amazonian Research (INPA), accredited by the National Commission of Ethics in Research, Ethical Review Certificate of Appreciation no. 80225317.6.0000.0006 in December 2017.

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Tables and Figures

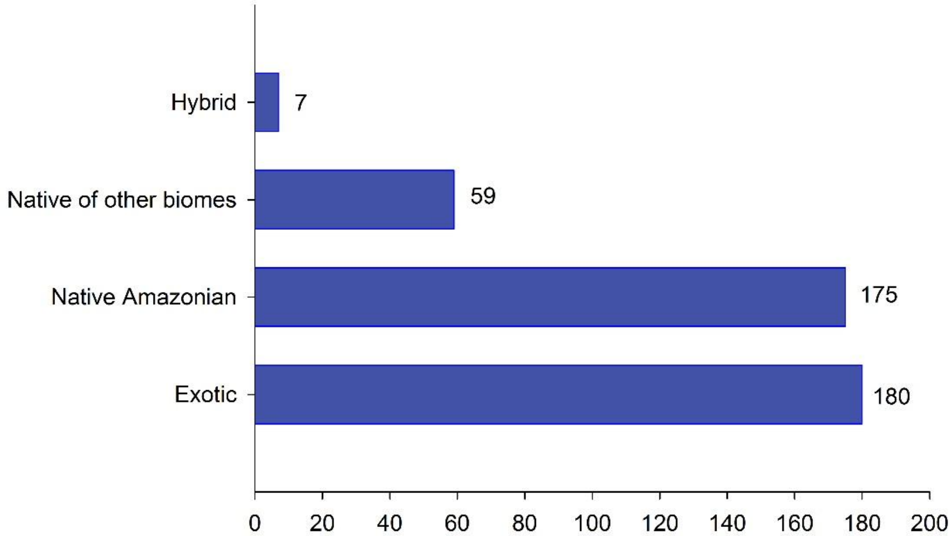

Figure 1: Classification of the 421 listed species in origin according to natural occurrence.

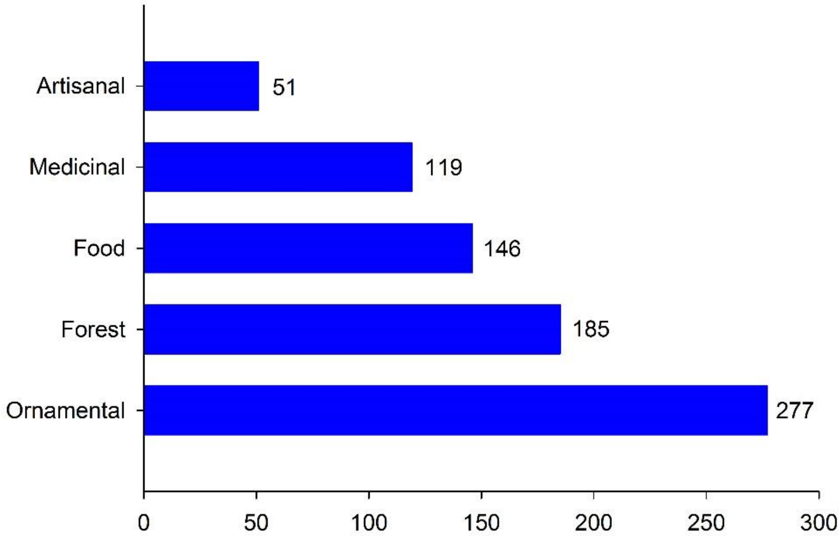

Figure 2: Possible (Artisanal, Medicinal, Food, Forest and Ornamental) uses for the 421 species listed.

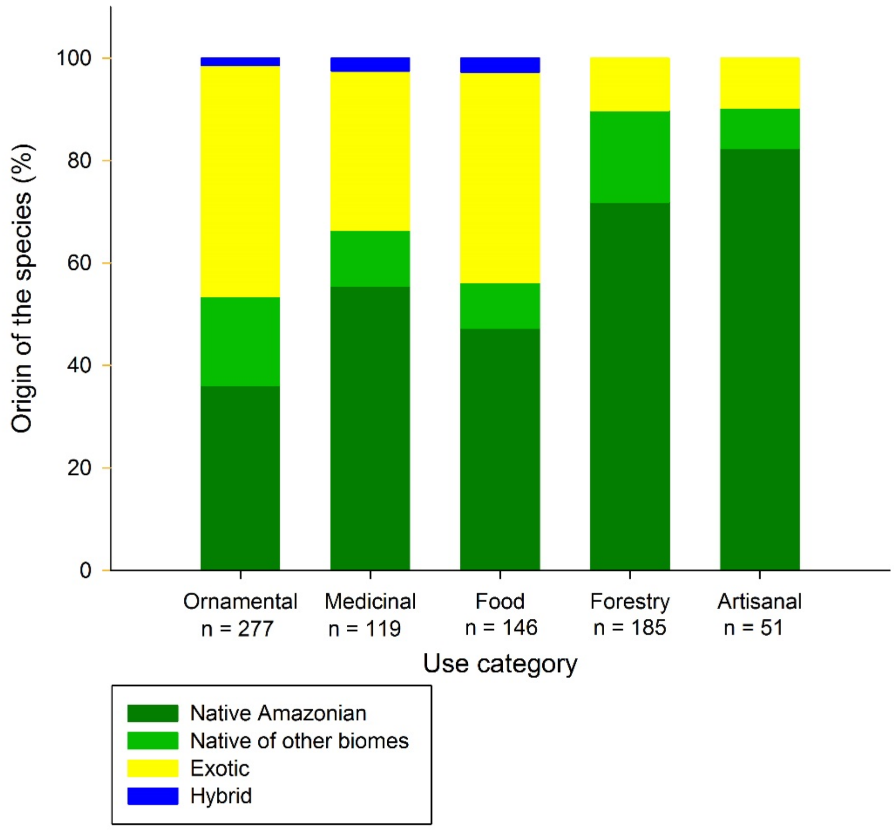

Figure 3: Origin of the species (n = 421) by use category (Ornamental, Medicinal, Food, Forestry, Artisanal).

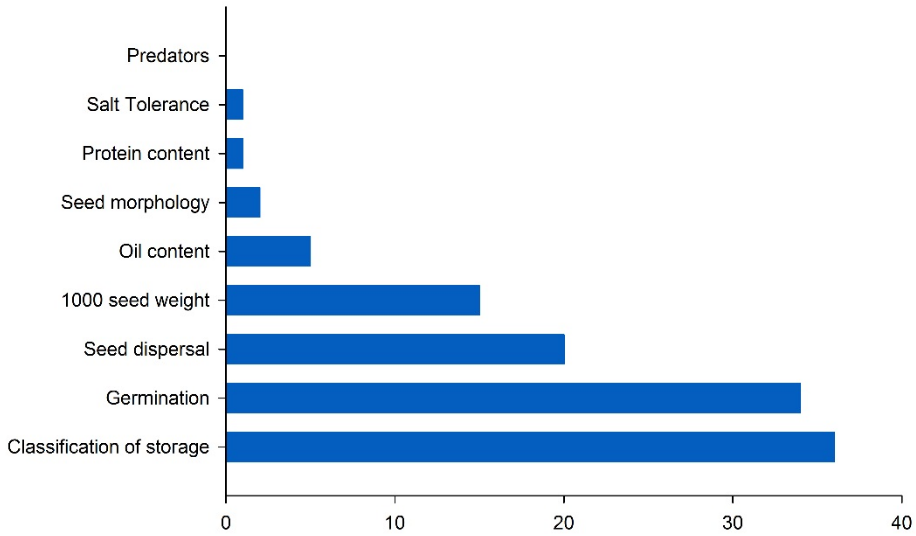

Figure 4: Availability of seed-related scientific information for the species pointed by producers as trade priority (n = 74).

Appendix 1

Table 2: List of species produced (n = 421) in the state of Amazonas. No. prod.: number of producers; Ornam.: ornamental use; Med.: medicinal use; Food prod.: food production use; * Endangered species in the IN nº 6/2008.

Family	Species	Origin	Uses					
			No. prod.	**Ornam.**	**Med.**	**Food prod.**	**Forestry**	**Artisanal**
Acanthaceae	*Crossandra infundibuliformis*	Exotic	1	1				
Acanthaceae	*Ruellia simplex*	Native of other biomes	1	1				
Acanthaceae	*Thunbergia alata*	Exotic	1	1				
Acanthaceae	*Thunbergia grandiflora*	Exotic	1	1				
Agavaceae	*Cordyline indivisa*	Exotic	1	1				
Agavaceae	*Cordyline terminalis*	Exotic	3	1				
Aloaceae	*Aloe barbadensis*	Exotic	3	1				
Amaranthaceae	*Alternanthera dentata*	Native Amazonian	1	1				
Amaranthaceae	*Celosia cristata*	Exotic	2	1				
Amaryllidaceae	*Allium fistulosum*	Exotic	2			1		
Amaryllidaceae	*Allium schoenoprasum*	Exotic	1			1		
Amaryllidaceae	*Hippeastrum* spp.	Hybrid	1	1				
Amaryllidaceae	*Zephyranthes carinata*	Native of other biomes	1	1				
Anacardiaceae	*Anacardium humile*	Native Amazonian	1		1	1		
Anacardiaceae	*Anacardium occidentale*	Native Amazonian	3	1	1	1	1	1
Anacardiaceae	*Anacardium spruceanum*	Native Amazonian	1	1			1	1
Anacardiaceae	*Mangifera indica*	Exotic	11			1		
Anacardiaceae	*Spondias globosa*	Native Amazonian	1		1	1	1	
Anacardiaceae	*Spondias mombin*	Native Amazonian	9	1	1	1	1	1
Anacardiaceae	*Tapirira guianensis*	Native Amazonian	2	1	1		1	
Annonaceae	*Annona coriacea*	Native Amazonian	1	1		1	1	

Family	Species	Origin	Uses: No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Annonaceae	*Annona mucosa*	Native Amazonian	6		1	1	1	1
Annonaceae	*Annona muricata*	Exotic	8		1	1	1	
Annonaceae	*Annona squamosa*	Exotic	3		1	1		
Anthericaceae	*Chlorophytum comosum*	Exotic	1	1				
Apocynaceae	*Adenium obesum*	Exotic	4	1				
Apocynaceae	*Allamanda blanchetii*	Native of other biomes	1	1				
Apocynaceae	*Allamanda cathartica*	Native Amazonian	2	1	1			
Apocynaceae	*Allamanda puberula*	Native of other biomes	1	1				
Apocynaceae	*Aspidosperma macrocarpon*	Native Amazonian	2	1			1	
Apocynaceae	*Catharanthus roseus*	Exotic	5	1	1			
Apocynaceae	*Couma utilis*	Native Amazonian	2	1		1	1	
Apocynaceae	*Plumeria rubra*	Exotic	3	1				
Araceae	*Anthurium andraeanum*	Exotic	2	1				
Araceae	*Dieffenbachia amoena*	Exotic	5	1				
Araliaceae	*Hedera* spp.	Exotic	1	1				
Araliaceae	*Schefflera actinophylla*	Exotic	1	1			1	
Araliaceae	*Schefflera morototoni*	Native Amazonian	1	1			1	1
Araucariaceae	*Araucaria angustifolia*	Native of other biomes	1	1		1	1	
Arecaceae	*Archontophoenix cunninghamiana*	Exotic	2	1				
Arecaceae	*Areca lutescens*	Exotic	5	1				
Arecaceae	*Astrocaryum aculeatum*	Native Amazonian	5			1	1	1
Arecaceae	*Astrocaryum vulgare*	Native Amazonian	1			1		1
Arecaceae	*Bactris gasipaes*	Native Amazonian	11	1	1	1	1	

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Arecaceae	*Bismarckia nobilis*	Exotic	2	1				
Arecaceae	*Caryota mitis*	Exotic	1	1				
Arecaceae	*Caryota urens*	Exotic	1	1				
Arecaceae	*Chamaedorea elegans*	Exotic	2	1				
Arecaceae	*Chamaerops humilis*	Exotic	3	1				
Arecaceae	*Cocos nucifera*	Exotic	9	1	1	1		1
Arecaceae	*Cyrtostachys renda*	Exotic	1	1				
Arecaceae	*Dypsis decaryi*	Exotic	3	1				
Arecaceae	*Dypsis lutescens*	Exotic	2	1				
Arecaceae	*Elaeis guineensis*	Exotic	1		1	1		
Arecaceae	*Elaeis guineensis* x *Elaeis oleifera*	Hybrid	2		1	1		
Arecaceae	*Euterpe precatoria*	Native Amazonian	11	1	1	1		1
Arecaceae	*Euterpe edulis* *	Native of other biomes	1	1		1		1
Arecaceae	*Euterpe oleracea*	Native Amazonian	26	1		1	1	1
Arecaceae	*Mauritia flexuosa*	Native Amazonian	1	1	1	1	1	1
Arecaceae	*Mauritiella armata*	Native Amazonian	1			1		
Arecaceae	*Medemia nobilis*	Exotic	1	1				
Arecaceae	*Oenocarpus bacaba*	Native Amazonian	6	1	1	1	1	1
Arecaceae	*Oenocarpus bataua*	Native Amazonian	6	1		1	1	1
Arecaceae	*Oenocarpus mapora*	Native Amazonian	4			1		
Arecaceae	*Oenocarpus minor*	Native Amazonian	3	1		1		1
Arecaceae	*Phoenix roebelenii*	Exotic	1	1				
Arecaceae	*Raphia farinifera*	Exotic	1	1				1

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Arecaceae	*Rhapis humilis*	Exotic	1	1				
Arecaceae	*Roystonea regia*	Exotic	4	1				
Arecaceae	*Sabal palmetto*	Exotic	1	1		1		
Arecaceae	*Socratea exorrhiza*	Native Amazonian	1	1			1	1
Arecaceae	*Syagrus romanzoffiana*	Exotic	1	1	1	1		
Arecaceae	*Trithrinax brasiliensis*	Native of other biomes	2	1				
Asparagaceae	*Agave angustifolia*	Exotic	1	1				
Asparagaceae	*Cordyline congesta*	Exotic	1	1				
Asparagaceae	*Cordyline spectabilis*	Native of other biomes	1	1				
Asparagaceae	*Cordyline terminalis*	Exotic	1	1				
Asparagaceae	*Polianthes tuberosa*	Exotic	2	1				
Asteraceae	*Aster* spp.	Exotic	1	1				
Asteraceae	*Chrysanthemum spp.*	Exotic	5	1	1			
Asteraceae	*Cichorium endivia*	Exotic	1			1		
Asteraceae	*Cichorium intybus*	Exotic	2		1	1		
Asteraceae	*Cosmus sulphureus*	Exotic	1	1				
Asteraceae	*Dahlia pinnata*	Exotic	1	1				
Asteraceae	*Dahlia* spp.	Exotic	3	1				
Asteraceae	*Gerbera* spp.	Exotic	1	1				
Asteraceae	*Helianthus annuus*	Exotic	1		1			
Asteraceae	*Lactuca sativa*	Exotic	1		1	1		
Asteraceae	*Rudbeckia* spp.	Exotic	1	1				
Asteraceae	*Tagetes* spp.	Exotic	3	1	1			

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Asteraceae	*Zinnia peruviana*	Exotic	1	1				
Balsaminaceae	*Impatiens walleriana*	Exotic	1	1				
Begoniaceae	*Begonia reniformis*	Native of other biomes	4	1				
Bignoniaceae	*Handroanthus albus*	Nativa de outro bioma	3	1			1	
Bignoniaceae	*Handroanthus chrysotrichus*	Native of other biomes	4	1			1	
Bignoniaceae	*Handroanthus heptaphyllus*	Native of other biomes	4	1			1	
Bignoniaceae	*Handroanthus impetiginosus*	Native Amazonian	9	1	1		1	
Bignoniaceae	*Handroanthus serratifolius*	Native Amazonian	3	1	1		1	
Bignoniaceae	*Handroanthus vellosoi*	Native of other biomes	3	1			1	
Bignoniaceae	*Jacaranda brasiliana*	Native Amazonian	1	1			1	
Bignoniaceae	*Jacaranda copaia*	Native Amazonian	4	1			1	
Bignoniaceae	*Jacaranda macrantha*	Native of other biomes	2	1			1	
Bignoniaceae	*Jacaranda puberula*	Native of other biomes	1	1	1		1	
Bignoniaceae	*Tabebuia cassinoides*	Native of other biomes	2	1			1	
Bignoniaceae	*Tabebuia roseoalba*	Native Amazonian	6	1			1	
Bixaceae	*Bixa orellana*	Native Amazonian	3	1	1	1	1	1
Boraginaceae	*Cordia goeldiana*	Native Amazonian	2	1			1	
Brassicaceae	*Brassica oleracea*	Exotic	2	1				
Bromeliaceae	*Aechmea fasciata*	Native of other biomes	1	1				
Bromeliaceae	*Aechmea* spp.	Exotic	1	1				
Bromeliaceae	*Ananas comosus*	Native of other biomes	4		1	1		
Bromeliaceae	*Ananas lucidus*	Native Amazonian	3	1				
Bromeliaceae	*Guzmania lingulata*	Native Amazonian	2	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Bromeliaceae	*Guzmania* spp.	Native Amazonian	1	1				
Bromeliaceae	*Neoregelia carolinae*	Native of other biomes	2	1				
Bromeliaceae	*Tillandsia* spp.	Native Amazonian	2	1				
Bromeliaceae	*Tillandsia wagneriana*	Exotic	1	1				
Bromeliaceae	*Tillandsia cyanea*	Exotic	2	1				
Bromeliaceae	*Vriesea* spp.	Native Amazonian	1	1				
Burseraceae	*Protium altsonii*	Native Amazonian	1		1		1	
Burseraceae	*Protium grandifolium*	Native Amazonian	1				1	
Burseraceae	*Protium heptaphyllum*	Native Amazonian	4		1		1	
Burseraceae	*Protium icicariba*	Native of other biomes	1		1	1	1	
Burseraceae	*Protium ovatum*	Native Amazonian	1		1	1		
Burseraceae	*Protium pallidum*	Native Amazonian	1		1			
Burseraceae	*Protium puncticulatum*	Native Amazonian	1		1		1	
Burseraceae	*Protium* spp.	Native Amazonian	2	1	1		1	
Burseraceae	*Protium spruceanum*	Native Amazonian	1	1	1		1	
Burseraceae	*Trattinnickia* spp.	Native Amazonian	1				1	
Buxaceae	*Buxus sempervirens*	Exotic	1	1				
Cactaceae	*Cereus forbesii*	Native of other biomes	1	1				
Cactaceae	*Cereus hildmannianus*	Native of other biomes	5	1		1	1	
Caricaceae	*Carica papaya*	Exotic	2		1	1		
Caryocaraceae	*Caryocar brasiliensis*	Native of other biomes	1	1	1	1	1	1
Caryocaraceae	*Caryocar villosum*	Native Amazonian	1		1	1	1	
Caryophyllaceae	*Dianthus barbatus*	Exotic	1	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Caryophyllaceae	*Dianthus chinensis*	Exotic	1	1				
Caryophyllaceae	*Dianthus* spp.	Exotic	3	1				
Caryophyllaceae	*Gypsophila paniculata*	Exotic	1	1				
Chrysobalanaceae	*Couepia bracteosa*	Native Amazonian	2	1		1	1	
Chrysobalanaceae	*Licania tomentosa*	Native of other biomes	4	1			1	
Clusiaceae	*Garcinia mangostana*	Exotic	1			1		
Clusiaceae	*Platonia insignis*	Native Amazonian	4			1	1	
Combretaceae	*Combretum indicum*	Exotic	1	1				
Cucurbitaceae	*Cucumis sativus*	Exotic	1			1		
Cucurbitaceae	*Cucurbita ficifolia*	Exotic	1			1		
Cucurbitaceae	*Cucurbita pepo*	Exotic	1		1	1		
Curcubitaceae	*Citrullus lanatus*	Exotic	1			1		
Cycadaceae	*Cycas revoluta*	Exotic	2	1				
Dracaenaceae	*Dracaena fragrans*	Exotic	1	1				
Dracaenaceae	*Dracaena marginata*	Exotic	3	1				
Dracaenaceae	*Sansevieria trifasciata* var. *laurentii*	Exotic	4	1				
Ericaceae	*Rhododendron simsii*	Exotic	1	1				
Euphorbiaceae	*Codiaeum variegatum*	Exotic	1	1				
Euphorbiaceae	*Croton macrobothrys*	Native of other biomes	1		1		1	
Euphorbiaceae	*Croton matourensis*	Native Amazonian	1		1		1	
Euphorbiaceae	*Euphorbia milii*	Exotic	3	1				
Euphorbiaceae	*Hevea rigidifolia*	Native Amazonian	1				1	
Euphorbiaceae	*Hevea brasiliensis*	Native Amazonian	6	1			1	1

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Euphorbiaceae	*Hevea camporum*	Native Amazonian	1				1	
Euphorbiaceae	*Hevea guianensis*	Native Amazonian	2	1			1	
Euphorbiaceae	*Hevea microphylla*	Native Amazonian	2				1	
Euphorbiaceae	*Hevea nitida*	Native Amazonian	1				1	
Euphorbiaceae	*Hevea pauciflora*	Native Amazonian	1				1	
Euphorbiaceae	*Jatropha curcas*	Exotic	1	1	1		1	
Euphorbiaceae	*Manihot esculenta*	Native Amazonian	1			1		
Fabaceae	*Acacia angustissima*	Exotic	1		1		1	
Fabaceae	*Acacia mangium*	Exotic	2				1	
Fabaceae	*Acacia mearnsii*	Exotic	1				1	
Fabaceae	*Amburana cearensis*	Native Amazonian	1	1	1		1	1
Fabaceae	*Arachis pintoi*	Native of other biomes	2				1	
Fabaceae	*Arachis repens*	Native Amazonian	1	1				
Fabaceae	*Bauhinia forficata*	Native of other biomes	2	1	1		1	
Fabaceae	*Caesalpinia pulcherrima*	Exotic	1	1				
Fabaceae	*Cajanus cajan*	Exotic	1		1	1		
Fabaceae	*Calliandra tweediei*	Native of other biomes	1	1				
Fabaceae	*Canavalia ensiformis*	Exotic	1		1	1	1	
Fabaceae	*Cassia ferruginea*	Native Amazonian	1	1			1	
Fabaceae	*Cenostigma tocantinum*	Native Amazonian	8	1			1	1
Fabaceae	*Clitoria fairchildiana*	Native Amazonian	1	1			1	
Fabaceae	*Copaifera duckei*	Native Amazonian	3		1		1	
Fabaceae	*Copaifera guyanensis*	Native Amazonian	1		1		1	

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Fabaceae	*Copaifera langsdorffii*	Native Amazonian	3	1	1		1	
Fabaceae	*Copaifera martii*	Native Amazonian	4		1		1	
Fabaceae	*Copaifera multijuga*	Native Amazonian	6		1		1	
Fabaceae	*Copaifera reticulata*	Native Amazonian	1		1		1	
Fabaceae	*Cynometra bauhiniaefolia*	Native Amazonian	3	1			1	
Fabaceae	*Cynometra spruceana*	Native Amazonian	1	1			1	
Fabaceae	*Dialium guianensis*	Native Amazonian	1			1	1	
Fabaceae	*Dinizia excelsa*	Native Amazonian	3	1	1		1	1
Fabaceae	*Dipteryx odorata*	Native Amazonian	7	1	1	1	1	1
Fabaceae	*Enterolobium schomburgkii*	Native Amazonian	2	1		1	1	
Fabaceae	*Enterolobium timbouva*	Native Amazonian	2	1			1	
Fabaceae	*Guibouria hymenaeifolia*	Exotic	2	1			1	
Fabaceae	*Hydrochorea corymbosa*	Native Amazonian	1				1	
Fabaceae	*Hymenaea courbaril*	Native Amazonian	13	1	1	1	1	1
Fabaceae	*Hymenaea intermedia*	Native Amazonian	2				1	
Fabaceae	*Hymenaea oblongifolia*	Native Amazonian	2			1	1	
Fabaceae	*Hymenaea parvifolia*	Native Amazonian	2				1	
Fabaceae	*Hymenaea reticulata*	Native Amazonian	1		1		1	
Fabaceae	*Hymenaea* spp.	Native Amazonian	1			1	1	
Fabaceae	*Hymenaea stigonocarpa*	Native Amazonian	1	1	1	1	1	1
Fabaceae	*Hymenolobium excelsum*	Native Amazonian	2				1	
Fabaceae	*Hymenolobium flavum*	Native Amazonian	1				1	
Fabaceae	*Hymenolobium heterocarpum*	Native Amazonian	1				1	

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Fabaceae	*Hymenolobium janeirense*	Native of other biomes	1				1	
Fabaceae	*Hymenolobium janeirense* var. *stipulatum*	Native of other biomes	1				1	
Fabaceae	*Hymenolobium modestum*	Native Amazonian	1				1	
Fabaceae	*Hymenolobium nitidum*	Native Amazonian	1				1	
Fabaceae	*Hymenolobium petraeum*	Native Amazonian	1				1	
Fabaceae	*Hymenolobium pulcherrimum*	Native Amazonian	1				1	
Fabaceae	*Inga barbata*	Native of other biomes	1			1		
Fabaceae	*Inga blanchetiana*	Native of other biomes	1				1	
Fabaceae	*Inga cinnamomea*	Native Amazonian	4	1		1	1	1
Fabaceae	*Inga cordistipula*	Native of other biomes	1				1	
Fabaceae	*Inga cylindrica*	Native Amazonian	1	1		1		
Fabaceae	*Inga edulis*	Native Amazonian	8	1		1	1	
Fabaceae	*Inga flagelliformis*	Native Amazonian	1			1		
Fabaceae	*Inga heterophylla*	Native Amazonian	2	1		1		
Fabaceae	*Inga ingoides*	Native Amazonian	1	1		1		
Fabaceae	*Inga laurina*	Native Amazonian	1	1		1	1	
Fabaceae	*Inga sessilis*	Native Amazonian	1			1	1	1
Fabaceae	*Inga vera*	Native Amazonian	1	1	1	1	1	
Fabaceae	*Inga vera* subsp. *affinis*	Native Amazonian	3	1		1		
Fabaceae	*Martiodendron elatum*	Native Amazonian	1				1	
Fabaceae	*Ormosia arborea*	Native of other biomes	1	1			1	1
Fabaceae	*Ormosia paraensis*	Native Amazonian	1				1	
Fabaceae	*Ormosia* spp.	Native Amazonian	1				1	1

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Fabaceae	*Parkia igneiflora*	Native Amazonian	1				1	
Fabaceae	*Parkia multijuga*	Native Amazonian	2	1			1	1
Fabaceae	*Parkia nitida*	Native Amazonian	2	1	1		1	1
Fabaceae	*Parkia paraensis*	Native Amazonian	1				1	
Fabaceae	*Parkia pendula*	Native Amazonian	1	1			1	1
Fabaceae	*Phaseolus vulgaris*	Exotic	1			1		
Fabaceae	*Schizolobium parahyba*	Native Amazonian	1	1	1		1	
Fabaceae	*Schizolobium parahyba* var. *amazonicum*	Native Amazonian	2	1	1		1	1
Fabaceae	*Senegalia polyphylla*	Native Amazonian	2	1			1	
Fabaceae	*Stryphnodendron pulcherrimum*	Native Amazonian	2	1	1		1	1
Fabaceae	*Tachigali melanocarpa*	Native Amazonian	1				1	
Fabaceae	*Tachigali vulgaris*	Native Amazonian	1				1	
Fabaceae	*Tamarindus indica*	Exotic	3	1	1	1	1	
Fabaceae	*Vachellia farnesiana*	Native Amazonian	1	1	1		1	1
Fabaceae	*Vatairea macrocarpa*	Native Amazonian	1	1	1		1	
Heliconiaceae	*Heliconia acuminata*	Native Amazonian	1	1				
Heliconiaceae	*Heliconia angusta*	Native of other biomes	1	1				
Heliconiaceae	*Heliconia bihai*	Exotic	4	1				
Heliconiaceae	*Heliconia episcopalis*	Native Amazonian	1	1				
Heliconiaceae	*Heliconia psittacorum*	Native Amazonian	3	1				
Heliconiaceae	*Heliconia rauliniana*	Exotic	2	1				
Heliconiaceae	*Heliconia rostrata*	Native Amazonian	6	1				
Heliconiaceae	*Heliconia schiedeana*	Exotic	2	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Heliconiaceae	*Heliconia velloziana*	Native of other biomes	2	1				
Heliconiaceae	*Heliconia psittacorum* x *spathocircinata*	Híbrida nativa	5	1				
Hemerocallidaceae	*Hemerocallis middendorffii*	Exotic	1	1				
Humiriaceae	*Humiria balsamifera*	Native Amazonian	1	1	1	1	1	1
Hydrangeaceae	*Hydrangea macrophylla*	Exotic	2	1				
Iridaceae	*Dietes iridioides*	Exotic	2	1				
Lamiaceae	*Mentha piperita*	Exotic	4	1		1		
Lamiaceae	*Plectranthus amboinicus*	Exotic	4		1	1		
Lauraceae	*Aniba canelilla*	Native Amazonian	2		1		1	
Lauraceae	*Aniba fragrans*	Native Amazonian	1		1			
Lauraceae	*Aniba rosaeodora* *	Native Amazonian	10	1	1		1	1
Lauraceae	*Cinnamomum glaziovii*	Native of other biomes	1	1			1	
Lauraceae	*Cinnamomum stenophyllum*	Native of other biomes	1	1			1	
Lauraceae	*Licaria chrysophylla*	Native Amazonian	1		1			
Lauraceae	*Mezilaurus duckei*	Native Amazonian	2				1	
Lauraceae	*Mezilaurus itauba*	Native Amazonian	1				1	
Lauraceae	*Ocotea curucutuensis*	Native of other biomes	1				1	
Lauraceae	*Persea americana*	Exotic	8	1	1	1	1	1
Lauraceae	*Persea willdenovii*	Native of other biomes	1	1			1	
Lecythidaceae	*Bertholletia excelsa* *	Native Amazonian	10		1	1	1	1
Lecythidaceae	*Cariniana rubra*	Native Amazonian	1	1		1	1	1
Lecythidaceae	*Lecythis pisonis*	Native Amazonian	1	1		1	1	1

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Lecythidaceae	*Lecythis prancei*	Native Amazonian	1			1	1	
Lythraceae	*Cuphea gracilis*	Exotic	1	1				
Lythraceae	*Punica granatum*	Exotic	2	1	1	1		
Malpighiaceae	*Byrsonima crassifolia*	Native Amazonian	1	1	1	1	1	
Malpighiaceae	*Byrsonima sericea*	Native Amazonian	1	1		1	1	1
Malpighiaceae	*Malpighia glabra*	Exotic	10	1		1		1
Malpighiaceae	*Malpighia punicifolia*	Exotic	2			1		
Malpighiaceae	*Malpighia emarginata*	Exotic	4	1	1	1		
Malvaceae	*Apeiba tibourbou*	Native Amazonian	2	1			1	
Malvaceae	*Ceiba boliviana*	Exotic	1	1			1	1
Malvaceae	*Ceiba glaziovii*	Native of other biomes	1	1	1		1	1
Malvaceae	*Ceiba pentandra*	Native Amazonian	3	1	1	1	1	
Malvaceae	*Herrania mariae*	Native Amazonian	1	1		1		
Malvaceae	*Hibiscus rosa-sinensis*	Exotic	3	1				
Malvaceae	*Hibiscus syriacus*	Exotic	1	1				
Malvaceae	*Hibiscus moscheutos*	Exotic	2	1				
Malvaceae	*Ochroma pyramidale*	Native Amazonian	1		1		1	1
Malvaceae	*Pachira aquatica*	Native Amazonian	1	1		1	1	
Malvaceae	*Pachira nervosa*	Native Amazonian	1				1	
Malvaceae	*Pseudobombax munguba*	Native Amazonian	3				1	
Malvaceae	*Theobroma cacao*	Exotic	7		1	1		
Malvaceae	*Theobroma grandiflorum*	Native Amazonian	14		1	1	1	
Marantaceae	*Calathea makoyana*	Native of other biomes	1	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Melastomataceae	*Pleroma mutabile*	Native of other biomes	3	1			1	
Meliaceae	*Azadirachta indica*	Exotic	3	1	1		1	
Meliaceae	*Carapa guianensis*	Native Amazonian	13	1	1		1	
Meliaceae	*Carapa procera*	Native of other biomes	3	1	1		1	
Meliaceae	*Cedrela fissilis*	Native Amazonian	5	1	1		1	
Meliaceae	*Cedrela odorata*	Native Amazonian	5	1	1		1	1
Meliaceae	*Khaya ivorensis*	Exotic	1				1	
Meliaceae	*Swietenia macrophylla* *	Native Amazonian	7	1	1		1	1
Meliaceae	*Toona ciliata*	Exotic	2	1	1		1	
Meliaceae	*Trichilia lepidota*	Native of other biomes	2		1		1	
Meliaceae	*Artocarpus altilis*	Exotic	4			1		
Moraceae	*Artocarpus heterophyllus*	Native Amazonian	2			1		
Moraceae	*Brosimum potabile*	Native Amazonian	1				1	
Moraceae	*Brosimum utile*	Native Amazonian	1				1	
Moraceae	*Ficus benjamina*	Exotic	1	1				
Moraceae	*Ficus retusa*	Exotic	1	1				
Moraceae	*Helicostylis tomentosa*	Native Amazonian	1		1	1	1	
Moraceae	*Naucleopsis ulei*	Native Amazonian	3			1		
Moringaceae	*Moringa oleifeira*	Exotic	1	1	1	1		
Musaceae	*Ensete ventricosum*	Exotic	1	1				
Musaceae	*Musa coccinea*	Exotic	2	1				
Musaceae	*Musa ornata*	Exotic	1	1				
Musaceae	*Musa paradisiaca*	Exotic	3	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Musaceae	*Musa velutina*	Exotic	2	1				
Musaceae	*Musa violacea*	Exotic	2	1				
Myrtaceae	*Eugenia egensis*	Native Amazonian	1		1			
Myrtaceae	*Eugenia involucrata*	Native of other biomes	2	1		1	1	
Myrtaceae	*Eugenia stipitata*	Native Amazonian	4	1		1		
Myrtaceae	*Eugenia uniflora*	Native of other biomes	7	1	1	1	1	
Myrtaceae	*Myrciaria cuspidata*	Native Amazonian	3	1		1	1	
Myrtaceae	*Myrciaria dubia*	Native Amazonian	5	1	1	1		
Myrtaceae	*Plinia grandifolia*	Native of other biomes	1	1		1		
Myrtaceae	*Plinia cauliflora*	Native of other biomes	3	1		1		
Myrtaceae	*Psidium acutangulum*	Native Amazonian	1	1		1	1	
Myrtaceae	*Psidium guajava*	Exotic	6	1	1	1	1	
Myrtaceae	*Syzygium cumini*	Exotic	1	1	1	1	1	
Myrtaceae	*Syzygium malaccense*	Exotic	5	1		1		
Nephrolepidaceae	*Nephrolepis exaltata*	Native Amazonian	1	1	1			
Nyctaginaceae	*Bougainvillea glabra*	Native of other biomes	4	1	1			
Nyctaginaceae	*Bougainvillea praecox*	Native of other biomes	1	1			1	
Nyctaginaceae	*Mirabilis jalapa*	Exotic	3	1	1			
Olacaceae	*Minquartia guianensis*	Native Amazonian	2				1	
Oleaceae	*Ligustrum sinense*	Exotic	1	1				
Orchidaceae	*Arundina graminifolia*	Exotic	1	1				
Orchidaceae	*Phaius tancarvilleae*	Exotic	1	1				

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Orchidaceae	*Stanhopea rodigasiana*	Exotic	1	1				
Oxilidaceae	*Averrhoa carambola*	Exotic	3			1		
Papaveraceae	*Papaver rhoeas*	Exotic	1	1	1	1		
Passifloraceae	*Passiflora edulis*	Native Amazonian	2		1	1		
Phyllanthaceae	*Hieronyma alchorneoides*	Exotic	1					
Pinaceae	*Cedrus libani*	Exotic	1	1			1	
Piperaceae	*Piper nigrum*	Exotic	2		1	1		
Plumbaginaceae	*Plumbago auriculata*	Exotic	2	1				
Poaceae	*Axonopus fissifolius*	Native Amazonian	1	1				
Poaceae	*Bouteloua gracilis*	Exotic		1				
Poaceae	*Cymbopogon citratus*	Exotic	4		1			
Poaceae	*Cynodon dactylon*	Native Amazonian	1	1				
Poaceae	*Festuca glauca*	Exotic	1	1				
Poaceae	*Paspalum notatum*	Exotic	2	1				
Poaceae	*Saccharum officinarum*	Exotic	1			1		
Poaceae	*Saccharum* spp.	Exotic	1			1		
Poaceae	*Zoysia japonica*	Exotic	7	1				
Podocarpaceae	*Podocarpus macrocarpus*	Exotic	1	1				
Portulacaceae	*Portulaca grandiflora*	Native of other biomes	2	1				
Rosaceae	*Cydonia oblonga*	Exotic	1			1		
Rosaceae	*Eriobotrya japonica*	Exotic	1			1		
Rosaceae	*Rosa hybrida*	Hybrid	4	1				
Rosaceae	*Rubus* spp.	Native of other biomes	1	1	1	1		

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Rubiaceae	*Alibertia edulis*	Native Amazonian	1	1		1	1	
Rubiaceae	*Amaioua guianensis*	Native Amazonian	1	1			1	
Rubiaceae	*Amaioua intermedia*	Native of other biomes	1	1				
Rubiaceae	*Coffea arabica*	Exotic	2		1	1		
Rubiaceae	*Coffea canephora*	Exotic	2			1		
Rubiaceae	*Genipa americana*	Native Amazonian	7	1	1	1	1	1
Rubiaceae	*Ixora chinensis*	Exotic	2	1				
Rubiaceae	*Ixora coccinea*	Exotic	6	1				
Rubiaceae	*Ixora finlaysoniana*	Exotic	1	1				
Rubiaceae	*Ixora gardneriana*	Native of other biomes	3	1				
Rubiaceae	*Ixora undulata*	Exotic	1	1				
Rubiaceae	*Ixora macrothyrsa*	Exotic	6	1				
Rubiaceae	*Tocoyena bullata*	Native of other biomes	1	1				
Rutaceae	*Citrus sunki*	Exotic	2			1		
Rutaceae	*Citrus aurantiifolia*	Exotic	2			1		
Rutaceae	*Citrus pennivesiculata*	Exotic	5			1		
Rutaceae	*Citrus reticulata*	Exotic	4			1		
Rutaceae	*Citrus* spp.	Exotic	7			1		
Rutaceae	*Citrus deliciosa*	Exotic	1			1		
Rutaceae	*Citrus jambhiri*	Exotic	1			1		
Rutaceae	*Citrus reshni*	Exotic	1			1		
Rutaceae	*Citrus unshiu*	Exotic	1			1		
Rutaceae	*Citrus volkameriana*	Exotic	1			1		

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Rutaceae	*Citrus × limonia*	Exotic	2			1		
Rutaceae	*Citrus* x *aurantium*	Exotic	7		1	1		
Rutaceae	*Citrus* x *limon*	Exotic	5		1	1		
Rutaceae	*Galipea jasminiflora*	Native of other biomes	1	1	1		1	
Rutaceae	*Murraya paniculata*	Exotic	1	1	1		1	
Rutaceae	*Ruta graveolens*	Exotic	4		1			
Rutaceae	*Zanthoxylum monogynum*	Native Amazonian	1	1			1	
Sapindaceae	*Nephelium lappaceum*	Exotic	3					
Sapindaceae	*Paullinia cupana*	Native Amazonian	9		1	1		
Sapindaceae	*Talisia esculenta*	Native Amazonian	3	1		1	1	
Sapotaceae	*Ecclinusa guianensis*	Native Amazonian	1			1		
Sapotaceae	*Manilkara elata*	Native Amazonian	2				1	
Sapotaceae	*Manilkara zapota*	Exotic	1	1	1	1	1	
Sapotaceae	*Pouteria caimito*	Native Amazonian	3	1	1	1	1	
Sapotaceae	*Pouteria gardneriana*	Native of other biomes	1	1		1	1	
Scrophulariaceae	*Torenia fourniere*	Exotic	1	1				
Simaroubaceae	*Simarouba amara*	Native Amazonian	2	1	1		1	
Solanaceae	*Capsicum annum*	Exotic	1			1		
Solanaceae	*Capsicum frutescens*	Exotic	3		1	1		
Solanaceae	*Capsicum* spp.	Native Amazonian	2			1		
Solanaceae	*Cestrum nocturnum*	Exotic	1	1				
Solanaceae	*Lycopersicon lycopersicum*	Exotic	1			1		
Solanaceae	*Solanum lycopersicum*	Exotic	1			1		

Family	Species	Origin	Uses					
			No. prod.	Ornam.	Med.	Food prod.	Forestry	Artisanal
Solanaceae	*Solanum melongena*	Exotic	1			1		
Solanaceae	*Solanum pseudocapsicum*	Native Amazonian	1	1				
Urticaceae	*Cecropia peltata*	Native Amazonian	2	1	1	1	1	1
Urticaceae	*Pourouma cecropiifolia*	Native Amazonian	3			1	1	
Velloziaceae	*Vellozia squamata*	Native of other biomes	1	1				
Verbenaceae	*Lantana camara*	Exotic	1	1				
Zingiberaceae	*Alpinia purpurata*	Exotic	5	1				
Zingiberaceae	*Etlingera elatior*	Exotic	5	1				
Zingiberaceae	*Hedychium coronarium*	Exotic	1	1				
Zingiberaceae	*Zingiber spectabile*	Exotic	3	1				

Appendix 2

Table 3: Priority species for trade and seed scientific information available. RAS: Rules for Seed Testing (in Portuguese); Class. Stor.: classification for seed storage; Morph.: morphology; Prot. Cont.: protein content; Oil Cont.: oil content; Germ.: germination; Disper.: seed dispersal; Pred.: seed predators; Salt Tol.: salt tolerance; No. prod.: number of producers; Prior.: number of priority citations; o: orthodox; r: recalcitrant.

Family	Species	RAS	Storage	Class. Stor.	1000 Weight	Morph.	Prot. Cont.	Oil Cont.	Germ.	Disper.	Pred.	Salt Tol.	No. prod	Prior
Arecaceae	*Euterpe oleracea*	0	1,2	r	0	0	0	0	0	1	0	0	26	10
Bignoniaceae	*Handroanthus impetiginosus*	x	0	0	0	0	0	0	0	0	0	0	9	8
Bignoniaceae	*Tabebuia roseoalba*	x	1,2	o	0	0	0	0	3	0	0	0	6	6
Fabaceae	*Hymenaea courbaril*	0	1,2	o	1	0	0	1	1,3	1	0	0	13	6
Lauraceae	*Aniba rosiodora*	x	1,2	r	0	0	0	0	0	1	0	0	10	6
Fabaceae	*Cenostigma tocantinum*	0	1	o	0	0	0	0	3	0	0	0	8	5
Meliaceae	*Carapa guianenis*	x	1,2,3	r	1	0	0	0	3	1	0	0	13	5
Sapindaceae	*Paullinia cupana*	0	0	0	0	0	0	0	0	3	0	0	9	5
Bignoniaceae	*Handroanthus heptaphyllus*	x	0	0	0	0	0	0	0	0	0	0	4	4
Meliaceae	*Swietenia macrophylla*	x	2	o	1	0	0	1	3	1	0	0	7	4
Bignoniaceae	*Handroanthus chrysotrichus*	x	0	0	0	0	0	0	0	0	0	0	4	3
Cactaceae	*Cereus hildmannianus*	0	1	o	0	0	0	0	0	0	0	0	5	3
Fabaceae	*Cynometra bauhiniifolia*	0	1,3	r	0	0	0	0	3	0	0	0	3	3
Lecythidaceae	*Bertholletia excelsa*	x	2	r	1	0	1	1	3	1	0	0	10	3
Meliaceae	*Cedrela fissilis*	x	1,2	o	0	0	0	0	3	0	0	0	5	3
Bignoniaceae	*Handroanthus albus*	x	0	0	0	0	0	0	0	0	0	0	3	2
Bignoniaceae	*Handroanthus serratifolius*	x	1,2	o	0	0	0	0	0	0	0	0	3	2
Bignoniaceae	*Handroanthus vellosoi*	x	0	0	0	0	0	0	0	0	0	0	3	2
Bignoniaceae	*Tabebuia cassinoides*	x	0	0	0	0	0	0	3	0	0	0	2	2
Bromeliaceae	*Ananas comosus*	0	1	o	0	0	0	0	0	0	0	0	4	2
Euphorbiaceae	*Hevea brasiliensis*	0	1,2,3	r	1	0	0	0	3	1	0	0	6	2

Family	Species	RAS	Storage	Class. Stor.	1000 Weight	Morph.	Prot. Cont.	Oil Cont.	Germ.	Dispers.	Pred.	Salt Tol.	No. prod	Prior
Fabaceae	*Amburana cearensis*	x	1,2	o	0	0	0	0	3	0	0	0	1	2
Fabaceae	*Bauhiniaforficata*	x	2	o	0	0	0	0	0	0	0	0	2	2
Fabaceae	*Copaifera langsdorffii*	x	1,2	o	0	0	0	0	3	0	0	0	3	2
Fabaceae	*Inga edulis*	0	2,3	r	1	0	0	0	3	1	0	0	1	2
Heliconiaceae	*Heliconia psittacorum*	0	0	0	1	0	0	0	0	0	0	0	3	2
Heliconiaceae	*Heliconia rostrata*	0	0	0	0	0	0	0	0	0	0	0	6	2
Malvaceae	*Pachira nervosa*	0	2	o	0	0	0	0	0	0	0	0	1	2
Malvaceae	*Pseudobombax munguba*	0	1	o	1	0	0	0	3	1	0	0	3	2
Malvaceae	*Theobroma grandiflorum*	x	1,2	r	0	0	0	0	3	0	0	0	14	2
Myrtaceae	*Eugenia uniflora*	x	1,2,3	r	1	0	0	0	3	0	0	0	7	2
Nyctaginaceae	*Bougainvillea glabra*	0	0	0	0	0	0	0	3	0	0	0	4	2
Solanaceae	*Capsicum* spp.	0	0	0	0	0	0	0	0	0	0	0	2	2
Annonaceae	*Annona mucosa*	x	0	0	0	0	0	0	0	0	0	0	6	1
Apocynaceae	*Aspidosperma macrocarpon*	0	0	0	0	0	0	0	0	0	0	0	2	1
Arecaceae	*Bactris gasipaes*	x	1,2	r	1	0	0	0	0	1	0	0	11	1
Arecaceae	*Euterpe precatoria*	0	1,2	r	0	0	0	0	0	1	0	0	11	1
Arecaceae	*Oenocarpus bacaba*	x	1,2	r	0	0	0	0	3	1	0	0	6	1
Bignoniaceae	*Jacaranda brasiliana*	x	0	0	0	0	0	0	3	0	0	0	1	1
Bromeliaceae	*Guzmania lingulata*	0	0	0	0	0	0	0	0	1	0	0	2	1
Bromeliaceae	*Neoregelia carolinae*	0	1	o	0	0	0	0	3	0	0	0	2	1
Bromeliaceae	*Tillandsia* spp.	0	0	0	0	0	0	0	0	0	0	0	2	1
Bromeliaceae	*Vriesea* spp.	0	0	0	0	0	0	0	0	0	0	0	1	1
Burseraceae	*Protium* spp.	0	0	0	1	0	0	0	0	0	0	0	2	1
Burseraceae	*Trattinnickia* spp.	0	0	0	0	0	0	0	0	0	0	0	1	1

Family	Species	RAS	Storage	Class. Stor.	1000 Weight	Morph.	Prot. Cont.	Oil Cont.	Germ.	Dispers.	Pred.	Salt Tol.	No. prod	Prior
Caryocaraceae	*Caryocar villosum*	0	2	o	0	0	0	1	3	1	0	0	1	1
Euphorbiaceae	*Croton matourensis*	0	0	0	0	0	0	0	0	0	0	0	1	1
Euphorbiaceae	*Hevea rigidifolia*	0	0	0	0	0	0	0	0	0	0	0	1	1
Euphorbiaceae	*Hevea guianensis*	0	0	0	0	0	0	0	3	1	0	0	2	1
Euphorbiaceae	*Hevea microphylla*	0	0	0	0	0	0	0	0	0	0	0	2	1
Euphorbiaceae	*Hevea nitida*	0	0	0	0	0	0	0	0	0	0	0	1	1
Euphorbiaceae	*Hevea pauciflora*	0	0	0	0	0	0	0	0	0	0	0	1	1
Fabaceae	*Copaifera duckei*	0	0	0	0	0	0	0	0	0	0	0	3	1
Fabaceae	*Copaifera martii*	0	0	0	0	0	0	0	0	0	0	0	4	1
Fabaceae	*Cynometra spruceana*	0	0	0	0	0	0	0	3	0	0	0	1	1
Fabaceae	*Inga cinnamomea*	x	1,2,3	r	0	0	0	0	3	0	0	0	1	1
Fabaceae	*Inga sessilis*	x	3	r	0	0	0	0	3	0	0	0	1	1
Fabaceae	*Inga vera*	x	1,3	r	0	0	0	0	3	0	0	0	1	1
Fabaceae	*Inga vera* subsp. *affinis*	x	1,2	r	0	0	0	0	0	0	0	0	1	1
Fabaceae	*Ormosia* spp.	0	0	0	0	0	0	0	0	0	0	0	1	1
Fabaceae	*Parkia multijuga*	x	1,2	o	0	0	0	0	3	0	0	0	1	1
Fabaceae	*Parkia nitida*	x	1,2	o	0	0	0	0	3	1	0	0	2	1
Fabaceae	*Stryphnodendron pulcherrimum*	x	0	0	0	0	0	0	3	0	0	0	2	1
Heliconiaceae	*Heliconia acuminata*	0	0	0	1	0	0	0	3	0	0	0	1	1
Heliconiaceae	*Heliconia angusta*	0	0	0	0	0	0	0	0	0	0	0	1	1
Heliconiaceae	*Heliconia episcopalis*	0	0	0	0	0	0	0	0	0	0	0	1	1
Lauraceae	*Mezilaurus duckei*	0	0	0	0	0	0	0	0	0	0	0	2	1
Malvaceae	*Pachira aquatica*	x	0	0	1	0	0	0	3	1	0	0	1	1
Melastomataceae	*Pleroma mutabile*	x	0	0	0	0	0	0	0	0	0	0	3	1

Family	Species	RAS	Storage	Class. Stor.	1000 Weight	Morph.	Prot. Cont.	Oil Cont.	Germ.	Dispers.	Pred.	Salt Tol.	No. prod	Prior
Meliaceae	*Cedrela odorata*	x	1,2	o	1	1	0	1	1,3	1	0	0	5	1
Myrtaceae	*Plinia cauliflora*	x	2	r?	0	0	0	0	0	0	0	0	3	1
Poaceae	*Cynodon dactylon*	x	1	o	1	1	0	0	1	1	0	1	1	1
Rubiaceae	*Ixora gardneriana*	0	0	0	0	0	0	0	3	0	0	0	3	1
Heliconiaceae	*Heliconia velloziana*	0	0	0	0	0	0	0	0	0	0	0	2	1

Síntese

Os resultados deste estudo, indicam que os dados registrados no MAPA são obsoletos, o que os torna ineficazes para servir como base de informações para planejamento de restauração. O número de viveiros registrados é superior ao de produtores em funcionamento. Além disso, os produtores não registrados perfazem cerca de 40% do total. Por outro lado, o número de viveiros no bioma Amazônico apontado por Moreira da Silva *et al.* (2017) foi menor do que encontramos para apenas um dos estados neste bioma. As espécies registradas no MAPA, também não são idênticas à produção real. Uma base de dados segura facilitaria o acesso às informações e poderia melhorar a utilização de recursos com eficácia (Broadhurst *et al.* 2015).

A capacidade de produção de sementes pode ser quintuplicada, enquanto o provisionamento de mudas pode aumentar em sete vezes. A absorção desses produtos para o mercado de restauração depende das técnicas e estratégias empregadas (Lamb *et al.* 2005, Chazdon 2008, Rodrigues *et al.* 2009). Freire *et al.* (2017) enumeram circunstâncias de maior e menor exigência de mudas e estimam uma demanda de 809 a 2.991 toneladas por hectare. A produção anual do estado do Amazonas seria capaz de restaurar um pouco menos de cinco hectares na hipótese de uso reduzido de sementes e aproximadamente um hectare ao utilizar técnicas que exigem mais sementes. No entanto, com produção máxima de sementes as áreas restauradas seriam cinco vezes maiores.

A destinação de sementes e mudas mais notável é para produção alimentícia, o que indica que a prioridade de produção ainda não é para restauração. O desmatamento no Amazonas é responsável por 5,8% da área total para Amazônia Legal em área pouco significante em relação ao território do estado (INPE 2019). Isso pode explicar menor destinação de sementes e mudas para restauração e grande quantidade de espécies exóticas com principal utilização ornamental. Calvi e Ferraz (2014) encontraram principal uso das espécies provavelmente produzidas na Amazônia Ocidental idêntico ao deste trabalho.

A baixa demanda, dificuldades no transporte e com trâmites burocráticos exigidos pela legislação de sementes e mudas foram as principais dificuldades apontadas pelos produtores. Problemas similares foram encontrados em países em desenvolvimento (Harrison *et al.* 2008, Nyoka *et al.* 2015).

A provisão de sementes e mudas para restauração no estado do Amazonas ainda precisa se aperfeiçoar. A riqueza e origem das espécies devem ser mais próximos da vegetação local. Para produtores na Amazônia, a biodiversidade de florestas tropicais pode ser um obstáculo para a provisão de sementes (Schmidt 2007). Nesses casos, é mais difícil representar a diversidade de espécies, identifica-las, conhecer a fenologia, processo de maturação dos frutos, sensibilidade ao armazenamento, necessidade de tratamentos para quebra de dormência, procedimentos de germinação, entre outros. Piña-Rodrigues *et al.* (2018) salienta a importância de estudos de ecologia, produção e análise de sementes florestais nativas. Esses avanços no conhecimento podem garantir a provisão de material em quantidade e qualidade. A qualidade genética da semente deve ser almejada, pois definirá sobrevivência, adaptação e estratégias reprodutivas das plantas (Sebbenn 2002, Broadhurst *et al.* 2008). Dessa forma, o êxito dos esforços de restauração estará salvaguardado.

Em termos práticos, o registro de produtores e espécies no RENASEM não corresponde à realidade atual e necessita de atualizações para que possa ser utilizado como ferramenta de restauração. Atualmente, a produção de sementes e mudas no estado do Amazonas não depende exclusivamente da restauração, ocupando outros nichos de mercado, como produção para setor alimentício e ornamentação. No entanto, há possibilidade de aumentar a quantidade produzida de cinco a sete vezes caso haja incremento na demanda. Ressaltamos a possibilidade da coleta e comércio de sementes ortodoxas para fornecer a estados fronteiriços com maior taxa de desmatamento. Os principais gargalos apontadas pelos produtores são baixa demanda de espécies florestais, transporte e burocracia. As dificuldades relacionadas com capacidade técnica de produção foram secundárias. Contudo, a partir da lista de espécies prioritárias foi possível notar uma evidente lacuna de conhecimento de informações básicas de germinação. Desta forma, o estado tem certa capacidade de provisionar sementes e mudas para restauração e é papel necessário do governo implementar as exigências da LPVN e acordos internacionais para aumento de demanda.

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