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NATIVE FOREST SEEDS AS AN INCOME GENERATOR WITHIN THE FOREST LANDSCAPE RESTORATION CHAIN

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1. FOREST LANDSCAPE RESTORATION: REGULATIONS AS DRIVERS OF NATIVE SEED PRODUCTION

The implementation of large-scale restoration programs has failed mainly because of the complex gaps among science, policies, communities, markets, and society (Aronson et al. 2010). Nevertheless, global commitments require a forest landscape restoration (FLR) of at least 350 million hectares by 2030, according to the Bonn Challenge (Bonn Challenge 2020). This target has triggered a worldwide process of goals being established regionally and nationally (Jacobs et al. 2015). Brazil is among these countries, with a target to restore 12 million hectares (Brasil 2017), as well as 22 million via the Initiative 20x20 by 2030 ("Brazil" 2020), including 3.28 million hectares pledged by three Brazilian states: São Paulo (0.3 million), Espírito Santo (0.08 million), and Mato Grosso (2.9 million). Initiative 20x20 is a country-led effort to bring 20 million hectares of land in Latin America and the Caribbean, launched at COP 20 to support the Bonn Challenge.

Over time, many mechanisms have been adopted to ensure restoration. Legislation has been said to be an effective, but not always efficient, strategy for mandatory restoration (Chaves et al. 2015). However, FLR is not an exclusive government agreement. It depends on the formal and informal network of multiple stakeholders, capable of incorporating livelihoods and social strategies into the restoration chain (van Oosten 2013). The Brazilian government has implemented environmental laws in favor of economic lobbying (Soares-Filho 2013; 2014). Still, the current Brazilian reforestation rate (FAO 2015) is ten times lower than the committed restoration target. For comparison purposes, it took half a century for the forestry industry to achieve 7 million hectares of Pinus and Eucalyptus plantations, with both strong governmental support and fiscal incentives. For upscaling, restoration requires innovation – developing new models and institutions based on local situations and knowledge (Brancalion et al. 2017). In this context, seed and seedling production is suggested as the initial gap in which to begin the FLR process in Brazil and other Latin American countries (León-Lobos et al. 2020).

The large-scale production of forest seed species was originally devised to supply the burgeoning pulp and paper companies. From 1967 to 1987, a governmental incentive (Law 5106/1966) supported large-scale afforestation programs. Over this period, around 4 million hectares were planted in Brazil, mostly with imported seeds from exotic species (Ferreira 1992). This was the starting point of a regulatory system focused on producing high-quality seeds and establishing seed collection areas. However, all of this collapsed in 1987 with the end of governmental incentives (Ribeiro-Oliveira and Ranal 2014).

The national seed laws were based on the agricultural system, controlling any plant material produced and traded to ensure its genetic quality (Brasil 1977; 2003). Nevertheless, the importance of native forest seed was only firstly raised in the context of international conservation debates at the beginning of the 1990s (Sandholz, Lange, and Nehren 2018). Successive international discussions induced mechanisms, such as the environmental agenda – including restoration in both private and public areas (Graichen et al. 2016; NYDF Assessment Partners 2019) – which were modified and consolidated in Brazil's Forest Code (Brasil 1965; 2012).

At this time, the pioneer commercial native seed producers were research institutes and public environmental agencies in the southeast region of Brazil (Ribeiro-Oliveira and Ranal 2014). After 1990, there was an increase in private commercial forest nurseries (Ribeiro-Oliveira and Ranal 2014; Moreira da Silva et al. 2016), and many initiatives contributed to diversifying the native forest seed system in Brazil. In 1994, the lack of seeds to meet governmental demands for restoration induced the state of Rio de Janeiro to set up the first network of stakeholders to produce seeds for the nurseries (Piña-Rodrigues et al. 2007). They were followed in the 2000s by the second generation of eight networks financed by the Brazilian Government (Table 1). These networks, which began in the main biomes, were the pioneer arrangements for the community-based systems (Urzedo et al. 2015; Piña-Rodrigues et al. 2017). The third generation is dominated by community-based networks, with multiple stakeholders focused on creating local opportunities for native plant supplies and significant household livelihood improvements (Schmidt et al. 2019; Urzedo et al. 2019) and the 4th generation has just started with networks induced by compensatory legal mechanisms and companies, such as the Arboretum and the Rio Doce Basin Seeds and Seedlings Networks.

The community-based system has enhanced the third generation of networks, and other initiatives have been implemented, based on the demand created by legal mechanisms in various regions of Brazil (Urzedo et al. 2019), mainly to comply with mandatory restoration (Brancalion et al. 2010). Seed networks have been recognized as an essential governance system, which necessarily involve multiple stakeholders for upscaling productive systems of (Schmidt et al. 2019; Urzedo et al. 2020)genetically diverse and locally adapted seeds from large number of species. However, scarcity of native seeds is a critical restriction to achieve restoration targets. In this paper, we analyze three successful community-based networks that supply native seeds and seedlings for Brazilian Amazon and Cerrado restoration projects. In addition, we propose directions to promote local participation, legal, technical and commercialization issues for upscaling the market of native seeds for restoration with high quality and social justice. We argue that effective community-based restoration arrangements should follow some principles: (i.e. Between 2001 and 2006, more than USD 3.7 million was invested, mostly for developing technologies, conducting training initiatives, and creating opportunities for quality native seeds to be supplied in a socially inclusive way. Initially designed to reinforce human resources, as well as to organize information and make it available, networks have become a system based on the commitment of local communities. However, after government financial support ended, the restrictions on autonomy, the deficient market integration, and the lack of continuity in public policies caused the second generation of seed networks to disintegrate (Table 1).

The delay in implementing the new forest code (Brasil 2012) greatly impacted the restoration chain. Almost 15% (F. C. M Piña-Rodrigues, unpublished review) of the 218 nurseries in the state of São Paulo, producing 41 million native seedlings per year (Martins 2011), either closed or paralyzed their activities. Moreover, the inflexibility of Decree 5153 (Brasil 2004), based on agronomic standards and procedures, induced informality in the seed and seedling chain. For example, in 2013, from 369 active nurseries in the state of São Paulo (Silva et al. 2015), only 36 were officially registered on the National Seed and Seedling Registry – RENASEM (Ministério da Agricultura 2019). This highlight important biases in the production chain and warns of the need for organization and legalization of plant material for the ecosystem restoration chain.

Table 1. Seed networks created in Brazil from 1994 to the present and the current situation. FNMA = National Environment Fund; CEPAN= Northeast Environmental Research Center ; INPA = National Amazon Research Institute; UFAM = Federal University of the Amazon; IOV = Ouro Verde Institute; IDESAM = Amazonas Conservation and Sustainable Development Institute; ISA = Socio-Environmental Institute; UFMT = Federal University of Mato Grosso; IBAMA = Brazilian Institute of Environment; UFMS = Federal University of Mato Grosso do Sul; UFS = Federal University of Sergipe; UNIVASF = Federal University of Vale do São Francisco; SFB = Brazilian Forest Service; UNB = University of Brasília; UFES = Federal University of Espírito Santo; UFRRJ = Federal Rural University of Rio de Janeiro; UFSCar = Federal University of São Carlos; FAI = UFSCar Institutional Research Support Foundation; UFSC = Federal University of Santa Catarina. AM = Amazonas state; AP = Amapá state; BA = Bahia state; DF = Federal District, Republic Capital; GO = Goias state; ES = Espirito Santo state; MG= Minas Gerais state; MS = Mato Grosso do Sul state; MT = Mato Grosso state; NE= Northeast Brazil; PR = Paraná state; RJ = Rio de Janeiro state; RS = Rio Grande do Sul state; SC = Santa Catarina state; SP = São Paulo State.

Name	State and Ecosystem	Foundation	Main Organization	Source of Funds	Current Situation	Main Activities
Amazon Seed Network	AM Amazon Forest	FNMA	INPA	Projects	Functioning	Scientific research
Amazon Native Seed Center (CSNAM)	AM Amazon Forest	Project	UFAM	Projects	Functioning	Training Areas of Seed Collection, Collection, Production, Management and Analysis of Native Seeds Scientific Research and Production
Apuí Seeds and Seedlings Network	AM Amazonia	Projects	IDESAM	Fundo Vale	Functioning	Native Seed and Seedling Production
Portal da Amazônia Seed Network (Portal Seeds)	MT Amazon Forest	Project	IOV	BNDES Amazon Fund	Functioning	Native Seed and Seedling Production
Amapá Seed Network	AP Amazon Forest	Projects	Embrapa-AP	Projects	Functioning	Training Seed Collection Areas by Matrices, Scientific Disclosure Native Seed and Seedling Production

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Name	State and Ecosystem	Foundation	Main Organization	Source of Funds	Current Situation	Main Activities
Pantanal Network	MS Pantanal	FNMA	UFMS	FNMA	Functioning	Training Scientific research Scientific disclosure
Southern Amazon Network	MT Amazon Forest	FNMA	UFMT	FNMA	Closed	Training Scientific Research and Disclosure
Xingu Seed Network	MT Deciduous Forest Cerrado (Savannah)	Projects	Xingu Seed Network Association (ISA)	Projects	Functioning	Training Native Seed and Seedling Production
Jirau Hydroelectric Dam Seed Network	MT Cerrado (Savannah)	Projects	IBAMA	Environmental Mandatory Compensation	Functioning	Native Seed and Seedling Production
Cerrado Seed Network	DF, GO Cerrado (Savannah)	Projects	Cerrado Seed Network Association UNB	FNMA	Functioning	Training Native Seed and Seedling Production, Scientific Disclosure

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Name	State and Ecosystem	Foundation	Main Organization	Source of Funds	Current Situation	Main Activities
Cerrado de Pé - Seed Collectors Association - Chapada dos Veadeiros National Park	DF, GO Cerrado (Savannah)	Projects	Cerrado de Pé Seed Collectors Association	Environmental Mandatory Compensation	Functioning	Native Seed and Seedling Production, Gramineae and Savannah Species
Caatinga Seed Network	NE Caatinga	FNMA	Embrapa UFS	Projects	Functioning	Training Scientific Research Scientific Disclosure
São Francisco Integration Project Seed Network	NE Caatinga Deciduous Forest	Project São Francisco PBA-23	UNIVASF	Projects	Functioning	Native Seed and Seedling Production
Arboretum	BA Atlantic Forest	Legal compensatory Fund	Public Attorney SFB	Environmental Mandatory Compensation	Functioning	Training Native Seed and Seedling Production
Regional Network of Seeds and Seedlings of Rio de Janeiro	RJ Atlantic Forest	Pool of Private and Governmental Organizations	Forest Institute of Rio de Janeiro UFRRJ	Private	Closed	Training Native Seed and Seedling Production Scientific Disclosure

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Name	State and Ecosystem	Foundation	Main Organization	Source of Funds	Current Situation	Main Activities
Caparaó Seed Network	ES Atlantic Forest	Projects	UFES	Projects	Closed	Training Native Seed and Seedling Production
Green Brazil Network	ES Atlantic Forest	Projects	Vários	Projects	Closed	Seed Collection Areas by Matrices Native Seed and Seedling Production
Rio Doce Seed and Seedling Network	ES, MG Deciduous Forest Atlantic Forest	Legal compensatory Foundation RENOVA	Agreement CEPAN, UFSCar, Xingu Seed Network	RENOVA Foundation	Functioning	Training Native Seed and Seedling Production
Atlantic Forest Seed Network from Rio de Janeiro, Espírito Santos and Bahia - RioESBa Network	RJ, ES, BA Atlantic Forest	FNMA	UFRRJ	FNMA	Closed	Training Seed Collection Areas by Matrices Scientific Research Scientific Disclosure

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Name	State and Ecosystem	Foundation	Main Organization	Source of Funds	Current Situation	Main Activities
Rio-São Paulo Network	RJ, SP Atlantic Forest	FNMA	Fundação de Florestal de São Paulo	FNMA	Closed	Training Seed Collection Areas by Matrices Scientific Disclosure
Seasonal Forest Network	SP Seasonal Forest	Projects	Refloresta Institute	Middle Tietê River Basin Committee	Closed	Training Seed Collection Areas by Matrices Native Seed and Seedling Production
Native Seeds	SP Atlantic Forest	Refloresta Institute	Refloresta Institute	Environmental Mandatory Compensation	Functioning	Seed Collection Areas by Matrices Native Seed and Seedling Production
Atlantic Forest Seed Network (REMAS)	SP Atlantic Forest	Projects	UFSCar FAI	CNPq and Projects	Functioning	Training Certification Seed Testing Services Scientific Research Scientific Disclosure
Southern Network	SC, PR, RS Atlantic Forest	FNMA	UFSC	FNMA	Closed	Training Seed Collection Areas by Matrices Scientific Research Scientific Disclosure

2. COMMUNITY-BASED SEED PRODUCTION FOR RESTORATION: CASE STUDIES

Community seed networks have applied common policies for promoting local integration with restoration markets. Although seed networks converge in the broader sense of methods, their organizational models vary according to specificities at the local level. Here, we describe three seed networks, delineating the major local approaches, applied on a spectrum, to achieve goals according to each network's identity and socioeconomic characteristics.

2.1. Amapá Seed and Seedling Network – Arraiol do Bailinque

The state of Amapá is an environmentally privileged region in the Brazilian Amazon. In addition to an incredible diversity of ecosystems associated with the territories of traditional communities, it has the lowest historical rate of deforestation (INPE 2019), which makes it the most preserved state in the Brazilian federation. Amapá's existing environmental liabilities are concentrated in areas of agricultural settlements located close to the main highways. Data from the Rural Environmental Registry – CAR (SFB 2020) points out a total of 6,919 registered properties, with an area of around 600 thousands hectares to be regularized. If we consider that this area will be restored by planting tree species, it represents almost one million seedlings to comply with the local commitments imposed by public policies (Brasil 2017).

Forest protection is a major challenge, and, therefore, it is necessary to seek methods that encourage people to continue preserving while generating income. However, especially in the north, there is no consolidated market for the restoration chain. The legislation is complex for small producers, and, consequently, seed and seedling production is informal. In Amapá, there are no regularized nurseries for producing seeds and seedlings of native forest species (Ministério da Agricultura 2019).

The Amapá Seed and Seedling Network was an initiative from Embrapa Amapá,[1] proposed with the participation of traditional communities and family farmers associated with the Amapá Family School Network – thus reconciling technical training, income generation, and environmental conservation. The Arraiol do Bailique community in the regional seed network, situated in the Eastern Amazon, near the mouth of the Amazon River on the banks of the Arraiol River (Figure 1), has a population of 75 inhabitants, gathered in 22 family units. Their activities

1 https://www.embrapa.br/amapa/busca-de-noticias/-/noticia/34842264/projeto-desenvolvido-no-bailique-recebe-premio-bndes-de-boas-praticas-em-sistemas-agricolas-tradicionais

are fishing, hunting, wood extraction, buffalo breeding, and management of native açaizais (*Euterpe oleraceae* Mart. – açai palm) and meliponiculture in lowland forests, in addition to management of agroforestry homegardens producing fruits, spices and medicinal plants (Euler et al. 2019). The community has stood out in recent years for its example of organization, having been the first certified by the Forest Stewardship Council (FSC) to produce native açaí palm fruits.

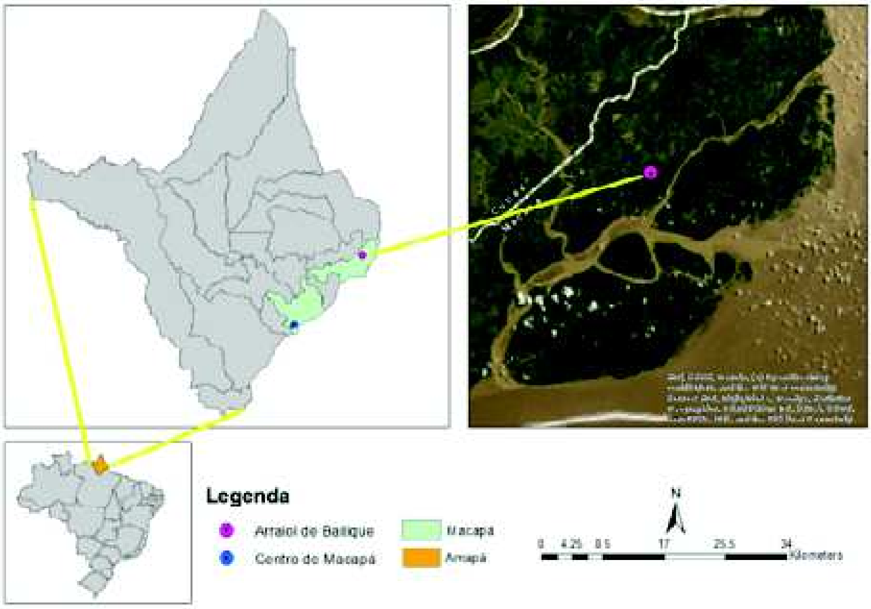

Figure 1: Arraiol do Bailique community location. Source: Andrade 2019.

In 2015, a partnership with Embrapa Amapá made possible the establishment of the first native seed collection areas (SCAs) of forest and creole seed[2] species. This project trained local inhabitants, with courses on tree mapping, participatory mapping of forest species, collecting and managing forest seeds, and good practices for processing and storing forest seeds associated with bottom-up strategies for business plans and marketing communication (Figure 2). This was done to transform seed production as an alternative for generating income, associated with the well-being and involvement of local inhabitants. The entire process followed participatory practices, both in decision making

2 These are cultivars developed, adapted, or produced by family farmers, land reform settlers, or indigenous people, which have well-determined phenotypic traits, are recognized as such by the respective communities and which, in the understanding of the Ministry of Agriculture, and considering sociocultural and environmental descriptors, are not substantially similar to commercial cultivars (Peschard 2017).

and in performing activities. Despite the great challenge, the community decided to produce legal seeds by accomplishing the requirements of the seed production regulatory framework, according to Decree 5.153/2004 (Brasil 2004). Along with workshops, they discussed principles, such as tree source selection (matrices), a minimum number of trees per species, seed processing, and harvesting and storage techniques based on principles from other forest seed networks and, at the same time, incorporating local knowledge.

The Arraiol do Bailinque engaged 16 collectors of 13 species with economic and social value (Table 2), totaling 153 matrices of native forest species spread out in the community areas. Based on their local knowledge, they designed a productive calendar to assist the community in planning family production throughout the year (Euler, Amorim, and Guabiraba 2018). The objective was reconciling forest seed production with other activities in the forest, homegardens, and agroforestry systems, as well as those involving açai management, forest restoration and enrichment, and the cultivation of medicinal plants. The main source of income and livelihood in the area is açai palm seed collection for the Arraiol do Bailinque people's own consumption, for selling to other local and national markets, and for seedling production.

Figure 2: Training activities for seed collection (a) and management of forest seeds (b) carried out in the Arraiol do Bailique community, Amapá, Brazil. Source: Ana M. C. Euler.

Table 2: List of species and matrices in the community SCA of the Arraiol do Bailique, Amapá, Brazil, in the Eastern Amazon. (Source: Ana M. C. Euler)

Common name	Scientific name	Number of selected trees
Murumuru	*Astrocaryum murumuru*	4
Pau-mulato	*Callycophylum spruceanum*	13
Andiroba	*Carapa guianensis*	13
Inter-havest açaí	*Euterpe oleracea*	14
Native açaí	*Euterpe oleracea*	26
Seringa	*Hevea brasiliensis*	8
Buriti	*Mauritia flexuosa*	15
Pracaxi	*Pentaclethra macroloba*	5
Tapereba	*Spondias mombin*	13
Cacau	*Theobroma cacao*	15
Cupuaçu	*Theobroma grandiflorum*	15
Ucuuba	*Virola surinamensis*	13

All collectors and their auxiliaries collect seeds from the matrices on their properties, most of which are 10 minutes away from their homes by boat. Seed harvesting is concentrated in the months of the Amazonian winter (January to June) because, during this time, the species are fruiting, and most of the seeds are recalcitrant, with great restriction for storage. However, the seed market is the bottleneck in the innovative seed business. Governmental programs have been the main driver of seed demand with Brazil's Food Acquisition Program (PAA). The main goal of the PAA is to "guarantee access to food in the proper quantity, quality and regularity according to the needs of populations living in food and nutritional insecurity, as well as to promote social inclusion in rural areas by strengthening family agriculture" (Chmielewska and Souza 2011). In the PAA, the "Seed Acquisition Program" purchased seeds from small farmers' organizations to distribute them to other smallholders' families (Silva and Almeida 2013). Despite the positive results in agricultural production – increasing the use of previously non-traded products, such as forest seeds – the PAA Seed Acquisition was canceled in Amapá after 2018. Still, the main destination of the seeds and seedlings was the smallholders' properties to improve their homegardens with fruit species and forest species of commercial value. They also sold (and still sell) small quantities to neighboring communities, with emphasis on açaí palm seedlings. The price of seedlings includes only the costs of inputs (seedling bags, fertilizer, pesticides) and consumption, not labor and working time.

The seedling production system engages everyone, from young people to elders (Figure 3). According to the Arraiol do Bailique nursery business plan, the expected annual production of seeds is 150kg, with a projected annual revenue of about USD $670 from seed's trade and USD $17,000 from the açaí seedling trade, and a production cost of USD $9,520. The final annual income per family from the nursery activity is about USD $470. The production of seeds and seedlings is a secondary economic activity, carried out by 16 families, along with açaí and agricultural production.

Figure 3: Substrate prepared by young people and local leaders in the nursery of the Arraial do Bailinque, Amapá, Amazon. (Source: Marcia do Carmo).

A future scenario must include the effective implementation of the Rural Environmental Register (CAR) imposed by Law 12.651/2012 (Brasil 2012), which mandates that all rural properties restore legal reserves and protected areas. This will increase forest seed demand. Nevertheless, in the short-term, it is necessary to encourage and to finance forest restoration and to purchase seeds and seedlings through public programs. The PAA's Seed and Seedlings design could be an opportunity. Prior to 2018, the Brazilian Committee of Seed Science proposed the program's nationwide implementation to the Ministry of Agriculture and received a good acceptance. A multi-stakeholder program design must be implemented, exploring the key issues and challenges of scaling up, such as farmers' organizational capacities, transportation, the design of payment systems, and financing (Nehring and Mckay 2013).

2.2. Amazonas Native Seeds Center

The Amazonas Native Seed Center (CSNAM) began its activities in 2001, linked to the Federal University of Amazonas. In partnership with the National Amazon Research Institute (INPA), the CSNAM has focused on educational performance. Production research and extension also contribute to maintaining the productive chain of native Amazonian seeds. The CSNAM is supported by national level governmental agencies and programs, developing projects to promote the restoration of urban areas, permanent forest reserves, and restricted areas, as well as establishing agroforestry systems (León-Lobos et al. 2012).

Since 2005, the CSNAM has worked toward capacity building and training of indigenous people (Sateré-Mawé) and smallholders for seed harvesting – resulting in more them 150 trained seed collectors, 100 species for afforestation. There are 11 SCAs across eight municipalities in the state of Amazonas, with 3,117 mother-trees of 240 species from 33 botanical families. Seed production is carried out only by collectors trained by the CSNAM to manage harvests and process seeds. First, seed collection areas are identified and inventoried; then, mother-trees are selected. The collecting groups receive equipment and carry out phenological monitoring. The seeds are transferred to the CSNAM, which performs quality tests and stores the seeds for selling via the website or directly to the municipality for afforestation programs (Figures 4A and 4B). The commercialization of 63 species has already produced about a ton and a half of seeds, giving smallholders opportunities to access markets and generate income. Seed collectors still need support for their self-organization, production, and logistic. Botanical identification, price of seeds demand, protocols for seed analysis, laboratory research and technical training are still pointed out as a bottleneck for the amazon tree seed species chain. We have been working with the tree seed researchers of our main partner, INPA (National Institute of Amazon Researches), in order to promote technical datasheet for seed information, where we had written up to now around 50 leaflets. We are also promoting together, the establishment of an Amazonia Native Seed Bank, in a research basis, for the protocols of seed analysis and conservation, and in a tree seed database for Amazon species.

Figure 4: Young collectors trained by the CSNAM, Manaus, Brazil (4A). Preparation of botanical material for identification (4B) course by the CSNAM, Manaus, Brazil. (Source: M. J. V. Lima Junior).

2.3. Atlantic Forest Seed Network

The Atlantic Forest Seed Network (REMAS) was organized in 2010 and is a mix of some organizations from the second generation of networks, such as Seasonal Forest (RESD), Rio-São Paulo,[3] and the Rio-Espirito Santo and Bahia (RIOESBA)[4] (Table 1). Currently, the REMAS serves as a technological-transfer link, collaborating with networks, groups of collectors, and nurseries to promote seed and seedling production according to the network's parameters (Piña-Rodrigues et al. 2007).

Here, we will report on the "Native Seeds Group" from Capão Bonito, in the southwest of São Paulo. It was instituted in 2005 with the project "Seeds of the Future," financed by a paper company to comply with environmental requirements. This community-based seed network (CSN) is supported by the Refloresta Institute, with 70 participants divided into 19 groups of seed collectors. The network is composed of farmers and residents of the largest Atlantic Forest continuum in Brazil: the Intervales State Park, in the state of São Paulo. They collect and manage native seeds of the Atlantic Forest, with the Refloresta Institute providing technical assistance, offering commercial management, and storing and selling seeds to forest nurseries, including those in the network itself. The network's activities are an important source of income generation and supplementation for the families that inhabit the region, which is characterized by a low human development index (HDI) compared to other regions in the state. Until 2013, there were 45 participants divided into nine groups, most of whom were women (75%), but now only nine women collectors remain in the group, and the others left the network to search for new sources of income. The main cause of this reduction was the low demand for forest seed

3 http://www.sementesriosaopaulo.sp.gov.br/

4 http://www.if.ufrrj.br/rioesba/capacitacao.html

caused by political uncertainties. They were generated by the insecurities and delay for implementing the Forest Law 12651/12 (Brasil 2012), which reduced the area planned for mandatory restoration by almost 58% (Soares-Filho et al. 2014).The Native Seed Group produces seeds from 225 species, with 2,000 matrices across 37 SCAs. The group's strategy for maintaining its activities is to use seeds to produce and sell seedlings via the Refloresta Nursery and in commercial partnership with the Forestry Institute of Research (IPEF) to sell small quantities of seeds to landscapers and other buyers, instead of focusing only on mandatory restoration (Figures 5A and 5B).

Figure 5: Training Course for seed multipliers and collectors (5A) with production planning practices (5B) and seed handling conducted by the REMAS in support of the Portal Seeds Network, Mato Grosso. (Source: F. C. M. Piña-Rodrigues)

2.4. Xingu Seed Network

In the Upper Xingu region of Amazonia, the most representative CSN began with the Y Ikatu Xingu campaign ("Save the Good Water of Xingu," in Kamayurá indigenous language). Its objective was to mobilize farmers in the vicinity of the Xingu Indigenous Park to ensure compliance with mandatory land restoration (Durigan, Guerin, and da Costa 2013). Attempting to meet seed demand, indigenous communities, smallholders, and urban residents for natives were mobilized to organize community-based seed collection, thus forming the Xingu Seed Network (RSX) in 2007 (Urzedo et al. 2016). This movement initiated the third generation of forest seed networks, with a bottom-up system of decision and organization and without direct interference from public authorities.

Ten years later, the RSX became an association and one of the most significant commercial native seed producers in Brazil (over 25 tons yearly), composed of 568 collectors. It is a reference for other national initiatives. The RSX is organized into fourteen groups, supported by a local seed house for storing all material produced by each group of collectors. These endeavors are coordinated by several local leaders, who are considered as "links" in the production chain. Each link is responsible for representing the community during network meetings for decision-making processes (Urzedo et al. 2016; Schmidt et al. 2019).

Annually, seed demand is surveyed by the Association Xingu Seed Network (ARX) with potential buyers, who place their "annual orders" to comply with mandatory restoration. Then, the links are contacted to send the lists of species and quantities that can be produced by each group of collectors to meet demand. Each collector processes the seeds and transports them to the nearest seed house. Regularly, seeds are transported to the central administration of the ARX, which is responsible for storing the seed long-term, conducting seed quality tests, selling seeds to those placing orders, and marketing and administrating the commercial process.

The main characteristic of the RSX is that it produces seed based on prior demand. This process ensures greater security and reduces losses because it prevents the collection, transport, and storage of seeds without having a potential buyer or use for the material, bringing more certainty of revenue to the communities. Its successfulness is evidenced by its long-term existence and productivity. Over ten years, the RSX has had a cash income of USD $1.3 million, producing almost 220 tons of forest seeds from 214 species. Urzedo et al. (2016) have explored how collectors' participation in the RSX has helped diversify household income sources and improve livelihoods in terms of nutrition level, education, home and shelter, local knowledge, cash income, and women empowerment (Figures 6A, 6B and 6C).

Figures 6: Participatory construction of the harvest schedule (6A and 6B), and comparison and joint construction of the harvest schedules (6C) in training workshops and exchange of knowledge in the Xingu Seed Network, São Felix do Araguaia, Mato Grosso, Brazil. (Source: F. C. M. Piña-Rodrigues)

3. CAN SEED PRODUCTION BE AN INCOME GENERATOR IN THE FLR CHAIN? LESSONS LEARNED FROM COMMUNITY-BASED NATIVE SEED NETWORKS

Nationwide estimates indicate that seedling production can reach 142 million seedlings yearly (Moreira da Silva et al. 2016), requiring more than 800 to 2,000 tons of native seeds annually (Freire, Urzedo, and Piña-Rodrigues 2017). However, Brazil´s production is far from achieving the restoration target of 12 million hectares (Brasil 2017), with an estimated production in 2013 of 57 million seedlings and 97 tons of seeds by 1,276 nurseries (Silva et al. 2015).

CSNs can be classified as social entrepreneurship. They are distinguished from "regular" entrepreneurs by three characteristics: the predominance of a social mission, the importance of innovation, and the role of earned income (Lepoutre et al. 2013). A CSN, as a social entrepreneurial organization, has an explicit and embedded social objective, which engages multiple stakeholders, promotes life quality, and empowers women. Here we can also add the notion of "social" for entrepreneurs who develop products and services that "cater directly to basic human needs that remain unsatisfied by current economic or social institutions" (Seelos and Mair 2005).

Like any entrepreneurial organization, a CSN requires initial investment, personnel, supplies, equipment, and a cash flux to maintain its economic and social sustainability. The majority of CSNs began with projects of organizations and governments, which provided much of the initial funding (Table 1). As a non-profit company, CSNs access capital that is unavailable for business entrepreneurs and set partnerships aimed at creating value for everyone involved, providing structures that help people escape from poverty and gain control over their lives.

The classic financial feasibility analysis for investments uses indicators to estimate the attractiveness of a scenario. The indicators are applied to cash flow (planned and ongoing capital inflows and outflows) based on a minimum expected rate of return on capital, which corresponds to the aforementioned gain. Among the main indicators of the financial viability analysis are the internal rate of return (IRR), the present value and net present value (PV and NPV), the net profitability index (ILL), and the discounted pay back (DPB).

To assess CSNs as social entrepreneurial organizations, we proposed a model based on a network from the Amazon, in the state of Acre (F. C. M. Piña-Rodrigues et al., 2020). We have chosen this group because it represents a typical CSN, with the engagement of multiple stakeholders, a formal association of indigenous and rural settlements, and forest seed harvesting as an alternative source of income. We applied a simulation–optimization procedure to estimate the expected profit and the associated probability of making a certain desired profit (Chen, Subprasom, and Chootinan 2001). We employed a traditional balance sheet to evaluate social entrepreneurship to obtain data concerning previous investments, total production, income, operating expenditures, revenue, and net cash flux (Tilghman 2015). Costs included the community organizing process itself in a pilot project with 30 collectors from 15 families, one engineer (part-time), and one technician (full-time), with the initial purchase of equipment, construction, and four annual meetings. We applied an attractiveness rate of 0.5% per month and a correction factor of 15.8% for seed price, based on a market survey for the same species during the studied period and at the time of analysis. We evaluated three scenarios: (1) refundable private investment, (2) nonrefundable public or private investments and (3) mixed association investment and nonrefundable private or public funds. All scenarios were proposed to meet a leverage ratio of 1:1 (each dollar invested generated USD $1 in a positive economic impact) in the shortest time, until 60 months, based on the total sale of the seed supply.

The studied community collected a total of 1,298kg of seeds, with an average market price of USD $97.70 and a gross revenue of USD $47,222. The initial investment was estimated to be USD $61,388, composed of USD $38,891 in investments and USD $22,297 as working capital. In Scenario 1, the network entrepreneurship had an attractiveness IRR below the projected minimum, a negative NPV, and an ILL < 1, demonstrating financial unfeasibility in the evaluated period (Table 3). There is an indication that the seed collection network was not viable in this model, with external repayable capital, and under market interest. However, the CSN paid for itself (PBD) at 37 months – that is, before the end of the 60 months of analysis – indicating its potential as a regular form of entrepreneurship.

In Scenario 2, it was not possible to calculate the IRR, NPV, or ILL, since these indicators are applied to an investment amount and, therefore, did not apply here. The NPV of the CSN is related to cash flow, and, in this case, it was positive. Thus, without any investment, there was a positive NPV, and the project was feasible in the first month after its establishment and complete operation (DPB). In this scenario, it is possible to consider that the CSN could reach a sustainable situation; however, it is necessary to pay attention, because, as capital depreciation occurs during the project, these values must be reserved, calculated and invested at the minimum rate stipulated.

Finally, in Scenario 3, the IRR was positive from the investment of USD $4,618 by the association and of USD $46,189 from private or public nonrefundable investment. PBD was positive from the beginning (one month after initiation); however, the other indicators (NPV and ILL) only became positive when the investment reached USD $50,808 in the fourth month after the total implementation of the CSN.

Social entrepreneurship, such as the proposed CSNs, may not bring the best financial indicators. However, once the social fragility of the actors is identified, social sustainability is compromised, so an external agent is needed to allow for social engagement. External contribution consists of technical assistance, management, planning, and strategic projects designs, but launching a CSN essentially requires at least an estimated nonrefundable capital of USD $61,388. In this condition, it is possible to generate an income of around USD $24,711 per year (USD $823.70 per year per collector), plus nearly USD $14,000 in salaries for a group of 32 members – thus, ensuring economic and social sustainability. Although the income of collectors in CSNs is higher than that in other networks (USD $256.50 per year per collector), it is important to consider the differences between the scenarios established by each author (Urzedo et al. 2020). As the CSN is a project that foresees the dissemination of native plant species, it is assumed that via the gains of this action – with regards to the carbon balance, which must be negative, and the dissemination of biodiversity through the restoration projects it originates – it is possible to indicate full sustainability in projects for the collection, processing, and trade of native seeds.

Table 3: Financial feasibility indicators applied for a seed network in Acre, Amazonia. Scenario 1 = refundable investments; Scenario 2 = public or private nonrefundable investments; Scenario 3 = association's equity investment and nonrefundable private or public funds. Exchange: USD $4.33 = R $1.00.

Indicators	Scenario 1	Scenario 2	Scenario 3
Nonrefundable initial investment	-		USD $50,808
IRR (Internal Rate of Return)	0.496%	High	22.3%
NPV (Net Present Value)	- USD $41,545	USD $9,611	USD $795
ILL (Net Profitability Index)	0.32	High	1.07
DPB (Discounted Pay Back)	37 months	1 month	4 months

4. KEY LESSONS – CSNS

The bridge between collectors and the market has been developed mostly via the efforts of non-governmental organizations (NGOs), universities, research institutes, and governmental agencies. Commercial production is established based on the collectors' supply capacity, which is directly connected to the market demand mapped by the partner organizations responsible for supporting the business management. Therefore, native seed markets are strongly associated with legal requirements and formal institutions, which can and have changed over time, resulting in unstable restoration demands and an uncertain future for these organizations.

Although arrangements vary according to each initiative regarding social and economic realities, the RSX in the state of Mato Grosso has been a national reference (Table 1). It is considered a model because of its commercial production of a substantial volume of seeds for sale across ten years (over 200 tons, i.e., around 5,000 hectares) and its efficient use of estimated prior demand to guide seed production. This arrangement has supported the development of seed suppliers in many other regions in Brazil.

Community seed supplies require multiple stakeholders to participate in bottom-up decisions for planning, managing, and evaluating the processes of income generation and rural development. Key organizations, such as NGOs, universities, associations, and cooperatives, are essential driving forces of sustaining the actions for seed supply. These organizations have been promoting resilience, maintaining local structure for seed supply and restoration. However, seed networks are isolated and require a national organization so that they may have more influence over the decision-making process – mainly in regulating seed production policies.

In general, for FLR, it is necessary to maintain both systems, the private system via nurseries and commercial seed suppliers and the community-based network for obtaining seeds and producing seedlings. However, each system demands different strategies for sustaining its productivity. While the private sector can profit from subsidized investments over one to five years, CSNs require nonrefundable investments to achieve their social and economic objectives. However, both need a market that remains more stable, with long-term public policies and legislation compatible with the characteristics of the seed sector and its present and potential reality.

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