agropolis fondation

RAPPORT FINAL : PROJET 1503-011

REFLORAMAZ

Forest restoration by smallholders in the Eastern Amazon: how to improve the balance between environmental and socioeconomic benefits?

Authors: Emilie Coudel, Joice Ferreira, Lívia Navegantes, Christophe Le Page

HISTORIQUE DE L'APPEL A PROPOSITION *: AAP AF-EMBRAPA*

RAPPEL DES DATES DE RAPPORT	
1ère rapport intermédiaire :	**Février 2019**
Rapport final :	**Décembre 2019 > fevrier 2020**

Index

List of figures

List of tables

1. RAPPEL DES INFORMATIONS GENERALES SUR LE PROJET SOUTENU		
Titre long **Titre court**	Forest restoration by smallholders in the Eastern Amazon: how to improve the balance between environmental and socioeconomic benefits? **Refloramaz**	
Domaines thématiques concernés	Agro-ecosystems, agri-environmental innovations and resource management, Innovation processes and social management of innovation	
Unité proposante	UPR GREEN Cirad	
Institutions de tutelle de l'unité	Cirad	
Responsable du projet (France)	Coudel Emilie	
Adresse postale **Courriel** **Tél/fax**	CDS-UNB, Campus Darcy Ribeiro - Asa Norte, Brasília - DF, Cep: 70910-900 emilie.coudel@cirad.fr +55.61.98332.8464	
Responsable du projet (Brésil)	Nunes Ferreira Joice	
Adresse postale **Courriel** **Tél/fax**	Amazônia Oriental Tv. Doutor Enéas Pinheiro, s/n - Marco, Belém - PA, Cep: 66095-903 joice.ferreira@embrapa.fr	
Partenariat	*Collaboration affichée dans la convention*	*Pour chacune des collaborations à lister, ci-dessous, préciser s'il s'agit :* ⇨ *Du renforcement d'une collaboration existante (R)* ⇨ *D'une nouvelle collaboration (N)*
Unités participantes au sein du Labex Agro	AMAP Fôrets et sociétés *à travers le DP (*Dispositif en Partenariat) Amazonie Autres : Cliquez ici pour entrer du texte.	☐RENFORCEMENT ☒NOUVELLE ☒RENFORCEMENT ☐NOUVELLE
Unités partenaires hors Labex Agro	Autres : Cliquez ici pour entrer du texte.	☐RENFORCEMENT ☐NOUVELLE
Partenaires étrangers (pays, institutions)	Europe : Stockholm Environment Institution North America : Indiana State University North America : Cornell University Europe : Lancaster University *(à travers le Réseau Amazonie durable)* Autres : Cliquez ici pour entrer du texte.	☒RENFORCEMENT ☐NOUVELLE ☐RENFORCEMENT ☒NOUVELLE ☐RENFORCEMENT ☒NOUVELLE ☒RENFORCEMENT ☐NOUVELLE
Catégories de demandes sollicitées	Support for small exploratory, risky and innovative projects , Support for publication and dissemination of research results, Support for the organization of high-level scientific events (conferences, seminars, workshops, etc.) in Montpellier or in Brazil	
Date de début et de fin de projet	du 1 janvier 2017 au 31 décembre 2019 (prolongation demandée à cause des difficultés de démarches administratives côté Embrapa) 36 months	
Montant alloué	50 000 euros (Budget demandé à l'Embrapa 50 000 euros)	
Dates de début et de fin de prise en compte des dépenses	1 janvier 2017 au 31 décembre 2019	

2. DESCRIPTION SYNTHETIQUE DU PROJET SOUTENU

Merci de renseigner les zones prévues à cet effet et d'apporter toutes les informations pertinentes liées au déroulement du projet

Résumé du projet et objet de la convention

This project will establish a **learning-practice network** of leading reforestation practitioners and researchers on the theme of forest restoration by smallholders in the Eastern Amazon. The project is led by researchers from the "Dispositif en Partenariat Amazonie" (Cirad-Embrapa-UFPA) and responds directly to the demand for technical guidance and decision making support laid out by the revision to the Brazilian Forest Legislation in 2012 and the recent inception of the National and State Programs on Environmental Restoration.

The main scientific objectives are to

i) identify, through a collaborative multi-stakeholder process, what are the key factors that motivate or limit smallholders to engage in forest restoration, and

ii) to assess the enabling conditions necessary to balance the provision of both environmental services and social and economic benefits to support the practical implementation of national and state policies for environmental restoration.

General progress of the project in relation to the objectives initially set: Cliquez ici pour taper du texte.

This project brought together a diversity of stakeholders from different action spheres to share knowledge around forest restoration in Eastern Amazon. The core team was constituted of 12 researchers (Brazilian & French), with a particularly multidisciplinary profile (ecology, forestry, agronomy, ethnology, sociology, economy, modelling) and 20 students (1 grad, 16 masters' and 3 doctorate fellows), as well as a high school biology teacher, also farmer and part of the cooperative of Irituia. Around this team, different circles were aggregated: researchers to orient and comment our work (approximately 20 researchers involved in several exchanges), other students who wished to know better our work (2 doctoral fellows), many women and men farmers (approximately 10 directly involved with us in recurrent meetings, field visits, conferences, while we did interviews and visited the restoration experiences with nearly 400 farmers total), as well as some 20 young farmers (age 17 to 19) as part of their biology course, a number of extension agents (approximately 20) and other institutional stakeholders (municipal agricultural departments, state forest institutions, social departments, cooperative leaders, etc.). To enable exchange between stakeholders, we promoted different spaces: in particular common field weeks, to meet many stakeholders in the region or during which we all lived together in farmer communities and visited the surrounding farms (we organized a dozen such visits during the three years of the project); or shorter field visits to bring external researchers to see promising initiatives; all these visits were most often the best moments to exchange about the farmers practices, assess together the success (environmentally and socially) of the experience, discuss the difficulties involved in implementing them. We also organized a number of events, with two seminars in Belem, discussion of results in three municipalities (Irituia, Bragança and Tomé-açu), and a capacity building workshop in Belem. Mobilizing such a diverse network, enabled us to confront many visions of the challenges of forest restoration by family farmers and of what motivates or limits them in engaging in forest restoration. We realized that few stakeholders have had the opportunity to discuss this topic. There is still a certain invisibilization of restoration processes by smallholders, confirming how important and relevant it was to undertake this first inventory of restoration initiatives. By mapping more than 400 farmers in 5 municipalities, we revealed that forest restoration is an emerging phenomenon that deserves more attention from policymakers at all levels.

By building a multi-agent model, developed as a simulation game, we progressively built with the different stakeholders a common representation of the links of restoration to other components of the farming system and how they link to the institutional context. This enabled us to define together the indicators which were important for assessing the restoration initiative, environmentally, socially, and economically, as well as the medium costs and labour investment for a series of activities. The indicators were established through a collaborative process among the different workpackages of the Refloramaz project, linking knowledge from the different realms, in particular ecology, production systems and social aspects. The process of building the simulation game fomented interdisciplinary discussions among the team and with the farmers, enabling horizontal relations among the different stakeholders and stimulating trust and learning. During the exploitation phase of the game (we did 6 sessions, involving together farmers, extension agents, decision makers), we were able to discuss how each person decided about the trade-offs and balance between environmental services and social and economic benefits. Discussions were rich, revealing how different visions of the ideal forest restoration can be. Often, farmers were proud to show technicians that they were able to balance better than them the different dimensions, as the technicians focused mainly on the economic dimension. Younger farmers sometimes had better results than elder farmers who in a debate would leave little space for the new ideas of younger people. This form of sharing knowledge proved to be very stimulating. Several ideas emerged from these exercises regarding the support that could be provided by public policies to encourage forest restoration by family farmers. We hope that the now stabilized online version of the game can continue to provide spaces for debate and encourage the emergence of new initiatives to support restoration.

The Refloramaz project enabled to consolidate a learning network and give visibility to the many emerging initiatives of forest restoration by family farmers in Eastern Amazon. We reached beyond the involvement of farmers, practitioners and researchers and had a strong focus on the young generation. We were able to build a stimulating research group, that has attracted many more students than we had hoped for, which continue to maintain strong links among them and with the university professors. The first ones now have jobs related to the valuation of forest restoration products and to environmental compliance. We are pleased to be able to contribute to the education of these young people that will, as educators, researchers or decision makers, act towards valuing forest restoration, define adequate support, and with a broader vision of how to work with farmers, valuing their own experience and knowledge.

Actions prévues, calendrier et délivrables associés *(lien avec le Gantt Chart)*

Pour chacune des actions prévues dans la convention, merci de préciser le statut de réalisation et de détailler brièvement le déroulement de celle-ci.

Pour chaque délivrable annoncé, préciser le statut de production et ajouter un commentaire, si nécessaire.

The fieldwork will be carried out in **Northeast Pará** where a number of restoration initiatives with smallholders has been developed over the last 20 years (see map, Figure 1). A total of **30 study sites** will be selected to represent the diversity of restoration processes, stratifying by municipality, institutional support, duration of the experiment, type of land tenure and forest cover.

The project will be managed by the **four work package leaders** (Joice Ferreira, Lívia Navegantes, Emilie Coudel and Christophe Le Page). Each of them will be in charge of facilitating the collaboration with the other participants of his work-package (from the core group, methodological support and guidance). Trimestral meetings of the core group (in some cases in person, in others via Skype) will enable information to be shared between work packages. These meetings will occur one month before the next field work (one week per trimester) and will enable each group to present results from the last fieldwork and objectives of the next field work.
In case of specific transversal problems, the four team leaders can have a short meeting to share preoccupations and define a common way to solve the problem.

To start out, the core team will carry out an exploratory field work, to make further contact with the promoting institutions and farmers involved and select the 30 restoration sites to be studied. During the first seminar with all the participants, a pilot methodology will be built and tested in field immediately after. The consolidated methodology will then be applied by the core team, along with PhD and master students. At the end of the first year, first results will be presented to the stakeholders involved, to foster science-practice interchange and prepare the following work.

The second year will be mainly oriented by the modeling process. A first model will be built based on the interdisciplinary assessment and progressively adapted with the stakeholders. Once a satisfying version is achieved, some first scenarios will be tested. The final seminar will discuss the results of the project and choose the scenarios that will be further explored among the multi-stakeholder group.

The major outputs of the project will be delivered in the second year including communication in scientific conferences and journals, and dissemination/interchange of main findings to a wide audience, including farmers, technicians and decision makers.

WP1 coordination, will support integration among WPs and communication among the different stakeholder.

Actions undertaken
Statut : Réalisé

Activity 1.1: Integration between WPs

From the beginning of the project, we aimed at fomenting interaction and knowledge sharing between disciplines, in such a manner that we ourselves can now hardly tell what was more related to one WP than to another. At a farm level, at a community level, environmental, production system and social dimensions are very intricately associated. We defined research questions together that we then addressed collectively, for example: how do farmers perceive environmental services and how does this translate in their production system? What are the trade-offs between ecological, social and economic dimensions?

In practice, to foment such integration between WPs, we defined a working routine based on regular interactions between the coordinators and with the other members of the project, through meetings, common field work or student co-orientation. We defined together common principles to orient our research (presented at each restitution and seminar to define our group identity):

Princípios da pesquisa: Partir das práticas dos agricultores

1/Start from the farmers practices, which involved observing and assessing together existing experiences. This led us to map out nearly 400 farmers, each with their own specific practices, which is an incredible source of information. We created little by little a data base with this information, which up to date has 160 entries, and which is to our knowledge quite unique regarding restoration practices. This data base has been used as an interdisciplinary source to each test our hypotheses and integrate our work. We plan to write together a common article based on this data base, to make visible these practices, their advantages and the challenges remaining.

2/ Practice interdisciplinarity through common field works, which meant that 10 to 15 people would go together to field, either all together when the farmer wasn't too shy, either splitting up and sharing afterwards the different visits. These moments where generally the richest ones, in terms of knowledge exchange with farmers and among researchers, each one having different questions, noting different aspects of the production system. We started out every year, in January, with a two-week common field. Other field expeditions were organized, to introduce our work to the farmers in a municipality, to accompany a student who was setting out, to do restitutions and game session. In all, we had more than a dozen common field visits.

Princípios da pesquisa: Praticar a interdisciplinaridade com campos comuns




Princípios da pesquisa: Formar e envolver estudantes






3/ Train and involve students: we had planned to prioritize student training, but we hadn't expected to have up to 20 students! They passed along the word about this stimulating team and we chose to attend the students who were interested. New colleagues, who weren't initially in the project also chose to orient their students within the Refloramaz project, as it created an enriching context for their students. This was a great challenge, as we needed to stimulate exchange between students, so as to pass on the work started with some to the others. We were very pleased to realize that the students soon formed a group of their own, exchanging information, reference articles, contacts of farmers, and helping each other during their masters'.
We also chose to focus our work in Itabocal, where a biology high school teacher opened her class to us. We thus accompanied young farmers (17 to 19 years old) during a year, in 2018, to talk about the importance of forest restoration and agroforests. The young students had to ask their family or neighbors about their practices and report back about them, which was an interesting way to explore about local practices. We also involved them in co-constructing the game, which was very stimulating for them, as they realized that agriculture can also be modern. We continued to meet these young people in the following year and several of them said how important our discussion spaces had been to them, in opening their curiosity about agroforests.

4. Favor debate between different points of view and build new knowledge, respecting each and every participant in our activities. We invited very different types of stakeholders and through different facilitation tools, we favored a constructive debate, giving the opportunity to each participant to put his/her view forward. We did have some animated debates, for example between technicians and farmers, but interestingly, the game turned out an impressive tool in enabling the participants to express themselves and show the others that their own practices are valid and can enable a balance between environmental and social benefits.

Principios da pesquisa: favorecer o debate entre pontos de vista diferentes e construir novos conhecimentos


Activity 1.2: Communication and dissemination

Our whole process with the farmers and other stakeholders was based on creating the conditions for social learning. We didn't aim at bringing "the truth" about forest restoration, but on the contrary, we wished to understand how the different stakeholders perceived and practiced forest restoration. Thus, our whole communication strategy was oriented by this principle. In the first steps of the project, we held meetings to ask the farmers and other stakeholders what were their own preoccupations linked to forest restoration and agroforests. We then set out to explore by realizing interviews with a series of different actors. Progressively, we focused our research on certain questions, but always in an iterative manner. So as to build trust with the farmers and their organizations (cooperatives in particular), we wished to inform them about our work in progress and first results. Throughout the project, we organized small technical events in the different municipalities, to present our work and stimulate debate with the participants. These events were rich in understanding how our results could be interpreted and better understand the political issues at stake, which always appear more clearly when the protagonists are in stage. In these events, we handed out a calendar, made with the highschool students of Itabocal, fruit of their work with us on agroforests, and which was largely distributed in the different rural communities. This was a way of thanking the farmers for their time and involvement in the project. We also found this calendar in many houses where we later went to make interviews, which was an good way to engage with the farmers.

Other products were specifically destined to the farmers, to present our results: a map of restoration initiatives, formatted as a poster, so farmers, teachers and extension agents could put them on their walls and make them available for others; and a video that we produced, showing many of the farmers with whom we worked more closely, available on youtube and that has already been visualized by more than 800 people on our own site. The municipality of Tomé-açu asked us if they could put the video on their site and other sites also used it (i.e. Agrosoft, which we don't even know).

As regards scientific communication, we of course invested in scientific communications in congresses (17 communications and 5 posters) and scientific publications (4 articles published, 1 accepted, 3 submitted and several under work). However, collectively, our strategy for our network to become more widely known was to invite important key note speakers to our seminars (August 2018 and November 2019), so they would take stock of our work. The main speakers of the first seminar (D1.1) were scientists we had invited to be part of the project (Eduardo Brondizio, Daniel Vieira) to act as special counselors. They indeed gave us good advice and more, they later invited us in several events related to forest restoration and environmental conservation, introducing us to other networks on these issues. At the final seminar, we chose well-known key note speakers to make audience for our own results, which proved to be a good strategy, as we filled the amphitheater. This enabled to present our results to more than 70 participants, mainly extension agents, decision makers, academics (see D1.4).

Instead of promoting more events of our own, we also chose to present our results to decision makers in events promoted by other institutions around restoration issues. These were excellent opportunities to show our results and expand our network on forest restoration (see D1.12).

General deliverables related to project coordination and cross-WP actions

Statut : Produit
Préciser :
D1.1. Minutes of first seminar
First general seminar of the project, with 30 participants on August 6-7, 2018 (M 8)

D1.2. Mid-term report (methodology and indicator sets)
Presentation for the different technical events (D1.11), showing the methodological principles and first results

D1.3. Multidisciplinary method to assess and accompany forest restoration
Co-construction with the technicians from INCRA, EMATER and SEMMA of an assessment method for forest restoration, at a training event in November 2019 (M23)

D1.4. Minutes of final seminar
Final seminar of project with 70 participants (25 November 2019) (M23)

D1.5. Knowledge sharing and scenarios
Eva Perrier (2018). Que peut apporter la co-construction d'un jeu dans le cadre d'un projet de recherche interdisciplinaire ? Suivi d'un processus de modélisation d'accompagnement sur les trajectoires de restauration forestière par les agriculteurs familiaux à Irituia en Amazonie Orientale. Master AgroParisTech (M12)

D1.6 Articles in the media
M13 : Article in the Embrapa news bulletin (january 2019)
M24 : Article in O Globlo (main national news media) (december 2019)
https://documentacao.socioambiental.org/noticias/anexo_noticia/51181_20200107_150129.PDF
M24 : Article in Beira-rio (newspaper of UFPA) (march 2020)
https://www.beiradorio.ufpa.br/index.php/component/content/article?id=417

D1.7. Mapping restoration experiences
Carte illustrée des expériences de restauration forestière dans le Nordeste du Pará
http://agritrop.cirad.fr/594902/1/Mapa%20Refloramaz%20leve.pdf

D1.8. Practical guide about restoration by smallholders
8 fiches techniques en cours d'élaboration

D1.9. Short video
A general public film of 20 minutes : Recuperando florestas, transformando vidas (Restoring Forests, Transforming lives) https://www.youtube.com/watch?v=US9mFWpmJfU

D1.10. A policy brief with insight on institutional arrangements which are most supportive for forest restoration
Stanturf et al (with participation of Joice Ferreira). 2020. Forest Landscape Restoration Implementation: Lessons learned from selected landscapesin Africa, Asia and Latin America. IUFRO, Viena.
https://www.researchgate.net/publication/340361901_Forest_Landscape_Restoration_Implementation_Lessons_from_selected_landscapes_in_Africa_Asia_and_Latin_America

D1.11. Technical events for sharing project findings
Four restitutions of the first results co-organised with the Departement of Agriculture of Irituia, in the Itabocal Highschool (open for all the farmers of the community), in Bragança and in Tomé-açu

Distribution of the "Calendar of restoration", with illustrations by the rural highschool students of Itabocal, Irituia

D1.12. Seminar with the policy arena of Municipios Verdes
Séminaire final à Belem avec plus de 70 participants (rapport avec présentations, photos et liste de présence)

D1.13. Student training and theses
13 masters' defended, 3 masters in preparation, 1 grad student, and involvement of 3 doctorate students (not financed by the project, but who participated in the activities)

Projects submitted:
Recuperamaz (CNPq, 2018-2020) : coordination par Lívia Navegantes (participation Embrapa et Cirad)
Sem-Flama (PrevFogo-IBAMA-CNPq, 2019-2020) et RAS-Race (Fundação Agag, 2020-2022) : coordination par Joice Ferreira (participation Embrapa, INPE, Lancaster U., Cambridge U., Cirad)
Projects under construction for European Union Desira Call (2020) on agroecological transitions in the Amazon

WP2 Forest ecology, will assess the extent to which environmental services, such as biodiversity conservation and carbon sequestration, have been provided by the restoration process.

Actions undertaken and main scientific results
Status : Réalisé

In WP 2, we performed an ecological assessment of forest restoration interventions in Northeastern Pará to identify the diversity of restoration processes and evaluate the level of ecosystem services gained from the restoration interventions. We assessed the ecosystem services recovery resulting from different approaches that dominate in the region.

Activity 2.1. Typology of restoration

Our first step was characterizing the diversity of restoration experiences in the target region, analyzing its diversity according to their overall attributes. We have visited approximately 400 farmers and interviewed with the same questionaire 160 family farmers, which managed more than 800 restoration plots, integrated in a data base of the different restoration initiatives. This work was initiated by our Master student Carneiro, R. in the following municipalities: Capitão Poço, Irituia, Bragança and Tomé-Açu, and also by Carvalho, R. at Abaetebuta region (Figure 1). These municipalities were chosen because they show a marked contrast in the social and historical contexts providing us the opportunity to understand different realities in the restoration process. Other students then enabled to collect data in these same municipalities on more specific topics.

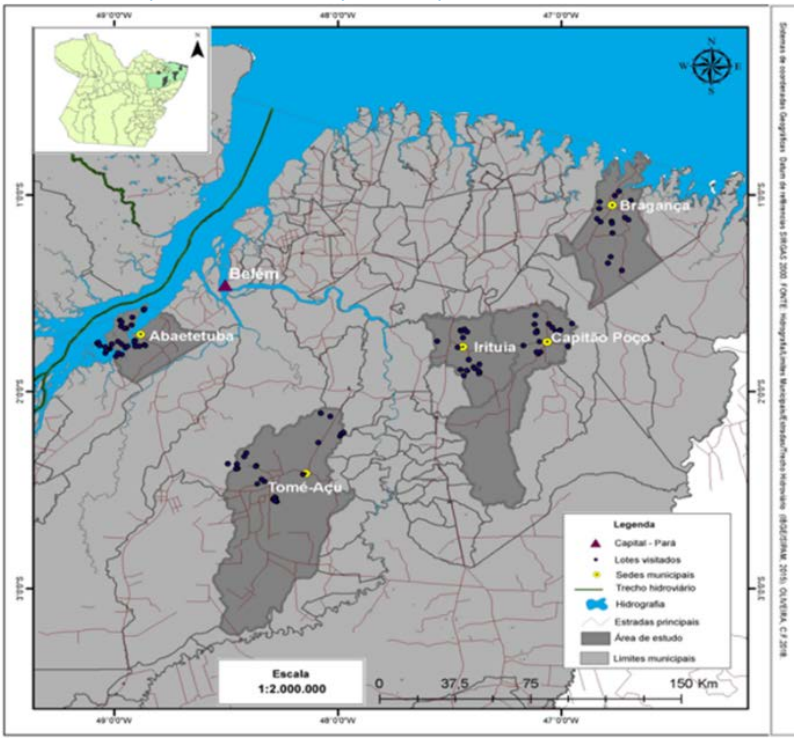


Figure 1 Assessment of restoration practices by family farmers across five municipalities in Northeast Pará

Through this wide assessment, we have classified eight different types of forest recovery practiced by the family farmers in the region, varying in plant species diversity and management intensity). Tree diversity in each system presented a high variation, from 3 to 200 species (Figure 2). They also varied substantially in terms of management practices, including chemical fertilization or irrigation (Figure 3). We further evaluated the distribution of these different restoration systems in the studied sample across the different municipalities. We were able to relate aspects such as territorial traditions, land-use history, natural environment and agricultural characteristics in each sub-region to the restoration category. For example, regeneration of tree species in floodplain areas was associated to the tradition on açaí extraction in Abaetetuba, while highly commercial agroforestry systems with lower species richness were cultivated in Tome-Açu. Agro-successional restoration presented intermediated tree species richness and were more fairly distributed across the region, although it predominates in Bragança.

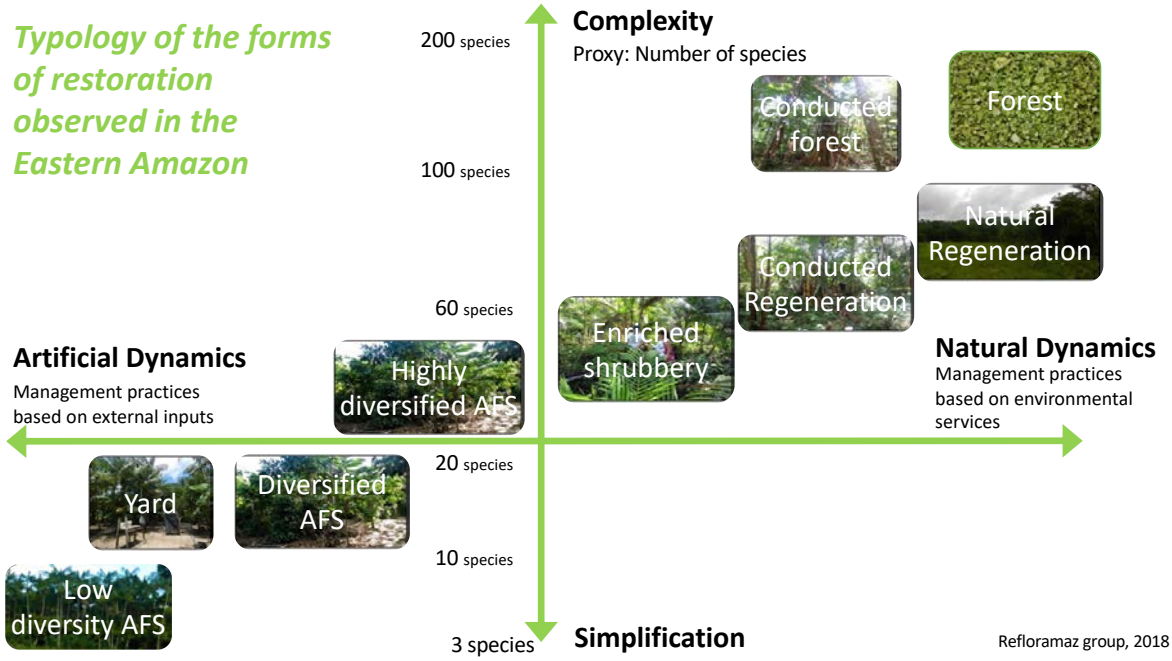
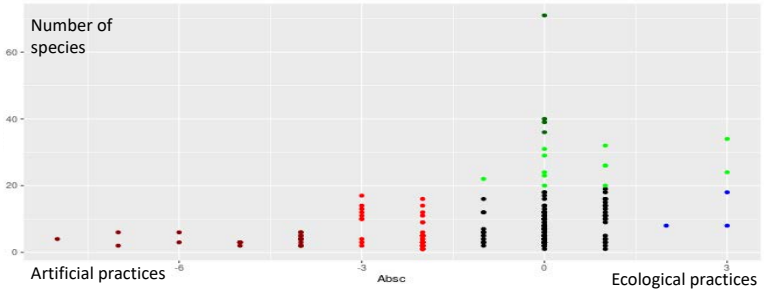


Figure 2 Typology of forest restoration found across the studied municipalities in Northeast Pará

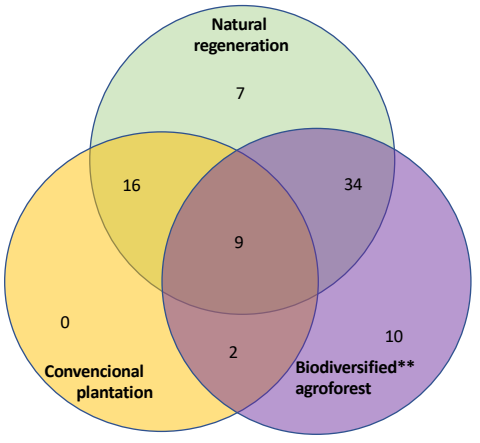
Practices used in restoration agroforests (per plot)



	Artificial intensification	Semi-intensification	Few practices	Biodiversification	Ecological intensification
N	25	45	117	14	5
Heavy mechanization	64%	47%	1%	0%	0%
Irrigation	48%	0%	0%	7%	20%
Herbicide	36%	22%	0%	0%	0%
Chemical pesticide	68%	22%	1%	0%	0%
Chemical fertilizer	100%	89%	45%	29%	0%
Limestone	12%	20%	3%	29%	0%
Organic pesticide	4%	2%	2%	14%	80%
Organic fertilizer	68%	69%	62%	57%	100%
Dead vegetal cover	0%	0%	1%	7%	40%

These restoration types are generally combined by the farmers.

Number of farmers with each combination



* 3 to 10 species
** more than 10 species

Agroforests enable to maintain natural regeneration.

Figure 3 Practices used in the different agroforest restoration systems

Despite the overall variation, we have shown that most family farmers rely on agroforestry as a restoration strategy in the region. The preference for this strategy results from the large amount of socioeconomic benefits these systems are able to offer to the family farmers. As of 2012, these systems have become accepted as alternatives for forest restoration by family farmers in the forest Brazilian legislation.

Activity 2.2. Ecological assessment at local and landscape scale

Our second step was performing a number of ecological assessments at local scale in order to assess key ecological parameters, such as plant diversity and structural attributes. These studies were developed in Terra Firme areas having different conservation status, as well as riparian areas that are considered Permanent Protected Areas in the Brazilian law. They were developed through a number of different dissertations (e.g. Costa 2020; Carvalho, 2018).

The vast majority of our studies was focused on trees – specifically on richness and floristic diversity of the restoration systems- considering that trees are the main component for restoring forests and creating the basic conditions for restoring the diversity of the remaining biodiversity taxa. We demonstrated the context in which agroforestry has been developed has had a great influence on plant diversity. Some agroforestry systems were highly commercial and provided only low biodiversity levels (3-5 species), while others had multiple purposes and a much higher biodiversity level (up to 20 species) (Carneiro, 2018; Oliveira-Neto, 2020).

We were able to examine the socioeconomic factors influencing the floristic diversity of agroforestry systems, as well as the farmers practices that were able to favor the diversity (Oliveira-Neto, 2020). The patterns shown by other studies were confirmed on the relevance of natural regeneration as outstanding biodiverse systems (+ 100 tree species). On the other hand, farmers are often less motivated to adopt natural regeneration as restoration strategy because the economic benefits are less prominent than agroforesty. Our studies have pointed out that efforts should be made to discuss with farmers about the potential of natural regenerating forests in providing timber and especially non-timber forest products.

Natural regeneration has been used by family farmers in the Northeast of Pará for multiple uses, but mainly for extracting timber and hunting, while Non Timber Forest Products - extraction and beekeeping management have been important motivations for a number of family farmers to conserve naturally regenerating areas. Using only one of the study sites we found the vast majority of species reported in the literature as having potential for timber (76%), followed by firewood/charcoal (34%), medicine (29%) and food (20%) (Ferreira et al., 2019).

Regarding the diversity of fauna groups, we have performed a pilot study evaluating bees and the pollination services. The study focused on how bees are perceived and how they might influence family farmers practices (Gonella, 2019). In this exploratory work, we have found that farmers' perception of bees is dependent on the interaction between bees and crops and the importance of the crops in the productive socio-ecosystem.

The perception of ecosystem services was a widely investigated topic in the Refloramaz Project. Our results identified a myriad of motivations that encouraged farmers to develop a type of restoration or another. We demonstrated through structured methods (figure 4) that farmers recognize the benefits accruing from agroforest systems and natural landscapes, and they show a high perception of ecosystem services in all proposed categories in the Millennium Ecosystem Assessment (Almeida et al. 2018).

Figure 4 Evaluation of farmers perception to different categories of ecosystem services

Although a variety of ecosystem services were valued by family farmers, restoring water quantity and quality ranked the highest in the motivation for forest restoration (Figure 5, Almeida et al., 2018; Costa, 2020). A number of cultural services was also highly valued by the family farmers, such as serenity and scenic beauty (Almeida et al., 2018).

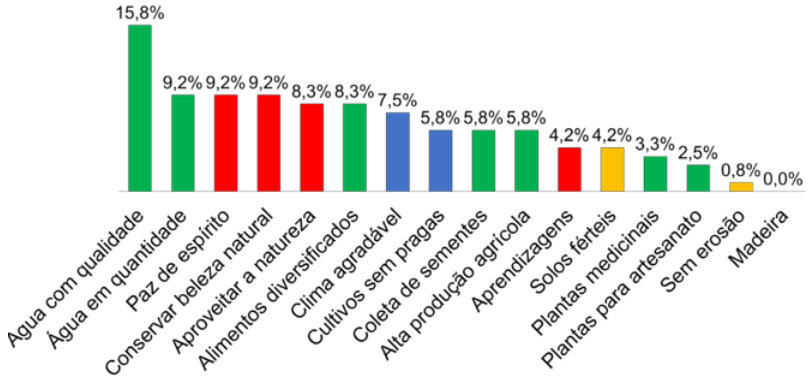


Figure 5 The most valued ecosystem services by family farmers in different communities living at Irituia municipality (Almeida et al., 2018)

In terms of large-scale analysis, we have identified a type of agroforestry associated with corridors of natural regeneration, which is able to deliver high socioenvironmental benefits (Oliveira-Neto, 2020). At the regional level, we have conducted a systematic review of the literature selecting a sample of 388 papers studying tropical ecosystems. This study produced a systematic map that shows that agroforestry and monoculture plantations were the most dominant restoration models (Blanc, Ratel et al., 2018). It also showed that very few papers analyzed socioeconomic attributes of restoration experiments. We also performed a general appraisal of the ecosystem services delivery from ecosystem restoration (Ganade et al., 2019, co-authored by Ferreira, J.). Within the Brazilian Amazon, regenerating forests increased 70% between 2004 and 2014, currently occupying more than 17 million hectares. These ecosystems have an important social role as increasing food security and alleviating poverty among thousands of family farmers in the Amazon region, while also being important repositories of biodiversity and carbon.
Finally, through our experience in the study regions, we contributed to an analysis of implementation of landscape restoration in Bonn Challenge countries providing lessons to enhance understanding of the ecological, social and economic dimensions of landscape restoration progress, as well as disseminating this information for policy making and learning (Stanturf et al., 2020, co-authored by Ferreira, J.).We have identified ten important lessons that are important to guide restoration programs on the ground (Fig.6).

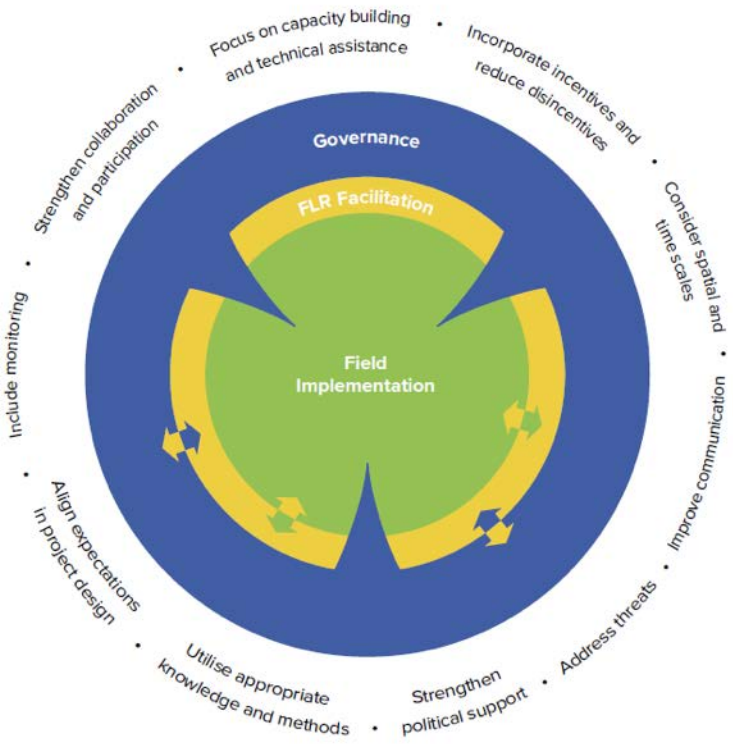


Figure 6. Ten overarching lessons learned in forest landscape restoration to be considered by actors in the governance and field implementation (from Stanturf et al., 2020)

Production of deliverables linked to the action
Status : Produit
D2.1. Typology of restoration initiatives
Article Carneiro et Navegantes, 2019. Diversidade de experiências de recuperação florestal praticada por agricultores familiares do Nordeste do Pará. Geoambiente, 35.
This initial typology based on a master's study was progressively discussed by the Refloramaz working group. We plan to publish a common publication, presenting the typology, the practices associated, linking it to the farmers' initial motivations and to the institutional context.

D2.2. Communications "Ecosystem services delivery from restoration programs in the Eastern Brazilian Amazon"
3 communications, 2 posters
Poster : Aurea Almeida, Joice Ferreira, Emilie Coudel : SISTEMAS AGROFLORESTAIS COMO ESTRATÉGIA DE RESTAURAÇÃO FLORESTAL NA AMAZÔNIA: PERCEPÇÃO E PROVISÃO DE SERVIÇOS ECOSSISTÊMICOS. Présenté lors du Congrès de la Société Brésilienne de Restauration Ecologique, Belo Horizonte.
Poster :Oliveira & Navegantes (2019. ESTRATÉGIAS DE RECUPERAÇÃO FLORESTAL DOS AGRICULTORES FAMILIARES COM A INSERÇÃO DE ESPÉCIES FLORESTAIS NATIVAS EM SISTEMAS AGROFLORESTAIS DE TOMÉ AÇU. Présenté lors du Congrès de la Société Brésilienne de Restauration Ecologique, Belo Horizonte.
Communication : Mendonça & Navegantes (2019). Caracterização dos processos de recuperação florestal em matas ciliares realizados por agricultores familiares da região de Itabocal, Irituia – PA. IX Encontro Nacional da ANPPAS, Brasília (Brésil), 08-11 Octobre 2019
Communication : Ratel et al. (2018) Forest restoration in the humid tropics: lessons drawn from a systematic map.

IUFRO conference "Adaptative management for forested landscapes in transformation", october 1-5, 2018, Posadas, Argentina.
Communication : Ferreira et al. (2019. Potential for managing natural regeneration by family farmers in the Amazon: making the most of biodiversity. Agroforestry 2019, Montpellier.

D2.3. Database of restoration initiatives
160 interviews realized by different master students were compiled together in a common data base (excel table), so as to enable cross-comparison and larger analyses. This will be the basis to the common article to be written on the assessment of existing restoration experiences. After we publish our work (probably 2021) we will make the data base public on the site: www.webambiente.gov.br. WebAmbiente is an interactive information system developed by Embrapa in partnership with other institutions to assist decision making for environmental compliance in rural landscapes. It includes the largest database ever produced in Brazil on native plant species for environmental restoration, enabling the selection of woody and herbaceous species according to the national biomes and local attributes of the areas to be recomposed.

D2.4 Protocol for ecological assessment of restoration initiatives
Master of Mario Oliveira Neto : Para além da renda: motivações para agricultores familiares incorporarem maior diversidade de árvores nativas em Sistemas Agroflorestais (SAFs) na Amazônia Oriental.
Master of Gabriel Gonella : Agroforêts et services écosystémiques : Place des abeilles dans les socio-écosystèmes de Tomé-Açú, Pará, Brésil

D2.5. Paper "Ecosystem services delivery from restoration programs in the Eastern Brazilian Amazon"
- Contribution of Joice Ferreira to the evaluation of the IPBES in Brasill : Restauração de Paisagens e Ecossistemas Brasileiros (Ganade et al.) and to a working paper of IUFRO (Stanturf et al.)
- Article accepted : Mendonça et Navegantes, Characterization of forest recovery processes in riparian forests carried out by family farmers in the region of Itabocal, Irituia – PA, Geoambiente.

WP3 Farm production system, will assess how restoration activities have been integrated in the farming system more generally.

Actions undertaken and main scientific results
Status : Realized

Activity 3.1. Management practices of the restoration process

According to a broad survey of production systems in northeastern Pará, we identified that forest recovery practiced in a systematic way has been expanding, especially since 2003, as a result of a series of public policies in several areas that have converged towards greater environmental conservation. These policies were not limited to the environmental or productive sphere, but were part of public and social initiatives of education, commercialization and infrastructure.
We showed that family farmers are the main protagonists of forest recovery practices in the eastern Amazon, especially considering the theoretical precepts surrounding this term, related to the functional and structural aspects of ecosystems, as well as based on native biodiversity (Clewell, Aronson and Winterhalder, 2004). These practices are known and used secularly, many originating from indigenous people, but in the face of adverse socio-political conditions they remained for a long time restricted to small areas of family use, in the form of what are known locally as "sitios" or "quintais" (backyards), which generally occupy an area of less than 1 ha. Currently, we have identified areas of forest restoration that correspond practically to the entire area of the agricultural establishment of family farmers, reaching 50 ha, corresponding in general to a minimum of 3 ha and a maximum of 15 ha (see Table 1).
Various types and practices of forest recovery are found in the eastern Amazon, generally adapted to the specificities of local socioeconomic contexts (see Figure 7). Based on our first typology (defined in WP2, see Figure 1), we identified and characterized seven main types of agroforestry production systems: Amazon species combination, Citrus combination, Agrosuccessional restoration, Diversification of açaizais in floodplains, Secondary forest management, Natural regeneration of secondary forests and Backyards agroforestry (home garden). These types correspond to a gradient of use of more or less native species, equivalent to more or less complex systems, and a more natural or more artificial dynamics, i.e., with greater or lesser use of external inputs, also based on the capacity to achieve a dynamic equilibrium of the ecosystem.

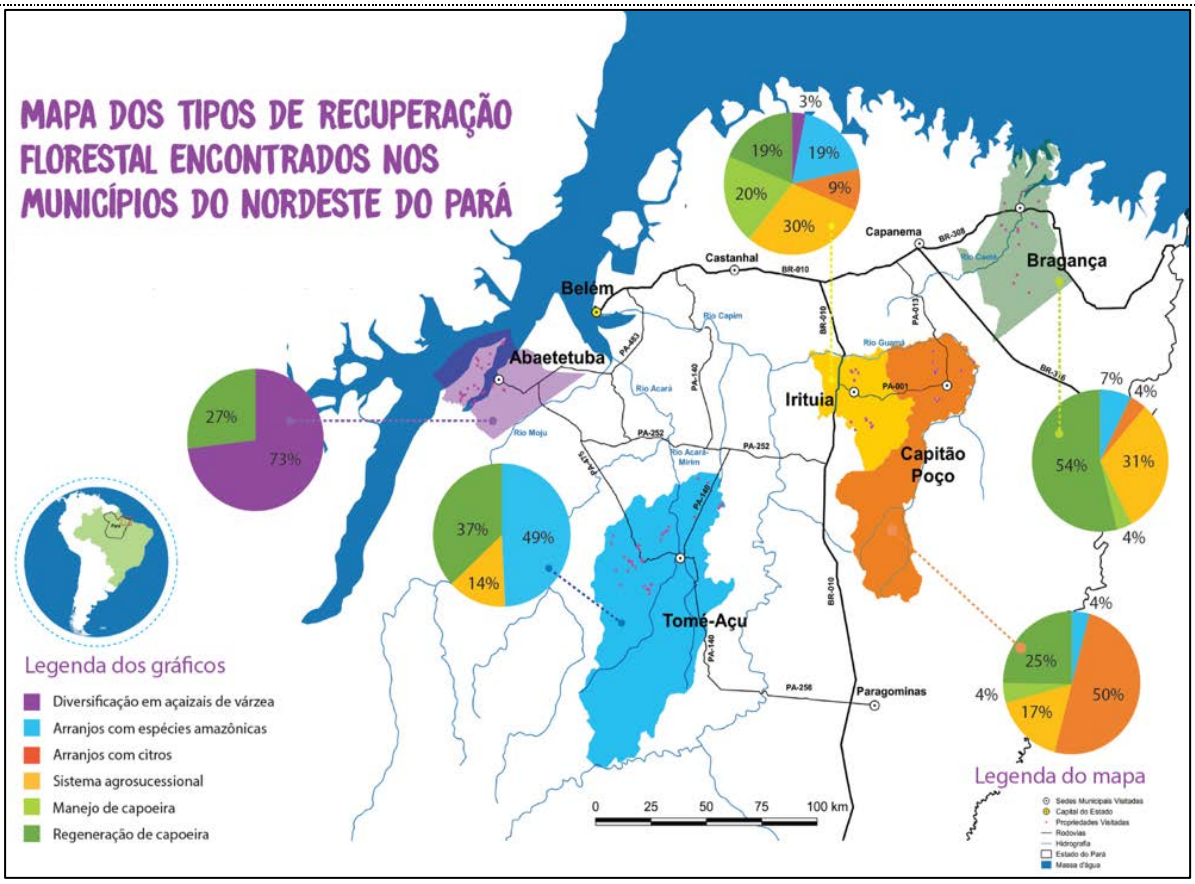


Figure 7 Types of restoration and agroforest systems present in the Northeast of Pará

Forest restoration carried out by family farmers in Northeast Pará involves a series of practices based on ecological principles and based on biological processes. These practices involve nutrient cycling and the increase of native biodiversity, effectively corresponding to the decomposition of dead material, the use of more native species, the use of leguminous trees, the collection, improvement, exchange and conservation of local and traditional seeds, and the reduction or elimination of the use of pesticides and burning.
The decision on the practices to be adopted is closely related to the type of forest recovery practiced. The more biodiverse types adopt more natural practices, as opposed to the more simplified types of recovery that result in the use of more artificial practices, as shown in Table 1. It should be noted, however, that forest restoration processes can be quite dynamic, and some more simplified types can gradually evolve into more biologically complex systems.

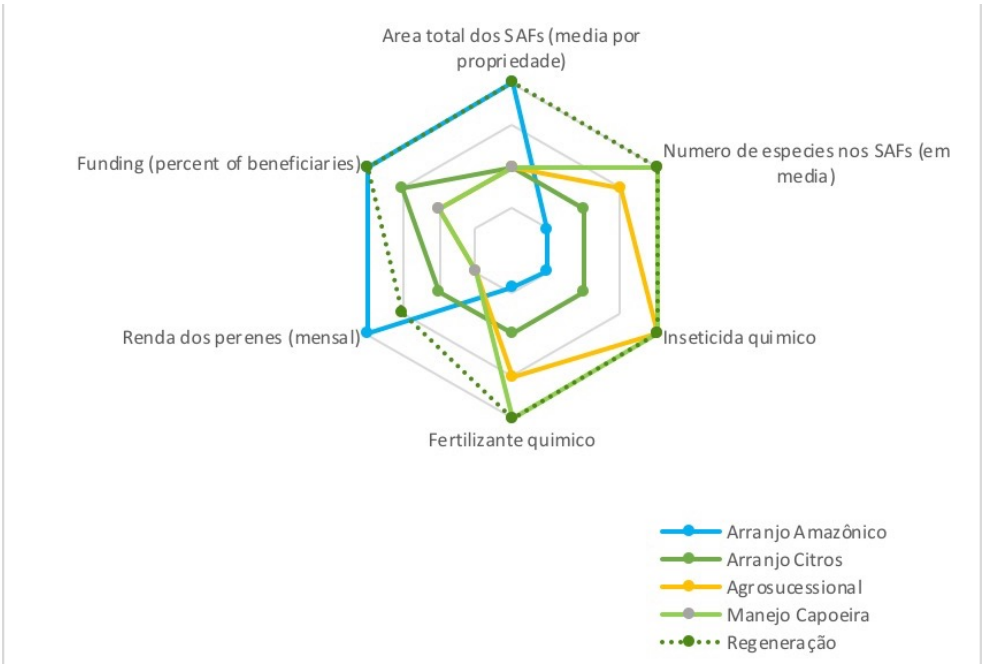
Table 1 Characteristics and practices of the different types of forest restoration identified in Northeast Pará

Characteristics and practices associated to forest restoration	**Type of Forest Restoration**					
	Amazonian arrangement	Citrus arrangement	Agro-sucessional	Diversification of açai	Secondary forest management	Forest regeneration
Restoration area per farm *	15 ha	3 ha	3 ha	15 ha	3 ha	2 ha
Number of species*	4,7	7,8	14,8	16	26,5	16,4
Monthly income *	4.340 R$	1.068 R$	413 R$	1.060 R$	424 R$	1.597 R$
Credit obtained (% de beneficiaries)	83%	70%	56%	63%	67%	80%
Use of chemical pesticides (%)	30%	10 %	0%	0%	0%	0%
Use of chemical fertilizers (%)	90%	60 %	24%	0%	0%	20%

*Medium value Source: REFLORAMAZ group (presented at the final seminar, November 2019)

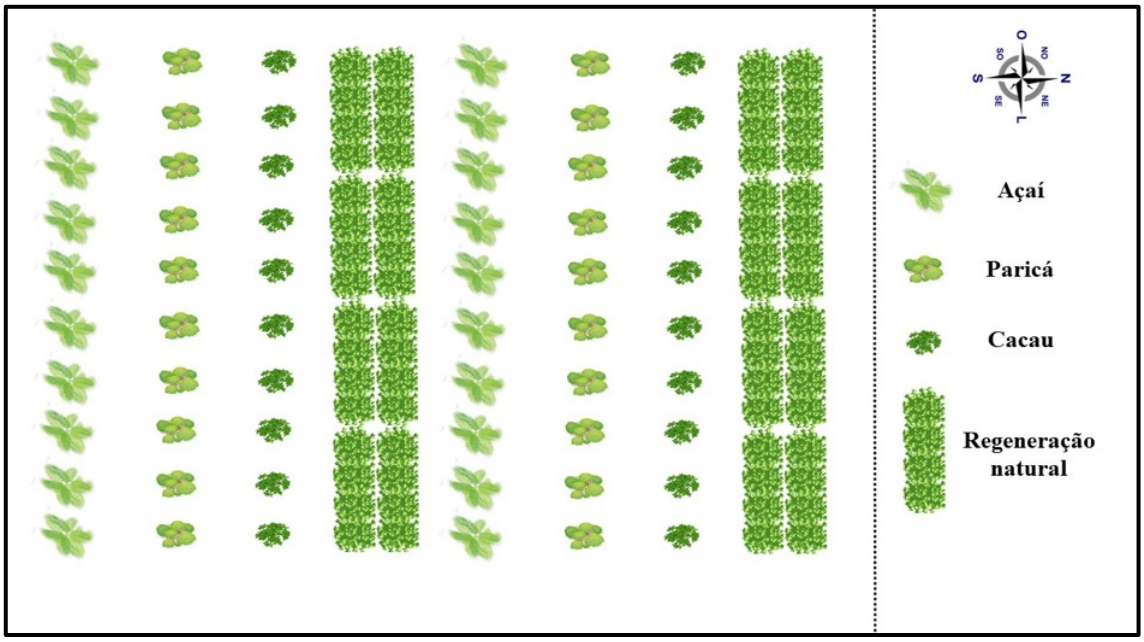
From the analysis of table 1 we deduce what was also observed in the field, that the type of recovery with less species is the one with the highest monthly income, which is a recurrent pattern among all types. This occurs because when using few species, the ones with commercial value are privileged. However, regarding the balance between economic and ecological aspects, the types with fewer species are also those that make use of more chemical inputs, being therefore less ecologically relevant. In general, there is a trade-off: the better the economic aspects, lesser are the ecological benefits (see Figure 8), with the types Diversification of açaí and Forest Regeneration (often involving bee hives) being an exception to this rule. These two types differ from the others because they are the most natural forms of restoration, with little or no human intervention.

Figure 8. Assessment of the balance between different dimensions of the types of restoration



Nonetheless, some human-implemented restoration systems have demonstrated at the same time the possibility of having high species diversity and being profitable. The differential of these systems is the high abundance of spontaneous species combined with the abundance of fruit species. For example, we studied some Amazonian Arrangement type restoration experiments that presented agroforestry systems with natural regeneration corridors (see Figure 9). Thus, competition for light, water and nutrients between commercial species and spontaneous species is less, when compared to other types of forest restoration with high floristic diversity. Thus, we consider that these experiences should be disseminated and discussed with farmers who intend to start forest restoration.

Figure 9 Spatial arrangement of species in agroforestry systems with natural regeneration corridors, in the municipality of Tomé-Açu, Pará (Oliveira Neto, 2020).



Source : Oliveira Neto, 2020

In order to characterize the biodiversity included in some types of forest restoration and a better understanding of farmers' choices of species, floristic surveys were carried out in 15 agricultural establishments of the types of forest restoration coming from plantations and not from natural restoration processes, since in the latter case the use of the species does not depend on the choice of farmers and on the practices of establishment. An average of 918 individuals (1,170 individuals per hectare) were identified, belonging to 72 species from 37 botanical families. All of the 10 main species identified are native to the Amazon, and the occurrence of exogenous species (less than 3%) is very rare. The most abundant species was Theobroma cacao L. (36.3%), followed by Euterpe oleracea Mart. (13.6%) and Theobroma grandiflorum (Willd. ex Spreng.) K.Schum (6.9%) (Table 2). These three species bear fruit and represent 57% of all species listed. Farmers have a preference for these species because they provide food and financial security for families, because they are easily marketable, given the market demand for these species. However, other categories were also abundant in the inventoried forest restoration systems, being: 1) Fertilizer species (6.4%), represented by legumes; 2) Timber species (10.0%), involving large trees (up to 70 m high); 3) Multipurpose species (3.3%), including supplying native plants; and 4) Spontaneous species (19.5%), which do not fit into any of the previous categories and regenerate naturally.

Table 2 Parameters of the 10 most abundant species in the agroforestry systems of family farmers in Tomé-Açu, Pará (Oliveira-Neto, 2020)

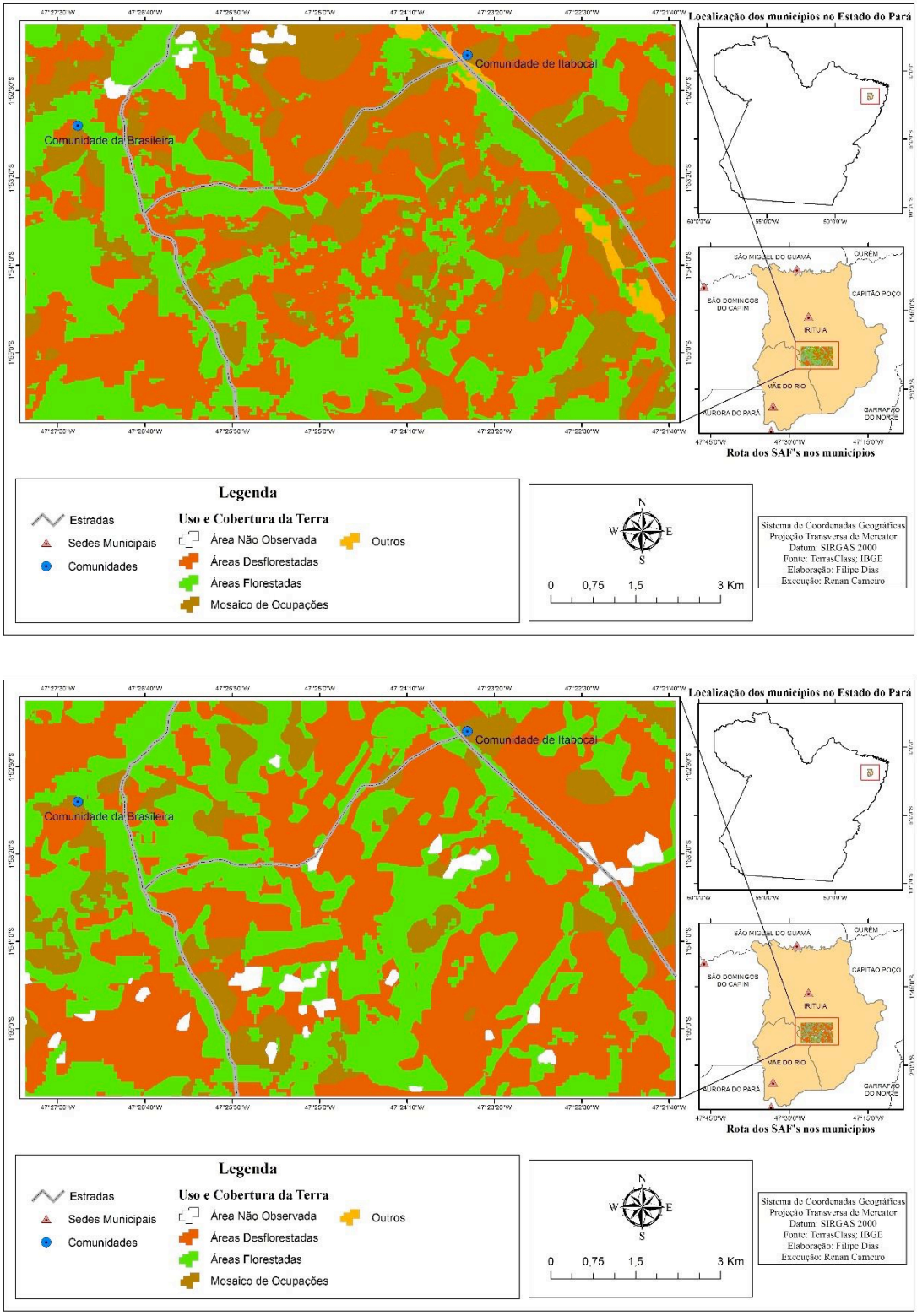
Scientific name	Popular Name	N	Na (N ha^{-1})	M	Fertilizers (%)	Sponta-neous (%)	Fruit (%)	Timber (%)
Theobroma cacao L.	Cacau	333	825	69			36,3%	
Euterpe oleracea Mart.	Açaí	125	455	38			13,6%	
Theobroma grandiflorum (Willd. ex Spreng.) K.Schum.	Cupuaçu	63	161	13			6,9%	
Clitoria racemosa Sessé & Moc.	Palheteira	56	231	19	6,1%			
Swietenia macrophylla King	Mogno Br	32	76	6				3,5%
Aspidosperma desmanthum Benth. ex Müll. Arg.	Gema de Ovo	29	55	5		3,2%		
Jacaranda copaia (Aubl.) D. Don	Parapará	26	310	26		2,8%		
Cecropia hololeuca Miq.	Embaúba Branca	23	37	3		2,5%		
Bagassa guianensis Aubl.	Tatajuba	21	84	7				2,3%
Xylopia nitida Dunal	Envira Cana	15	78	6		1,6%		
Other species (62)		195	1043	87	0,3%	9,4%	4,0%	4,2%
Total		918			6,4%	19,5%	60,8%	10,0%

N= number of individual; Na= number of individual per hectare; M= average number of individual per hectare

Activity 3.2. Adaptation of the farming system

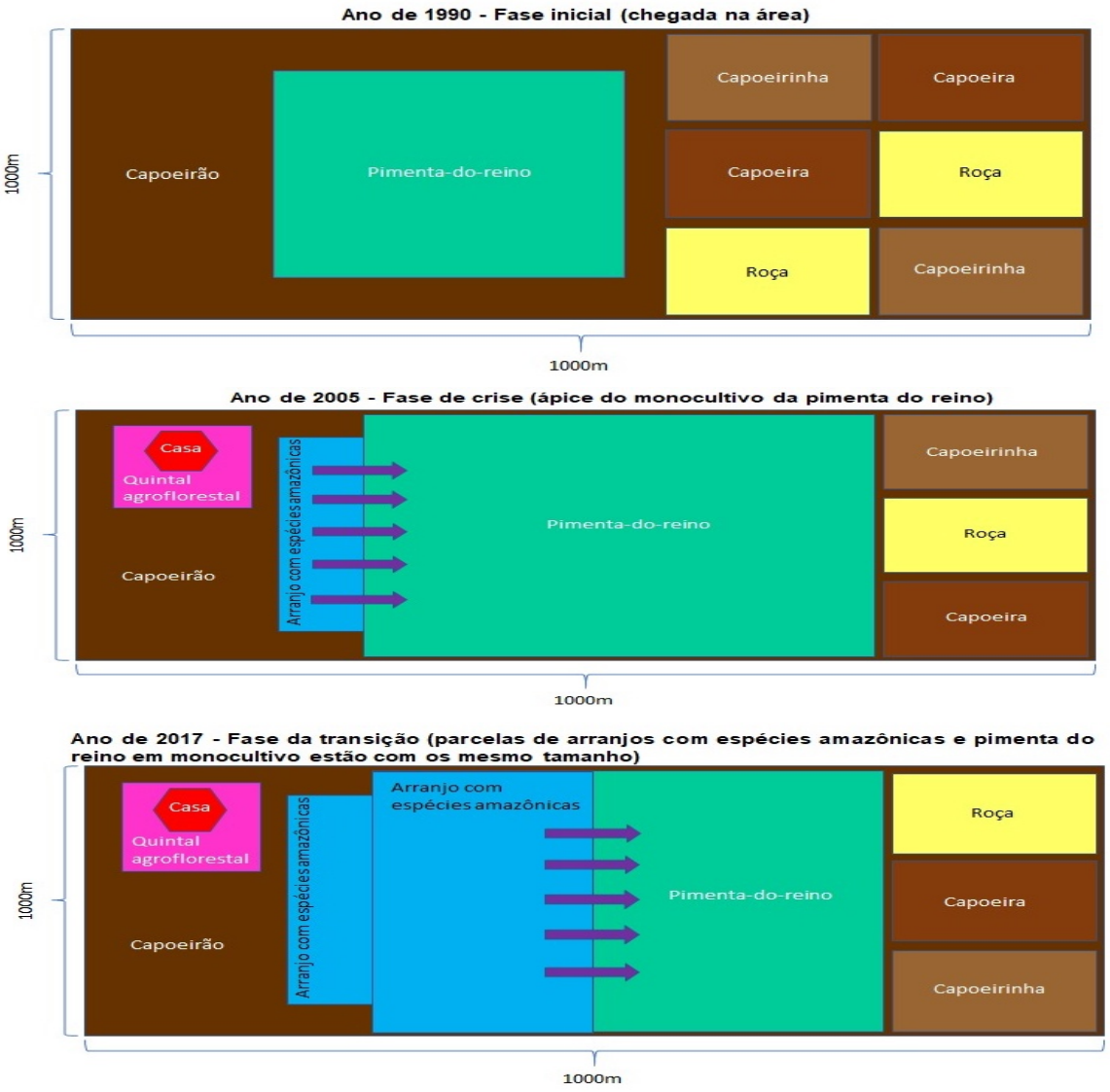
Forest restoration in Northeast Pará is dynamic, especially in relation to changes in the use of species, diversification of species used, expansion of areas and adhesion of farmers. In fact, what can be observed is that a profound process of transformation of the production systems in the Northeast of Pará is underway. While farm trajectories have long been determined by the dynamics of deforestation and intensification of production, recently, especially since the beginning of the 2000s, experiences of forest restoration by family farmers, often based on agroforestry systems, have begun to emerge and expand. In some municipalities, these experiences multiplied and resulted in changes at the landscape level, as was the case in the municipality of Irituia and especially in the Itabocal River region, as shown in the figure below (Figure 11), where some activities and research of the Refloramaz project were focused in order to investigate the process of expanding forest restoration experiences.
The area shown on the maps below is formed by a mosaic of family farming lots, surrounded by cattle farms. The geoprocessing of the images compared the evolution of land use and coverage between 2004 and 2014. The processing of the images generated, by proportionality of scale, the size of each of the areas represented by classes in both maps. Thus, we showed that the forested area increased by 21% in this period, countering a historical and regional trend of increased deforestation.

Figure 10 Land cover of the micro-region of Itabocal in 2004 (above) and 2014 (below), revieling a progressive forest restoration (Carneiro, 2018)



At the scale of production systems (in agricultural establishments) we also observed the expansion of forest recovery areas over the years. This finding was illustrated by the sketch of a studied farm (Figure 12), and demonstrates what a farmer from Bragança – Pará told us during a retrospective interview. The temporal perspective of space allows a better understanding of the current conformation of the production systems, as well as to observe the trend of evolution, even in the future.

Figure 11 Sketch of a family establishment in Bragança - Pará, in three periods (1990, 2005, 2017) (Carneiro, 2018)



The trajectory of the production system, demonstrated in the figure above, shows a pattern reported by several farmers in northeast Pará of adaptation and redesign of the systems over time. Forest restoration areas generally expand over temporary or semi-perennial crop areas. However, these crops do not disappear, they only lose space. Another type of land cover that persists over time is secondary forest, with varying ages of succession. Thus, with time, the establishments that take the path of forest restoration experience a diversification of both species and types of production and products, demonstrating the possibility of making various forms of production compatible with greater environmental conservation.

The privileged areas for starting forest restoration are the riparian forests, given the particular relationship that family farmers in northeast Pará have with water. This relationship encompasses aspects that extrapolate individual consumption of this resource, such as those dedicated to the provision of their production systems, and are linked to more specific cultural issues and local models of social organization. In general, family farmers organize themselves in a non-institutional way in favor of the restoration and conservation of these areas, considering that the environmental management dedicated by the local government to the protection of riparian vegetation is inefficient. Figure 13 shows one of the meetings held between members of the Refloramaz project with family farmers in Irituia on collective management aimed at the conservation of riparian forests.

Figure 12 Meeting with farmers at the Itabocal state school, Irituia - PA, August 2019


Production of deliverables linked to the action

D3.1. Communication: The importance of restoration processes within the farming system

Status : Produit

Several communications in congresses in particular Carneiro et al. 2017, Carvalho et al. 2017, Gonzaga et al. 2018, Oliveira et al. 2019, Garcia et al. 2019

D3.2. Article: The importance of restoration processes within the farming system

Status : produit

1 article published, 3 articles submitted.

Carvalho et al (submitted) Recuperação Florestal em Áreas de Várzea Submetidas ao Manejo Intensivo de Açaizais no Estuário Amazônico. Ambiente e Sociedade.

Carneiro et al. (2020). Diversidade de experiências de recuperação florestal praticada por agricultores familiares do Nordeste do Pará. Geoambiente, 35.

Resque et al. (submitted) How do stakeholders supporting smallholders perceive ecosystem services and their relations to agricultural practices? A case study in the Brazilian Amazon. Cahiers d'Agricultures.

Carvalho et Navegantes (in preparation). TRAJETÓRIAS DE RECUPERAÇÃO FLORESTAL DE AÇAIZAIS MANEJADOS INTENSIVAMENTE, POR RIBEIRINHOS, NO ESTUÁRIO AMAZÔNICO. Interciência

WP4 Institutions and farmers motivations, will assess the motivations as well as barriers to farmers' engagement in forest restoration focusing on the institutional conditions such as extension support, land title and social capital.

Actions undertaken and main scientific results

Status : Réalisé

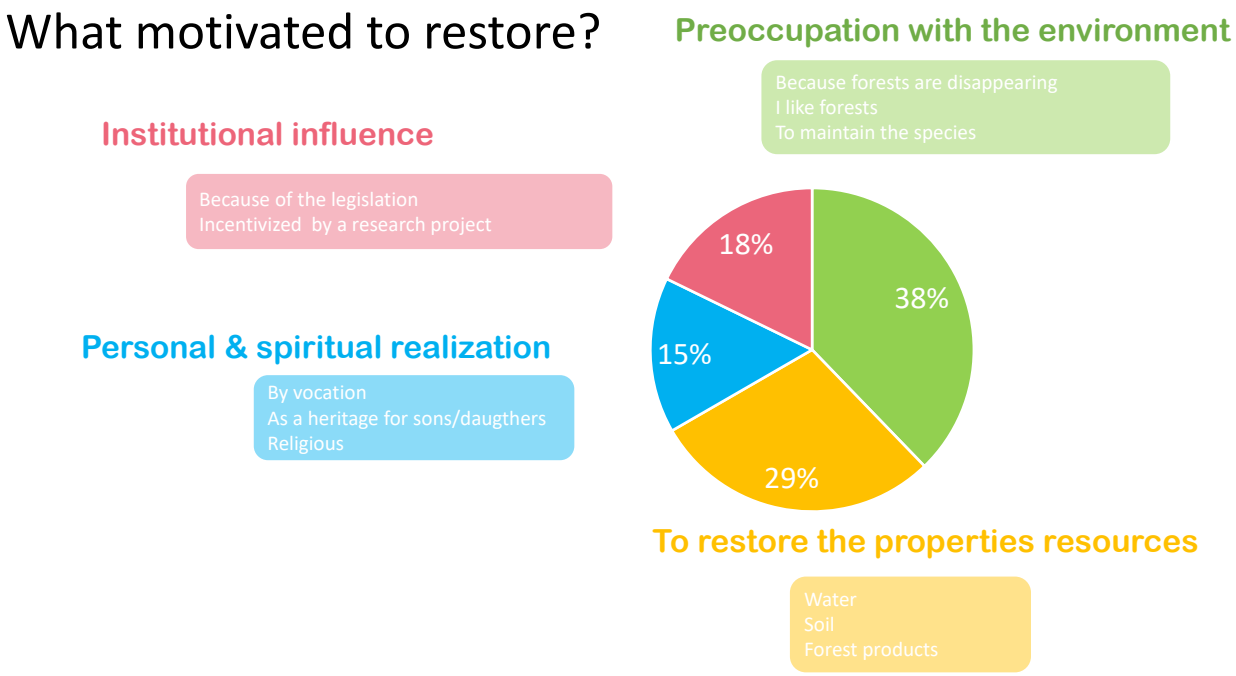
Activity 4.1. Farmers' motivations depending on the institutional conditions

Before the Reforamaz project started, a master's research project was engaged to do some exploratory work on farmers' motivations in Paragominas, an area we were then working in (Bessa, 2016). Ideflor-Bio, a public institution dedicated to forest plantation and restoration, had implanted two tree nurseries in traditional communities and we wished to understand what led farmers to participate in this initiative or not. We discovered that restoring forests interested also farmers who had not been selected by the governmental program, questioning the selection critaria and how to outscale from the initial participants. Contrary to our initial hypotheses, we showed that the farmers who have the best knowledge of forests and have most contact with forests are the ones who are less interested in restoring, probably because they still have forests near them. Knowledge of environmental laws didn't lead to better compliance in terms of forest conservation: farmers with less forest, who were more distant from complying, seemed to be more informed about the forest law. Finally, young people were less motivated to restore forests, driven by more economic considerations. This demonstrates the importance of investing in environmental education programs targeting this public.

This work opened the ground for new hypotheses within the Refloramaz project. We focused less on the knowledge and implementation of environmental laws and more on the local knowledge that influenced the farmers' practices and on how the institutional conditions acted as a driver of different restoration systems. In different student master's work (Carneiro, 2018; Almeida, 2019), we asked the farmers what was the main reason to restore their forest and what were the main difficulties. We presented the first integrated results based on the common data base (160 farmers) at a poster session of the Brazilian Forest Restoration Society, in Belo Horizonte, November 2018 (Coudel et al., 2018).

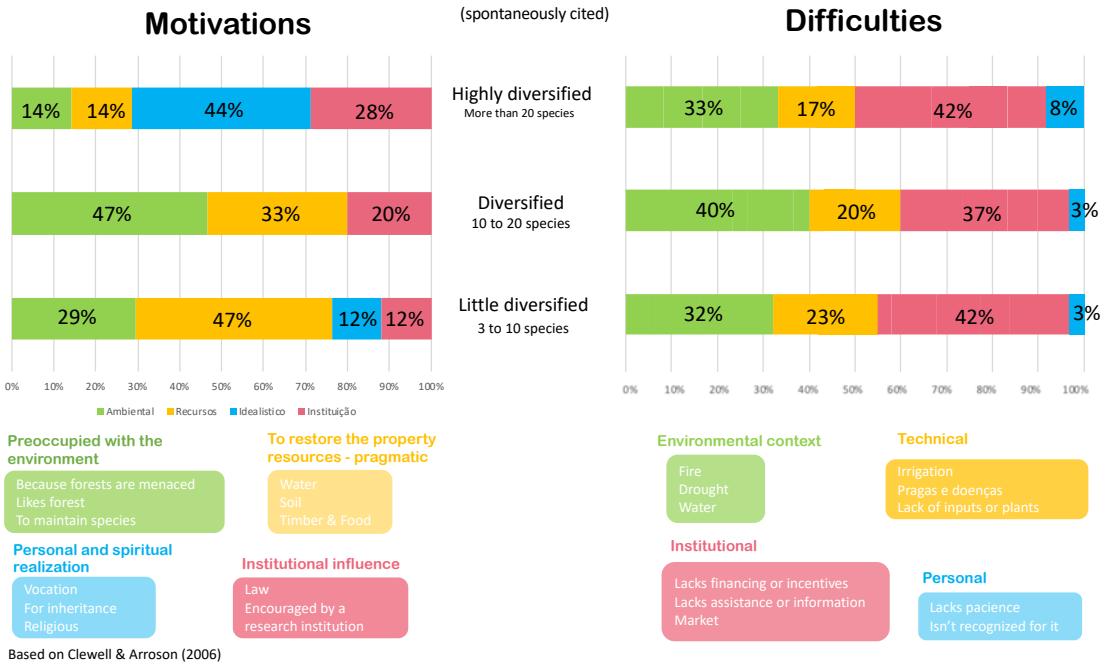
Based on the typology presented by Clewell & Arronson (2006), we defined 5 types of motivations (see figure 14): 38% of farmers are driven by environmental motivations, which involve a non-egoistic dimension, because farmers like forest in general and are preoccupied by the general state of the environment; 29% have a resource-driven motivation, because the resources of their own property are menaced; 18% of farmers have been influenced by diverse institutions (law, research projects, governmental programs); and 15 % of farmers have restored for personal or spiritual realization, because they believe it is a vocation for them and often want to pass this on to their children and neighbors.

Figure 13 Motivations spontaneously cited by farmers for having engaged in forest restoration



Based on the typology defined in WP2 and WP3, which defined tree diversity as one of the main variables, we questioned what led farmers to plant more biodiversity in their agroforests and what were the difficulties of each system. We presented these results at the Congress of Agroforestry in May 2019, in Montpellier (Coudel et al, 2019; figure 15). This analysis shows that in fact, the motivations behind the different systems are quite different.

Figure 14 Motivations and difficulties according to the number of species in the restoration plots



The main motivation of those who have less diversified agrosystems is to restore their own resources (47%). This is also an important motivation for those who have diversified systems (33%), but their main preoccupation is with the environment as a whole (the environing forests for example). And interestingly, the main motivations of the highly diversified systems are first of all personal and spiritual realization (44%), and institutional influence, mainly involvement in research projects (28%). Considering that most of those who have pragmatic motivations (water, soil, products) have less diverse agroforests, this points to the importance of building more awareness about the potential role of biodiversity in restoring environmental services.

Regarding the difficulties, they are quite similar from one type of system to another. The first difficulty for all types is institutional, as they feel they lack financial support, assistance and information and difficulties to insert in markets. The second main category of difficulties come from the environment, with fire, droughts and lack of water in the property. Interestingly, these are difficulties for which restoration can be a solution, pointing out at how important it is to bring support to the farmers to invest in restoration to overcome these difficulties and heal the environment.

Activity 4.2. Conditions for expansion of initiatives

The first contribution of the project regarding institutional conditions was through an involvement of Emilie Coudel in the IPBES (International Platform for Biodiversity and Environmental Services) assessment report on land degradation and restoration in 2018 (Chapter 6, Pandit et al. 2018). We namely contributed through a literature review to examine the responses based on institutional reforms (6.4.5). Two paragraphs from this part can be highlighted, as they oriented much of the way we defined the Refloramaz project:

"In recent years, the evolution of conservation or restoration policies beyond the traditional top-down state policies has led to a range of governance regimes and new institutional arrangements, with a transfer of responsibilities towards local governments and non-state actors (Agrawal et al., 2008; Hayes & Persha, 2010). This decentralization can be more or less successful depending on the power transfer, accountability mechanisms and local participation involved (Ribot & Larson, 2005). Although effective stakeholder involvement is often cited as one of the main factors of success (France, 2016; Light, 2000), in practice, it is far from being systematic, often because of a lack of definition of who are the important stakeholders (Couix & Gonzalo-Turpin, 2015), and because formal institutions usually lack the flexibility and openness to cope with the more dynamic and innovative informal organizations. Furthermore, the history of community-based natural resource management suggests that simply understanding the value of local participation is complementary to reforming existing institutions or establishing new institution (e.g., community-based organizations, for example)." (p713)

"Several studies show that innovative types of collaborative network governance are emerging that bring together natural resource users, NGOs, concerned citizens, private corporations and various branches of government. Such arrangement can accommodate, numerous initiatives within a large-scale framework (Adams et al., 2016; France, 2016; Petursdottir et al., 2013; Pinto et al., 2014). These forums or advisory committees ensure the representation of the different interests at stake. However, as underlined by Baker et al. (2014), there are still limited studies in which

these interests are articulated and negotiated. Too many programmes are still focused on end-products and not enough on the developmental process and social learning that such networks enable, to build true adaptive capacity (Pahl-Wostl, 2006; Zedler et al., 2012).” (p714)

We thus focused on identifying local practices of restoration and how the existing institutions were working with the farmers. We also put social learning at the center of our project, so as to stimulate a capacity building process that would continue after the end of the project.

Regarding the institutional factors that might encourage more restoration initiatives, we carried work at different levels, at community level, municipal level and at a regional level.

At the community level, various studies explored the knowledge exchange and collective dynamics that occurred between farmers that have agroforests and with farmers who haven’t initiated restoration yet. We aimed at understanding the drivers of the expansion of first initiatives (Borges), of collective action (Andreata) and of agrobiodiversity exchange and conservation.

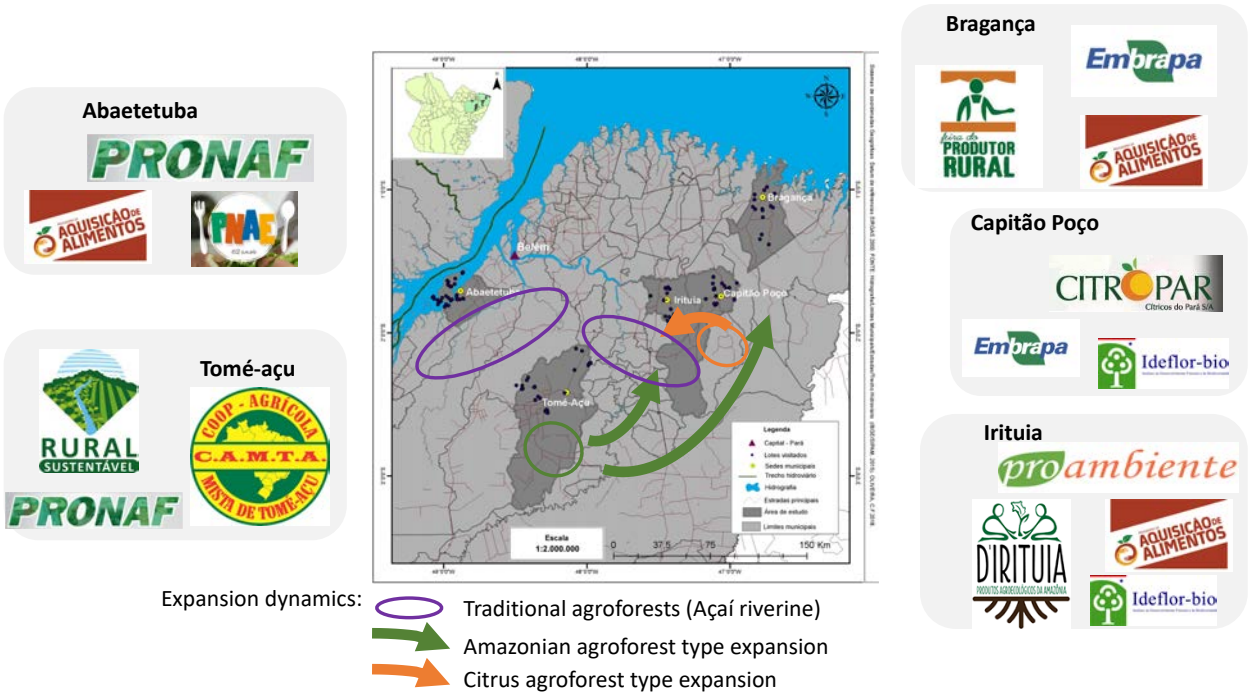
To understand how consolidated experiences of agroforest restoration had repercussions among neighbors in rural villages of northeastern of Pará, in her master’s study, Borges (2019) realized interviews with neighbors surrounding 6 outstanding experiences, in Bragança, Irituia and Tomé-açu, both with agroforests and without. She showed that the biggest reason for the non-adoption of agroforests is lack of interest and misinformation about the benefits and the techniques involved. On the other hand, there is strong a recognition of how positive the experience of agroforest is for the farmers who adopt it. She concludes that more awareness must be built among farmers who don’t know the benefits of the system. In a complementary article, Borges & Mota (2018) analyse specifically the motivations of women, who represent one third of the farmers who have agroforests in their sample. Borges shows that the motivations vary between men and women. The reasons for the women to plant agroforests are: diversification of family food, income, beautification of the area, shading, conservation of streams, and conservation of the soil. Men's reasons are more productive, economic and to recover resources.

In a quilombola community of Moju, Andreata (2020) studied in his masters’ an interesting experience where agroforests were implanted through the collective action of a group of farmers. The first agroforest arrived in the community in 2015, brought by one of the farmers (who has agricultural training), and had great repercussions after the community verified the success of the system. A group of 15 farmers was formed to work together to build and manage the seedling nursery and to plant other agroforest areas collectively. Through interviews Andreata shows that the agroforestry system had a good acceptance among farmers because it was brought by one of the members of the community. Collective action was fundamental in the success of restoration, since most farmers reported that they would not be able to implement their areas alone, reason why this community strength was essential for the success of a system which aims to generate income through diversification of production, resignifying the territory with their occupation through productive conservation.

To understand how the conservation of agrobiodiversity is linked to restoration, Santos (to be published), in her master’s work, investigates the dynamics of knowledge exchange and the solidarity of seedling and seed exchange among farmers who have agroforests in Irituia. She aims at understanding the relationship of the locality with nature, how this relationship influences the advancement of agroforests in the region and the farmers' perception of agrobiodiversity conservation.

To address the drivers at a municipal level, first we carried out interviews with key actors in different municipalities, so as to identify which municipalities would be most interesting to study and to define some contrasting institutional drivers (figure 16, presented at final seminar). Managed forests and agroforests have been present traditionally for centuries in this region, mainly along the rivers, acai being the favored species in these riverine zones (Abaetetuba, Irituia). They were the most menaced systems when the region was deforested, and more recently, because farmers have simplified their systems to privilege only acai, leading to environmental issues. In the inland, other types of agroforests were present traditionally, but on relatively small slash-and-burn parcels or as backyard orchards. Most key actors agree in recognizing Tomé-açu as a strong influence towards more commercial agroforests, on a larger scale. In this municipality, Japanese immigrants started agroforest in the 1960s after a crisis linked to pepper fusariose. In the 1990s-2000s, different institutions (cooperative, university) organized visits for farmers from other municipalities (in particular Irituia and Bragança) and many of them decided to enlarge or implant agroforests.

Figure 15 Institutional factors present in each municipality that have possibly influenced forest restoration dynamics



50% of farmers declare that they decided to implant an agroforest or restore their forest spontaneously. Nonetheless, many indirect institutional factors may have affected their decision. In all municipalities, market perspective are a strong driver: in Tomé-açu and Capitão Poço, large agroindustries, driven by large producers, also offer a market access to smallholders. In Irituia and Bragança, organizations created by the family farmers themselves have been offering increasing opportunities, through an organic cooperative (Irituia) that sells all the way to Rio de Janeiro, or a rural producers market in Bragança. However, governmental support is fundamental as a complement to these markets. Institutional markets, for school catering or poorer families, have encouraged the creation of family farmer cooperatives. Credit and technical support is also more than necessary to enable initial investment in the agroforests, through the Pronaf credit program or the Ideflor-bio governmental support to implement tree nurseries.

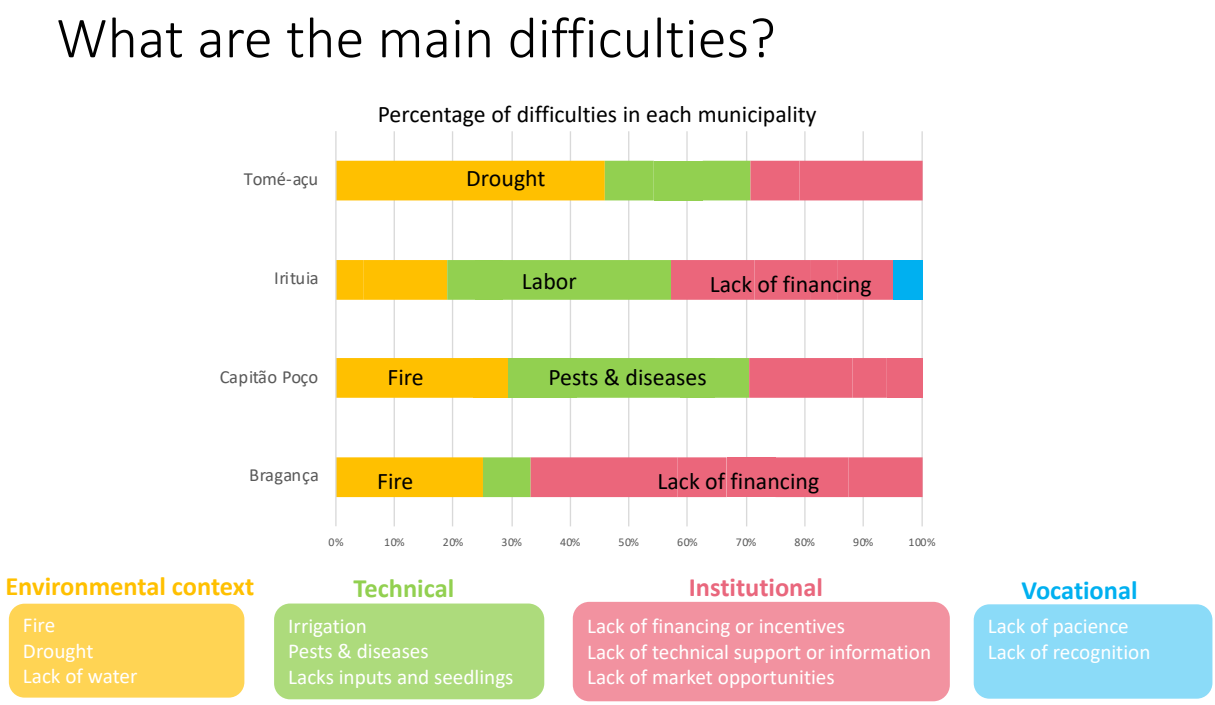
A more specific study in Irituia and Paragominas, through the doctoral work of Gabriel Resque, showed that the way the institutional markets are implemented can have an important influence on the motivations to implement agroforests (Table 3). In Irituia, where institutions have prioritized agroforests, the farmers who are part of the governmental program and sell their produce this way predominantly have agroforests (88% of them), whereas in Paragominas, institutions focused more on vegetable production.

Cropping systems	**Paragominas**		**Irituia**	
	Participants (n=9)	Non-participants (n=21)	Participants (n=17)	Non participants (n=13)
SAF	11%	38%	88%	38%
Horta	88%	28%	35%	23%

Table 3 Frequency of cropping systems of farmers's participating or not in institutional markets (Resque et al., 2019)

We also compared the difficulties mentioned by farmers according to each municipality (Figure 17, presentation at the final seminar). This revealed three types of institutional contexts. In Tomé-açu, where agroforests are implanted at a large-scale and mainly according to a commercial type, the main problem is because of the environmental context: most agroforests need irrigation and a collective problem is emerging regarding water resources. In Irituia and Capitão Poço, technical issues dominate, as there is still limited extension services. In Irituia and Bragança, lack of financing is also an strong restraining factor.

Figure 16 Main difficulties cited by the farmers according to each municipality



At the knowledge sharing workshop for extension agents, organized on November 27th 2020 in Belem, we discussed with 21 technicians and farmer leaders from the municipalities of Bragança, Abaetetuba, Irituia e Capitão Poço the limits and challenges for the up-scaling of restoration initiatives (figure 18 and table 4). Each person (technicians and researchers) identified one challenge, progressively building a conceptual map, and then we had a debate on the common challenges.

Figure 17 Workshop with extension agents and institutional stakeholders and challenges identified

Table 4 Challenges identified by the participants of the technical workshop held in Belem on November 26th, 2020

Motivations	Knowledge exchange	Public policies	Local arrangements for implementation	Research assessments
-Convince society that restoration is important -Disseminate knowledge on the benefits of restoration -Actors of restoration as proponents -Farmers as the subject of the process -Awareness-building among farmers -Environmental education of children -Understand restoration as a productive chain	-Technical assistance -Capacity-building -Field training -Knowing what is important for the farmers -Respect the different knowledges -Willingness of the technicians -Awareness building and capacity building of technicians -Strengthening extension agencies -Increase action capacity -Co-construction of the systems -	-Public policies to support restoration -Government policies -Regionalization of the policies -Consider up-scaling -Respect the forest law -Payments for environmental services -Simplify the bureaucracy to access credit -Define an institutional policy to encourage restoration within Emater (the state extension agency) -Mechanisms to finance credit -Define parameters and technical coefficient to support credit -Define indicators of economic viability for credit -Favor coordination between institutions -Transversal governmental program -Unify partnership with banks	-Structuring a general system for agroforests -Recognize institutional partnerships -Shared governance -Improve access to roads and transportation -Attend basic necessities of population -Land ownership legalization -Plan availability of seedlings -Quality seeds -Give better value to products from restoration -Strengthen commercialization -Improve income -Solidary economy -Continuity of actions	-Feed-back on the -Evaluating ex experiences -Systematizing experiences -Monitoring resto with maps -Monitoring the q of soil/water

This workshop revealed how much technicians consider the main challenge to be a structuration of public policies to prioritize forest restoration, both locally, through specific institutional arrangements for tree seedlings and markets, and at a state and federal level, to enable a better coordination between institutions. They also hope for a change in attitude from farmers and technicians, to build awareness on the benefits of forest restoration.

This workshop was important to validate the results obtained with farmers, as we put them in discussion with the technicians and as they showed that their own preoccupations are quite similar to the difficulties and challenges identified by the farmers.

Production of deliverables linked to the action
Statut : Produit

D4.1. Communication: Motivations of smallholders to restore forests: implications for institutional arrangements
4 communications, 1 chapitre, 1 poster
- Poster: Coudel et al. Agroflorestas como estratégia de recuperação : Motivações de agricultores familiares em fazer recuperação ambiental no Nordeste Paraense. Congres of the Brazilian Society for Ecological Restoration, Belo Horinzonte, 21-23 Nov 2018.
- Contribution of Emilie Coudel to a chapter in IPBES, report presented in 2018 at Medellin :
Responses to halt land degradation and to restore degraded land (Chapter 6). Pandit Ram, Parrotta John, Anker Yaakov, Coudel Emilie, Diaz Morejón Cristóbal Félix, Harris Jim, Karlen Douglas L., Kertész Adám, Mariño De Posada Juana L., Simelane Phumza Ntshotsho, Tamin Noraini M., Mascia Vieira Daniel Luis. 2018. In : Intergovernmental science-policy platform on biodiversity and ecosystem services: Chapters of the thematic assessment of land degradation and restoration. IPBES. Medellin : IPBES, 629-764. Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. 6, Medellin, Colombie, 18 Mars 2018/24 Mars 2018. https://www.ipbes.net/event/ipbes-6-plenary
- Borges & Mota (2018). SISTEMAS AGROFLORESTAIS NA AMAZÔNIA: A ATUAÇÃO DE MULHERES PARA DESCONSTRUIR O MONOPÓLIO MASCULINO NA RECUPERAÇÃO FLORESTAL NO NORDESTE PARAENSE. ENCONTRO DE REDE FEMINISTA NORTE E NORDESTE DE ESTUDO E PESQUISA SOBRE MULHER E RELAÇÃO DE GENERO, Salvador, 4-7 décembre 2018
- Braga-Galvão et al (2018). A valorização dos conhecimentos tradicionais: De sítios a Sistemas Agroflorestais na Amazônia Oriental. CONGRESSO BRASILEIRO DE SISTEMAS AGROFLORESTAIS, Aracaju (Brésil), 27-31 août 2019

Agroforestry 2019
- Coudel et al. (2019). Agroforestry as a restoration strategy: Motivations of farmers to plant more biodiverse systems in the Eastern Amazon. 4th World Congress on Agroforestry, Montpellier.
Resque et al. (2019) Institutional markets as a driver public policy for the adoption of agroforestry systems in the Brazilian Amazon. 4th World Congress on Agroforestry, Montpellier.
- Oliveira et al. (2019). Para além da renda: motivações para agricultores familiares incorporarem maior diversidade de árvores nativas em Sistemas Agroflorestais (SAFs) na Amazônia Oriental. XXV IUFRO World Congress, Curitiba.

D4.2. Articles

3 articles published
- Resque et al. (2019). Agrobiodiversity and public food procurement programs in Brazil: Influence of local stakeholders in configuring green mediated markets. Sustainability, 11(5):1425.
- Bessa et al. (2019). Motivações de agricultores familiares para participarem de ações de recuperação florestal em Paragominas, Pará
- Tisovec-Dufner (2019). Intention of preserving forest remnants among landowners in the Atlantic Forest: The role of the ecological context via ecosystem services. 1(4): p. 533-547.
: Cliquez ici pour taper du texte.

WP5 Multi-stakeholder modeling, will integrate these different assessments through the co-design of a stylized agent-based modeling of forest restoration, enabling the different stakeholders - ecologists, farmers, decision makers, restoration promoters, and other researchers - to share their perspectives regarding the ecological and socioeconomic benefits of restoration.

Déroulement de l'action
Statut : Réalisé

Activity 5.1. Agent-based model design

A conceptual model representing in a simplified and stylized manner the parallel functioning of four identical agricultural properties served as the basis for the development of a "role-playing game" type of tool that invites participants to manage these properties, i.e. to define the agricultural activities and associated practices according to their vision of the ideal functioning of this virtual agro-ecosystem. Each group leaves with identical conditions (financial resources, amount of work and biophysical conditions of the property. Each activity and practice is characterized by a financial and labor cost, a likely income and an environmental impact. The decisions are fed into a computer simulation model that simulates vegetation dynamics and calculates a set of indicators to assess the balance between socio-economic benefits and costs (see figure 19).

Figure 18 Main elements of the role playing game: board with 4 properties, activity cards, types of agroforests

A precise description of the role-playing game and its components is presented in deliverable D5.3. We present here the different stages of the construction and use of this tool and the learning that this process has entailed.

Co-construction process of the role-playing game: involvement of three spheres of actors

- Academic sphere (researchers and master students)

Initially, 19 Brazilians and 11 foreign researchers from 9 different disciplines were registered on the submitted project. Of these, 7 Brazilians and 3 French researchers from six different disciplines (Economics, Ecology, Forestry, Agronomy, Sociology, Modeling) constitute the active core of the project. In addition to these 10 researchers, 2 researchers who were not on the initial list have joined the project along the way. The project coordinators wished to strongly involve students, especially master's students, because in Brazil, the master's degree is characterized by a large project over two years, with a large part of field work. 20 Brazilian students have therefore been involved since the launch of the project, also from different backgrounds (Agronomy, Ecology, Forestry, Geography and Social Sciences). This group included a great heterogeneity in terms of familiarity with support modelling processes.

- Irituia Farmers' Sphere and Related Institutions

Some of the project researchers already had contacts with the Irituia Agri-Ecological Cooperative, and we used this as one of the entry points into the municipality to present our research and get some initial indications of farmers we could visit. We tried not to limit ourselves to just the farmers in this cooperative, since there are two cooperatives in Irituia, and many farmers are not part of either one. However, it should be noted that most farmers with agroforestry systems are members of the Irituia agro-ecological cooperative. We involved 4 farmers (we had invited 7, only 4 came) in the co-construction of the tool. Thus, with these 4 farmers, who represented very different types of agroforests (which was interesting for us to build the game and represent these differences), we had several interactions: group visits to the property, discussions, individual interviews and a workshop to co-construct the game. Indirectly, other farmers were involved through individual interviews and property visits, particularly through the work of the students. These surveys were complementary to understand the context and obtain technical information useful for improving the model.

Figure 19 Game test at the Itabocal highschool

- The Sphere related to the Itabocal High School (Irituia)

One of the elements that influenced the choice of Irituia as a study site was the presence of a biology teacher, farmer herself, who was eager to work on issues related to sustainable agriculture and agro-forestry systems with her students (12th grade, 17-19 years old). The students are all sons and daughters of farmers, and most of them already work part time with their parents. This teacher has proven to be an important resource person and a key player in our anchoring in the territory. With this class we realized a continuous work, with small workshops and general discussions on agriculture, tree species and the importance of sustainable systems, in order to start collecting their perceptions before introducing real test workshops of the game (Figure 20).

Description of the different collective highlights

- The meetings for the Refloramaz project management

These meetings are held in large groups (at least 10-15 people present) and take place in Belém since most of the researchers are based in this city and most of the students are linked to the Federal University of Para. These meetings, which take place at the university, are an opportunity to take stock of the progress of the project, to present the work of the students, to discuss the next congresses or events, to organize the next field periods. For those who are not so involved in the construction of the game, these meetings are also an opportunity to take stock of the progress of the construction of the game and to discuss ideas for improvement.

- Smaller co-construction meetings

These meetings in smaller groups of students and researchers are exclusively based on discussions and work around the advancement of the model. Organised in a slightly less formal way, these meetings occurred in Brasilia and Belém, and some during field activities, during moments that allow to work together on the game.

- Field periods and group visits to properties

Every two months, a field mission is organized. These weeks are divided between meetings in Belém and a few days in field in Irituia. These field periods usually involve between 5 and 10 people (including 3 to 5 researchers) and allow to visit some farmers, to make some small meetings or presentations of the project to key actors (cooperative, agriculture secretariat) and to do one or two co-construction sessions or workshops to test the game.

- Informal discussions

During these very intense field periods, informal discussions in very small groups (2 or 3) are a source of ideas, innovations and progress on the project. These are very rich moments in general and particularly important for the co-construction of the game. Being a tool in development, we do not know where exactly the next steps will lead, there are a multitude of possibilities on the forms that the tool could take. Informal discussions are therefore those creative moments when many ideas come together, with a totally different dynamic from that which prevails in slightly more formal meetings in larger groups with time constraints, where not everyone has the time or the opportunity, or dares to express themselves so freely. These informal discussions cover a wide range of topics, exchanging knowledge but also sharing personal impressions. All these ideas then form a real resource that can be mobilized later on for co-construction moments and other meetings.

- Co-construction and test workshops

These are the moments during which the core group interacts with other types of actors: farmers, students not involved in the Refloramaz project, institutional stakeholders, with a version of the model not yet complete but with the aim of

testing, exchanging, observing, in order to draw conclusions on important things to be modified or improved (Figure 21).

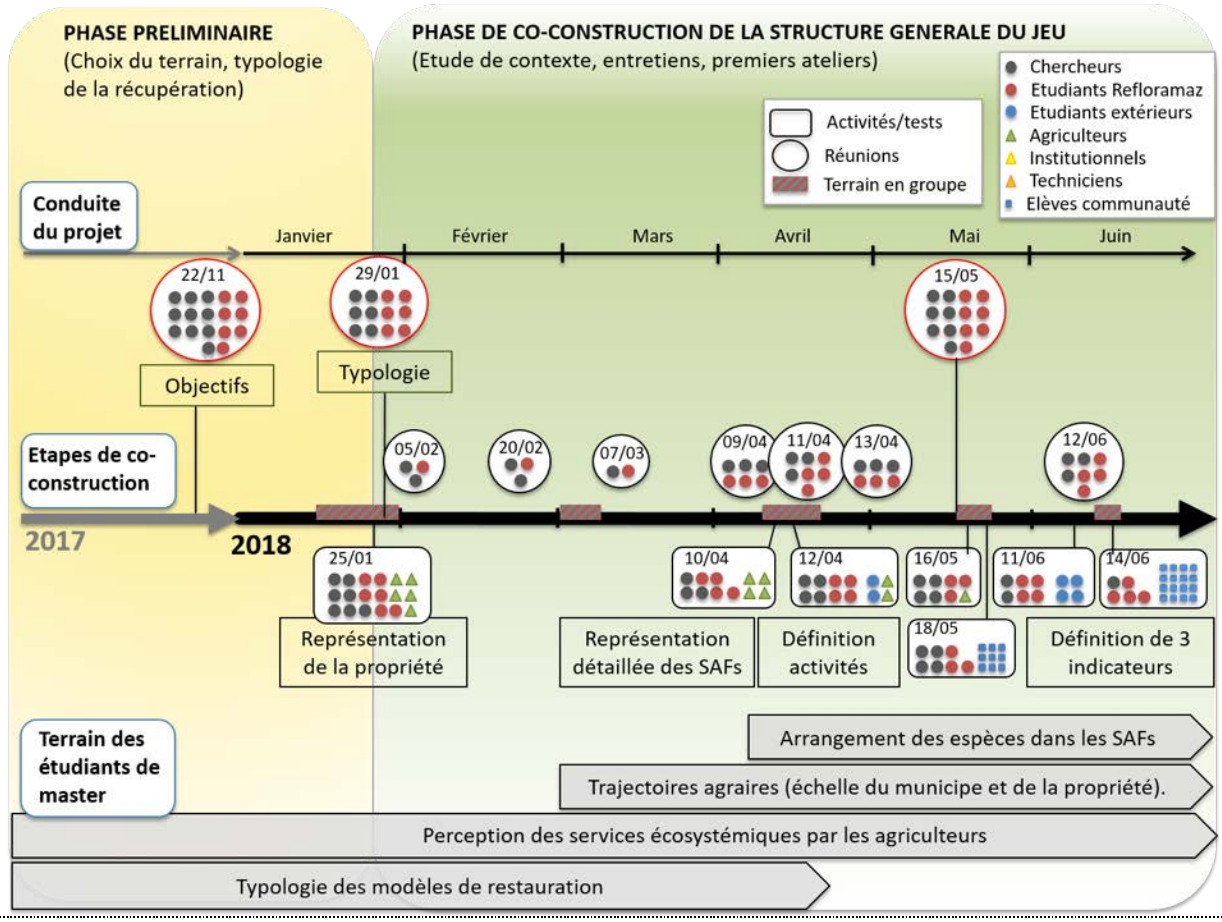
Figure 20 Understanding how the farmers organize the species within their agroforest

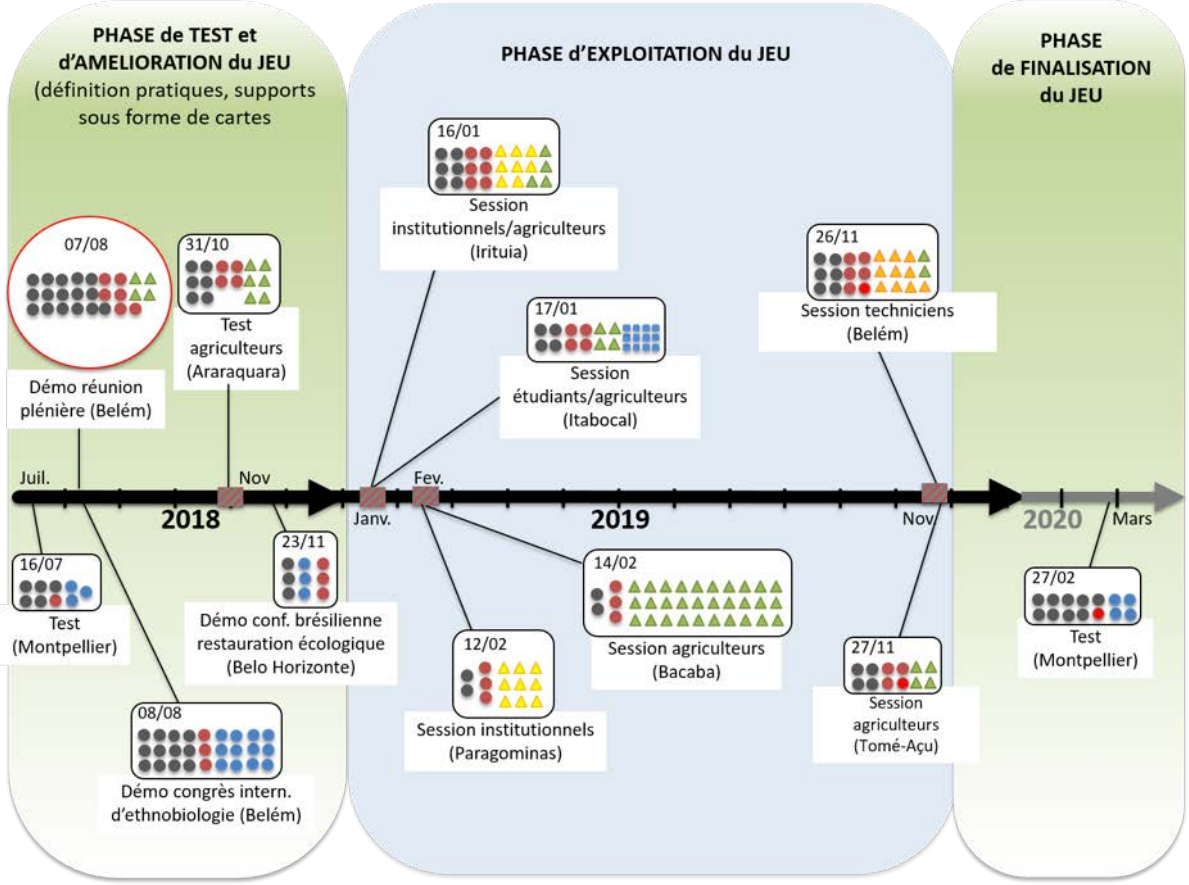
- The operational game session

Once a first version of the game was stabilized (January 2019), sessions were organized. Depending on the number and type of participants invited, the four groups - set up to manage the 4 properties - are strategically constituted in order to observe, on the one hand, the intra-group discussions and, on the other hand, the intergroup differences in the trajectories and the discourses justifying these trajectories. Each group is accompanied by a helper, who observes interactions and reports them at the end of the session. In this exploitation phase of the game, most of the sessions bring together participants of different types (i.e. farmers, institutions, researchers, technicians) in order to promote the sharing of representations and generate collective learning.

The chronogram below shows the involvement of the different stakeholders during the different phases of development of the game (Figure 22).

Figure 21 Timeline of the co-construction of the multi-agent simulation model





Learnings related to the co-construction process

During the co-construction of the game, interviews were conducted (mainly with researchers, professors, master's and doctoral students and a key player, a professor and a farmer) in order to characterize the learning. These were very diverse, as show the following verbatim:

"With this methodology, we can see what has been done, what is being done and what will be done; it makes it much easier to understand" "it allows us to have a quick perception of everything. "(A researcher)

"The construction of the game in itself attracted my attention because it allows this tightening of bonds" and "bringing people throughout the process, the social construction between us, the building of friendships, we don't often see this in other projects". (A researcher)

The teacher and farmer of the Itabocal school, during the interview, to the question what did you like the most, answers: "this friendship relationship that has arisen, regardless of the language, this exchange: nobody is worth more than the others, the researcher puts him/her-self in the farmer's place, he puts himself in the student's place, and the student can discuss as an equal, that's very important. There is no superiority, there is an isonomy of contribution".
Enthusiasm and ownership of the project:
"People like to play a lot, especially me, and farmers like to do different things, so for those reasons I thought it was really great.

A student noted as a surprise: "Because it's colourful and it's a game, people get involved. It's a fun game, not as boring as paper surveys, it makes you want to get involved".

"I would like to make [the game] available for research (doctorate, master's degree) and disseminate it [to] make the link between universities and farmers, where the university is acting. My students are already thinking about how to adapt the tool for their own research context." (researcher)

"First I'd like to finish the game, and then I'd like to popularize it (make it available and usable by everyone) because we're using [a technology] that people won't have at their disposal like a vertical datashow. (a researcher particularly involved in the process).

Activity 5.2. Game session held, scenarios and next steps

Six different game sessions were held during 2019 (Table 5). The decision are recorded by the computer and can be analysed afterwards. Observation of the sessions and discussion with the participants also enable to understand the choices of the players during the sessions.

Table 5 Game sessions held during the exploitation phase and participation of the different types of stakeholders

	Nb de chercheurs	Nb d'étudiants	Nb d'agriculteurs	Nb d'institu-tionnels	Nb de techniciens	Nb d'élèves des communautés
16/01/2019 à Irituia	6	6	4	8		
17/01/2019 à Irituia (Itabocal)	4	4	4			16
12/02/2019 à Paragominas	2	3			9	
14/02/2019 à Paragominas (Bacaba)	2	3	30			
26/11/2019 à Belém	6	6	2	11		
27/11/2019 à Tomé Açu	4	4	4			

The results of the sessions showed the possibility to observe from the game how a set of factors (e.g. income, labor availability, ecosystem services) are taken into account in planning the spatial-temporal configuration of the agro-ecosystem and associated farming practices. They also revealed some trade-offs involved in this decision-making process. It was also possible to deduce how these logics can change according to the type of actor or municipality, as exemplified in figure 23.

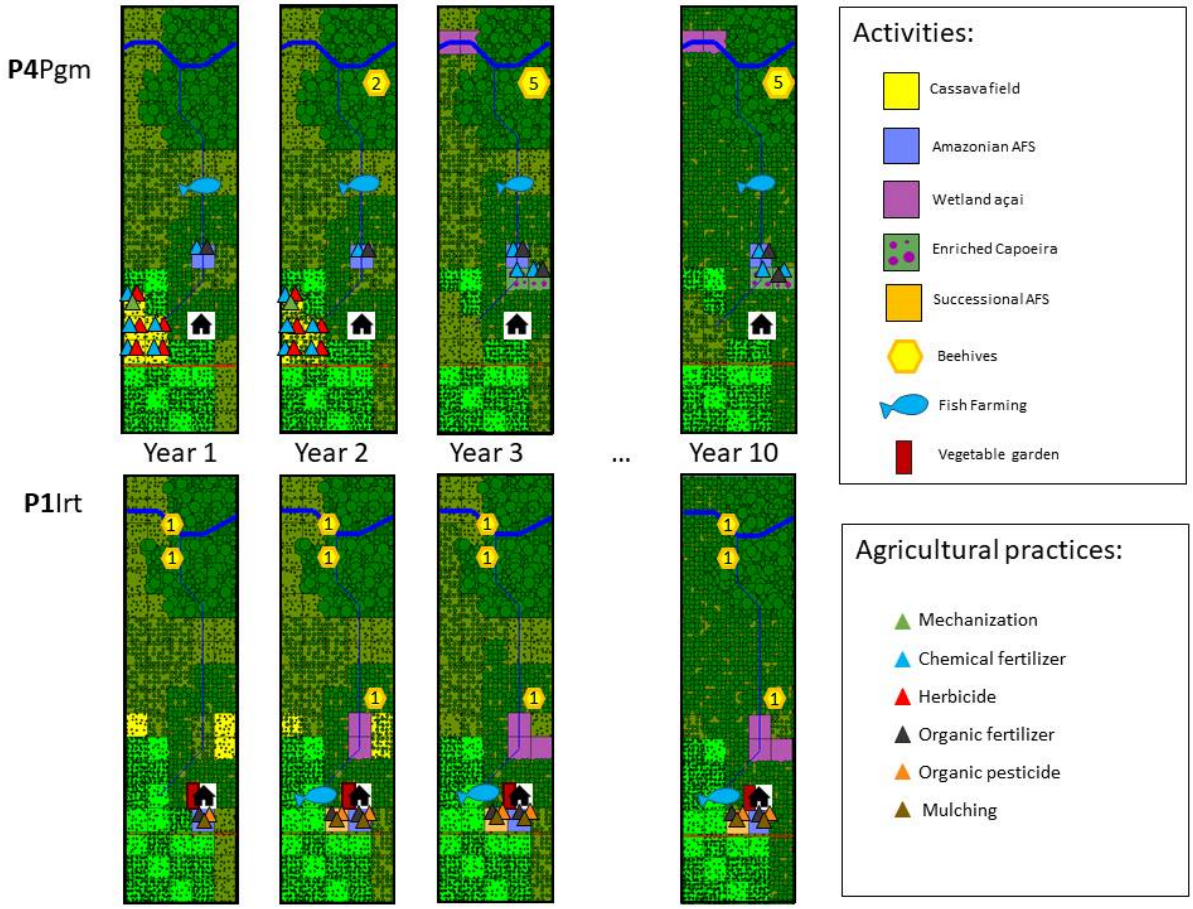


Figure 22 Representation of the results of two properties run by actors representing the same entity (department of agriculture) in different municipalities. The figure shows the 3 agricultural years played in the game and a projection of the state of the property after 10 years. These groups have similarities in terms of diversification of activities, but differ mainly in terms of the type of farming practices implemented (i.e. chemical versus ecological).

During the testing and exploitation phases of the game (the results of which are analysed in the article by Lima Resque et al, submitted in January 2020), we also sought feedback from farmers and agricultural technicians about this tool.

Here are some debriefing extracts illustrating what farmers and technicians thought of the game and what they said they learned during the sessions:
"I would find it interesting to play this game in any community or farmers' group so that they learn how to plan. Many of them don't know how to do this planning. They come to the property, and they do things the way they think best and end up with losses". (Agricultural Technician, Paragominas)
"I found this interesting because I compared it to my property" (Farmer, Irituia)
"You could see the difference between people who were farming [farmers] and people who are on the land but not always on a property [technicians]. Our group [group of farmers] could make decisions faster and more intuitively without looking at maps. The others had to make calculations" (assistant to a group during a game session).

The game sessions demonstrated the potential of the model as a tool for learning and knowledge exchange. As a learning tool, the game can be used in two different ways. The first is to enable local stakeholders to improve their understanding of the processes and dynamics of the agroecosystems included in the model. The second is to allow researchers to undertand stakeholders' preferences regarding the agroecosystem management, based on the choices and attitudes of these stakeholders during the game sessions. The game has also proven to be capable of being used as a knowledge-sharing tool. Although each type of stakeholder had its own way of "playing" (more or less empirical or technical), the game sessions placed farmers and local stakeholders in an experimental situation that allowed them to synthesize and discuss the different knowledge they had and their conceptions of how agro-ecosystems should be managed (i.e. farming practices and agrobiodiversity).

Perspectives
Following the final seminar, we decided to introduce climate scenarios, in order to better understand how farmers adapt to these phenomena. Recent model modifications include year-to-year variations in climatic conditions and rainfall, including two years of drought (in year 4 and year 9) that cause a decrease in production and mortality of some species. The idea in introducing a second year of drought in year 9 is to see whether decisions were taken accordingly after the first drought in year 4 and whether they were effective in limiting damage in future droughts. These scenarios are already introduced in the model but have not yet been tested, we plan a test at the autumn of 2020. Other scenarios such as fires, pests, and public policies (modification of the forestry code etc...) are under discussion.

Communication and Dissemination Strategy

Participation in international congresses (16th Congress of the International Society of Ethnobiology, Belém August 2018; 4th Congress of Agroforestry, Montpellier May 2019) and national congresses (SOBRE 2018, 2nd Brazilian Conference of Ecological Restoration, Belo Horizonte November 2018; 2nd edition of Jeux & Enjeux, Marseille, May 2019) has enabled us to implement a dual communication strategy: on the one hand, in a classical way, by using the oral presentations as a basis for writing an article submitted for publication in a scientific journal (case of the presentation in Montpellier submitted to the journal "Agroforestry Systems"). On the other hand, by proposing role-playing sessions during some of these congresses (in Belém and Belo Horizonte), we also offered the opportunity to participants to discover the tool by playing it.
The work carried out was also communicated via the ComMod "Companion Modelling" network. A first presentation was made during the 17th edition of the association's annual meetings (Montpellier, July 2018). Recently, a ReflorAmaz case study was published on the website www.commod.org.
At the end of the project, we have continued the development of the tool to produce a version that is more easily usable by anyone interested. Indeed, it turned out that the way of deploying the first prototype (with the use of an ultra-short focal length projector to materialize a game board whose update is automated thanks to a multi-agent simulation software) was difficult to reproduce at the technological level. The latest version of the software required to organize a game session, as well as the documentation necessary for its use, are available for download on the ComMod website dedicated to the ReflorAmaz project.
Cliquez ici pour taper du texte.

Production of deliverables associated to the action

D5.1. Communication: Scenario building for forest restoration
Statut : Produit
1 special session, 3 communications, 1 poster
Session de jeu lors de Ethnobiology 2018, Belem.
Communication : Le Page Christophe, Perrier Eva, Coudel Emilie, Galvão Layse, Garcia Vitor, Navegantes Lívia. 2018. Fostering knowledge sharing about agroforestry systems through the codesign of a role-playing game with farmers and students from the Municipe of Irituia (Northeast Para, Brasil).. ISE. Bélem : ISE, Résumé, 1 p. Congress of the International Society of Ethnobiology. 16, Bélem, Brésil, 7 Août 2018/10 Août 2018.
Poster : Le Page Christophe, Perrier E., Coudel Emilie, Resque Antonio Gabriel Lima, Galvão Layse, Garcia V., Navegantes-Alves Livia. 2018. Compartilhamento de conhecimentos sobre sistemas agroflorestais entre agricultores familiares e estudantes através do uso de um jogo.. Belo Horizonte : Sociedade Brasileira de Restauração Ecológica, 1 p. SOBRE 2018: Conferência Brasileira de Restauração Ecológica. 2, Belo Horizonte, Brésil, 21 Novembre 2018/23 Novembre 2018.
Le Page et al. (2019). Fostering knowledge sharing about agroforestry systems through gaming and simulation in Irituia (Northeast Para, Brasil). 4th World Congress on Agroforestry
Le Page et al. (2019). Un jeu de rôles pour accompagner la transition agro-écologique de l'agriculture familiale en Amazonie brésilienne, Colloque Jeux et enjeux, Mai 2019, Marseille.

D5.2. Article
Resque et al. (soumis). Discussing ecosystem services of managemen of agroecosystems: a role playing game in the eastern Brazilian Amazon. Agroforestry systems.

Scientific conclusions

Over the past 10 years, forest restoration has been gaining importance worldwide, inextricably linked to the climate change agenda. Historically, restoration was viewed as an attempt to return an ecosystem to its pre-disturbance state, but this paradigm has been changing. Enlarging to a socioecological perspective, human wellbeing goals have become more center-stage. Moreover, the focus has changed to the landscape level, rather than site level. In this context, family farmers become main players of forest restoration. After having managed to contain deforestation in the Amazon region, Brazil committed itself internationally in 2015 to the recovery of 12 million hectares of forests by 2030, and Pará state has the largest area to be restored. The forest legislation has opened up new options for forest restoration by smallholders, allowing in particular the use of agroforestry in conservation areas. This has triggered a vigorous national debate, involving social movements, scientists and policy makers: while these legislative changes may encourage farmers to engage in restoration, the provision of environmental services greatly varies according to the type of agroforestry system.

In the eastern Amazon, many farmers have been spontaneously developing forest restoration experiences, based on traditional knowledge about local ecosystems. At the same time, there are institutional initiatives encouraging agroforestry systems by smallholders, such as the State Biodiversity and Forest institute in Pará. Their strategies are mainly driven by cultivating agroforestry systems, pursuing a balance between economic viability and ecological benefits. In the Refloramaz project, we aimed at assessing the balance between these different dimensions, putting in discussion the different points of view of the actors involved in forest restoration.

To contribute to this debate, we analyzed agroforestry systems implemented by farmers in the Northeast of the state of Pará, in a 300 km diameter around Belem, a region colonized almost a century ago and where there is a great diversity of agroforestry systems. By combining interviews with key actors, 160 questionnaires with farmers and in-depth analyses of different production systems, we elaborated a typology of the different agroforestry systems, to assess their potential for environmental restoration. 78% of farmers restored through agroforests. Although environmental restoration is rarely the prime objective, in many cases, the farmers have consciously tried to restore environmental functions and consider that production has improved following the diversification of the system. Moreover, the environmental restoration can involve more than the agroforestry plot, as 83% of farmers who have agroforests also let surrounding forest regenerate naturally. In ecological terms, we demonstrated the different agroforestry systems developed in the region have distinct impacts on regaining plant diversity. Some agroforestry systems are highly commercial and provide low biodiversity levels, while others are multifunctional and lead to much higher biodiversity and ecosystem service recovery.

Investigating the motivations of the farmers towards more biodiverse agroforestry systems, that better restore environmental services, we showed that most farmers who have pragmatical motivations (restoring the environmental services of their property, such as water, soil, products) have less diverse agroforestry systems. Those with broader environmental motivations (preoccupation with overall forest degradation and biodiversity loss) have more biodiverse systems. This points out to the importance of building more awareness about the potential role of biodiversity in restoring environmental services. Moreover, the knowledge developed by the farmers, including the combination of species and the integration of the agroforestry within the production system, must be better valued and contemplated by the institutions which support restoration programs.

A role playing game enabled to discuss the priorities of the different stakeholders, both during the construction of the game and then during the sessions. By comparing the trajectories of 4 initially identical properties, we reveal how the different choices of systems and practices lead to different balances between environmental, social and economic benefits. Farmers, technicians, students, decision makers, researchers were all involved in the game sessions, evidencing different points of view on how they planned the restoration of their virtual property. The first sessions we featured revealed the potential of this game as a learning tool, to stimulate knowledge exchange between stakeholders.

As we finalize this project, having identified more than 400 farmers who restore forests in the studied region, we wish to point to the main research questions that open to us: how can restoration be addressed at a landscape level, in a multi-stakeholder perspective? what are the barriers and enabling conditions to achieve an up-scaling? how can public policies support such an up-scaling? Although many individual experiences are occurring, reflections regarding the coordination among these initiatives is almost inexistent. The multi stakeholder network created in the Refloramaz Project helped to identify the main barriers to restoration and initiate this reflection process, but much more has to be done. The open questions invite us towards different research avenues: understanding better the link between agroforestry and naturally regenerating forests, as it is the best strategy to rapidly upscale restoration processes within landscapes; analyzing with remote sensing the restoration trajectories of the landscapes where we identified many individual initiatives, work that has been initiated by our most recent doctoral student; and finally, assess the functioning of the social markets that have been emerging to sell products from biodiverse systems, to understand their potential in orienting farmers in adopting more biodiverse agroforestry systems. All these research questions are highly relevant to be addressed in the current moment when federal (Amazonia+) and state policies (Amazonia Now) were launched to incentivize forest restoration and ecosystem services. Pará state alone has the target of restoring around 5 million hectares, more than a third of the national target. The continuity of the network within the Refloramaz scope is therefore more than ever necessary.

Moyens mis en œuvre par l'unité pour la réalisation du projet	
Mise en œuvre de tous les moyens nécessaires à la réalisation du projet, notamment : Principaux scientifiques (investis plus de 2 mois): • Emilie COUDEL 6 mois • Christophe LE PAGE 6 mois • Joice FERREIRA 6 mois • Livia NAVEGANTES 6 mois • Dalva Mota 3 mois • Angela May 3 mois • Socorro Ferreira 3 mois • Lilian Blanc 2 mois Autres moyens : - Recuperamaz project, financed by Brazilian CNPq (50.000 R$) - Stradiv project, financed by Agropolis Foundation - Odyssea project, financed by EU H2020 RISE program (enabling mobility of european researchers)	Statut : Réalisé Commentaires : Les principaux scientifiques sont engagés comme prévu de manière active et ont su mobiliser une équipe soudée comptant sur d'autres chercheurs et de nombreux étudiants. Plusieurs projets complémentaires ont été mobilisés pour offrir des moyens supplémentaires autour des mêmes objectifs. Ainsi, Lívia Navegantes a obtenu un financement du CNPq pour le projet Recuperamaz, pour financer notamment une partie des frais de terrains des étudiants de l'UFPA et leur participation dans des conférences. Ceci a permis d'impliquer de nombreux étudiants dans la dynamique du projet Refloramaz. Le projet étendard Stradiv, financé par Agropolis Fondation, a financé le doctorat de Gabriel Resque et a été mobilisé en 2019 pour mettre en place les sessions de jeu. De fait, le jeu qui a été initialement construit pour discuter de restoration forestière a pu être mobilisé aussi pour discuter de la biodiversité fonctionnelle, sujet de Stradiv. Ce financement a aussi été utilisé pour appuyer la réalisation du film et de la carte illustrée. Enfin, le projet Odyssea, Observatoire des Dynamiques Socio-Environnementales en Amazonie financé par l'Union Européenne au sein du programme H2020-RISE, a permis de financer une partie des missions sur le terrain des agents du Cirad Emilie Coudel, Christophe Le Page et Lilian Blanc et a offert une arène de discussion importante avec d'autres acteurs impliqués en Amazonie autour de la restoration forestière et de l'agroforestrie.

Indicateurs *Merci de renseigner les lignes ci-dessous*	
Aide à l'organisation d'évènements scientifique de haut niveau	Nom de l'évènement : Session de jeu « Me safando nos SAFs » lors du congrès international de ethnobiology, Belem, 8-10 Août 2018 Nom, prénom et nationalité des personnes soutenues sur les fonds AF (si pertinent) : Emilie Coudel, Christophe Le Page Nombre de participants total : 25 participants au congrès, dont 4 agriculteurs invités spéciaux pour une table ronde sur la restauration avant le jeu Nombre de participants du réseau : 8
Soutien à la préparation de dossiers de candidatures aux appels à projets nationaux ou internationaux	Nom de la proposition déposée : Cliquez ici pour taper du texte. Guichet : Cliquez ici pour taper du texte. Accepté : ☐ Oui ☐ Non Si oui, préciser le montant obtenu : Cliquez ici pour taper du texte. *(à dupliquer si plusieurs propositions soumises)*
Soutien aux déplacements de scientifiques du réseau	Si déplacement de plus de 2 mois Date de début : Cliquez ici pour taper du texte. Date de fin : Cliquez ici pour taper du texte. Institution d'accueil (+ pays) : Cliquez ici pour taper du texte. *(à dupliquer si plusieurs déplacement)*
Soutien à des projets à vocation pédagogiques	*(Si écoles thématiques)* Nom de l'école thématique : Discussion sur l'intérêt des systèmes agroforestiers avec l'Escola Estadual de Ensino Medio de Itabocal, commune d'Irituia Date(s) : Journées tout au long de 2018 avec les étudiants de biologie du professeur Ana Alice Nombre de participants : 20 étudiants
Productions scientifiques	**Fait l'objet d'un fichier excel à part (« Suivi des productions scientifiques)**

Accueil de scientifiques *(voir encarts plus bas)*

	Prévus	Effectifs
Soutien à des post-doctorants	Nombre : 0	Nombre : 1
Soutien à des doctorants	Nombre : 0	Nombre : 2
Soutien à des accueils de courte durée	Nombre : 0	Nombre : 2
Soutien à des pré-docs	Nombre : 1	Nombre : 3

3. RETOMBEES ET PERSPECTIVES

Poursuite des travaux sur le sujet du projet

Préciser :
Le projet Refloramaz continue à mobiliser les chercheurs et étudiants impliqués pendant le projet pour valoriser par des publications les riches informations collectées. Nous avons prévu de finaliser avec les étudiants des fiches techniques pour les agriculteurs, chaque étudiant étant responsable d'une fiche avec un thème précis. Les coordinatrices du projet (E. Coudel, J. Ferreira et L. Navegantes) se mobilisent pour écrire une publication commune présentant des analyses sur l'ensemble des données collectées, à soumettre dans une revue scientifique renommée (en discussion). Enfin, nous envisageons ensemble de préparer un numéro spécial sur le thème de la restauration forestière, où chaque chercheur, accompagné des étudiants qu'il a encadré, pourrait proposer un article sur son thème de prédilection.

Le jeu et le Modèle de Simulation Multi-Agent associé continuent à évoluer. Une version stabilisée est déjà disponible en ligne, sur le site www.commod.org, téléchargeable gratuitement. Mais nous avons en projet de nous rapprocher des institutions d'assistance technique et de formation pour leur proposer une version à adapter à leurs besoins, autour de l'agroforesterie et de la restauration forestière. Enfin, ce jeu sert aussi comme base à une réflexion sur un nouveau jeu à développer à Madagascar autour de l'agroforesterie, mené par Christophe Le Page et Eva Perrier (devenue consultante pour ce projet).

Enfin, plusieurs projets ont été déposés et obtenus pour continuer à avancer sur le thème de la restauration forestière et de l'agroforesterie. Le projet Sem-Flama, financé par le programme PrevFogo de l'IBAMA (agence environnementale du Brésil), s'intéresse aux expériences collectives de restauration forestière suite à une dégradation liée au feu, dans la région de Santarém. Le projet INCT Odisseia, financé par le CNPq, CAPES et Fondation d'Appui à la Recherche du District Fédéral, continue à la suite d'Odyssea (H2020) à travailler avec les acteurs sociaux de la région de Santarém sur l'agroécologie, l'expansion des initiatives d'agroforesterie, et favorise la rencontre entre acteurs des deux régions (Santarém et Nordeste du Pará).
Deux grands projets sont également en cours de montage par le Cirad et pourront s'appuyer sur les résultats du projet Refloramaz : le projet TerrAmaz, financé par l'AFD à hauteur de 4 millions d'euros, appuiera sur 4 terrains amazoniens les dynamiques territoriales de transition forestière et s'intéressera notamment à la restauration forestière par les agriculteurs familiaux ; un projet Desira, en cours de montage, associera institutions de recherche (Cirad, Embrapa, UFPa), ONG (IPAM) et institutions semi-publiques (SEBRAE) pour promouvoir des transitions agroécologiques en Amazonie, en valorisant particulièrement les systèmes agroforestiers.
Nous souhaitons aussi déposer une demande de projet Capes-Cofecub d'appui à la mobilité entre France et Brésil pour continuer à financer notre réseau dans les années qui viennent.

Ajouter en annexe si besoin est

Une information sur la visibilité, l'attractivité et le positionnement national et international du projet

Préciser : Lors du premier séminaire scientifique du projet, les scientifiques engagés sur la restauration forestière ailleurs au Brésil (notamment Daniel Vieira) et dans le monde (notamment Eduardo Brondizio) ont confirmé le grand intérêt des recherches sur l'Amazonie, où il y a très peu de travaux, ainsi que l'abordage interdisciplinaire, car les études associant écologie et sciences sociales sont encore rares. Nous avons pu le constater lors du Congrès de la Société Brésilienne de Restauration Ecologique (SOBRE), où la grande majorité des travaux est encore en sciences écologiques.
Les deux sessions de jeu que nous avons organisé lors de congrès (Ethnobiology 2018 et SOBRE 2018) ont eu un grand succès, confirmant l'intérêt d'approches qui permettent de mettre en discussion par un jeu les trajectoires de restauration forestière et ses différents bénéfices.
Lors du séminaire final, nous avons invité deux scientifiques parmi les plus reconnus sur la restauration forestière au Brésil, pour donner les conférences d'introduction : Ricardo Rodrigues (ESALQ) e Ivan Crespo (UFPR). Tous deux ont félicité le projet, considérant qu'il est fondamental d'évaluer les expériences des propres agriculteurs et qu'il est particulièrement important de faire ce travail en Amazonie, où très peu de travaux ont été réalisés.
Par ailleurs, Joice Ferreira, coordinatrice de Refloramaz, a gagné en 2019 le prix international de la Société d'Ecologie Britannique, pour l'ensemble de ses travaux scientifiques de haut niveau, au service de la société. https://www.embrapa.br/busca-de-noticias/-/noticia/46096648/pesquisadora-brasileira-ganha-premio-internacional-de-ecologia

Ajouter en annexe si besoin est

Une information sur les impacts du projet

Préciser :
L'objectif du projet Refloramaz était d'identifier et analyser les expériences en cours et de les faire connaître.

Dans ce sens, nous pouvons affirmer que le projet a bien eu l'impact attendu, voire même est allé au-delà de nos attentes. De fait, nous avons identifié plus de 400 agriculteurs familiaux dans 5 municipalités qui ont initié des expériences de restauration forestière et nous avons pu faire connaître cette réalité au travers du film « Recuperando florestas, transformando vidas », de la carte illustrée des expériences de restauration foresitère, qui toutes les deux ont déjà atteint plus de 1000 personnes, surtout des agriculteurs, techniciens agricoles et étudiants du supérieur. Les autres institutions du Pará travaillant sur la restauration forestière et sur l'agroforesterie nous connaissent bien maintenant et apprécient notre travail. Nous espérons pouvoir continuer à les mobiliser au sein d'un réseau qui se consolidera dans les années qui viennent.

Nous devons maintenant consolider notre visibilité nationale et internationale, notamment par des publications scientifiques démontrant l'intérêt de ces expériences de restauration forestière au travers d'une méthodologie rigoureuse d'évaluation des trade-offs entre bénéfices environnementaux et socio-économiques.

Ajouter en annexe si besoin est

4. BUDGET

Réalisation budgétaire par rapport à la convention

Statut : Modifications effectuées
Commentaires : Avenant signé en décembre 2018

5. INFORMATIONS COMPLEMENTAIRES

Merci de porter ici toutes informations que vous jugerez utiles (changements dans le programme, nouveau développement du projet, nouveaux débouchés etc.)

Cliquez ici pour taper du texte.

Ce rapport doit être accompagné :

- ✓ *du fichier « **Suivi des productions scientifiques** »*
- ✓ *de la fiche projet actualisée*

Si ce rapport est le rapport final, merci de joindre également :

- ✓ *le récapitulatif financier (original signé à envoyer directement à la Fondation)*
- ✓ *le questionnaire de satisfaction (FR03) lié au suivi de votre projet (fourni par la Fondation)*

RAPPEL :

Le soutien de la Fondation ainsi que le logo du programme des « Investissements d'avenir » devront apparaître sur les publications et communications portant sur ce projet.
Dans le but de faciliter cette communication, vous trouverez, ci-dessous une formulation de texte que vous pouvez utiliser pour les publications *: « This project is supported by Agropolis Fondation under the reference ID 1503-011 through the « Investissements d'avenir » programme (Labex Agro:ANR-10-LABX-0001-01) ».*
Les logos sont disponibles sur le site internet.

ANNEXE: SCIENTIFIQUES ACCUEILLIS

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => DOCTORANT		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Daugeard	
Prénom	Marion	
Genre	F X ou M ☐	
Nationalité	Française	
Adresse mail personnelle		
Etablissement d'inscription en master ou équivalent	AgroParisTech	Pays : France
Date(s) de début de séjour	21 Novembre 2017	
Date(s) de fin de séjour	25 Novembre 2017	
Institution d'accueil	Cirad et UFPA	
Unité d'accueil	Brésil	
Nature des activités au cours de l'accueil	Présentation de sa thèse lors du premier séminaire interne : Perfis de agricultores e politicas municipais de apoio a restauração florestal no Mato Grosso	
Salaire financé par AF ?	Oui ☐ ou Non X	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => POST-DOCTORANT		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Pepper	
Prénom	Leonora	
Genre	F X ou M ☐	
Nationalité	Etats-Unis	
Adresse mail personnelle	leonora.g.pepper@gmail.com	
Etablissement d'inscription en master ou équivalent	Cornell University	Pays : USA
Date(s) de début de séjour	21 Novembre 2017	
Date(s) de fin de séjour	1 décembre 2017	
Institution d'accueil	CIRAD et UFPA	
Unité d'accueil	Brésil	
Nature des activités au cours de l'accueil	Présentation sur les pratiques de récupération utilisant l'açaï et travail de terrain à Capitão Poço (12 entretiens de la base de données)	
Salaire financé par AF ?	Oui ☐ ou Non X	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => PRE-DOCTORANT (MASTER OU EQUIVALENT)		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Perrier	
Prénom	Eva	
Genre	F X ou M ☐	
Nationalité	Française	
Adresse mail personnelle	evaperrier@protonmail.com	
Etablissement d'inscription en master ou équivalent	AgroParisTech	France
Date(s) de début de séjour	15/01/2018	
Date(s) de fin de séjour	15/07/2018	
Institution d'accueil	Cirad	
Unité d'accueil	Green	
Nature des activités au cours de l'accueil	Suivi du processus de construction du jeu de rôle	
Salaire financé par AF ?	Oui X ou Non ☐	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => PRE-DOCTORANT (MASTER OU EQUIVALENT)		
RAPPEL DU CODE PROJET : 1503-011		
Nom	RATEL	
Prénom	Ophélie	
Genre	F X ou M ☐	
Nationalité	Française	
Adresse mail personnelle	ophelie.ratel@etu.umontpellier.fr	
Etablissement d'inscription en master ou équivalent	Université Montpellier	France
Date(s) de début de séjour	26/03/2018	

Date(s) de fin de séjour	29/06/2018
Institution d'accueil	Cirad
Unité d'accueil	Forêts & Sociétés
Nature des activités au cours de l'accueil	Analyse bibliographique des systèmes de restauration forestière mis en œuvre dans les forêts tropicales humides sous la forme d'une carte systématique
Salaire financé par AF ?	Oui X ou Non ☐

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => CHERCHEUR		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Ferreira	
Prénom	Joice	
Genre	F X ou M ☐	
Nationalité	Brésilienne	
Adresse mail personnelle	joice.l.ferreira@gmail.com	
Etablissement	Embrapa	Brésil
Date(s) de début de séjour	15/06/2018	
Date(s) de fin de séjour	01/07/2018	
Institution d'accueil	Cirad	
Unité d'accueil	Green	
Nature des activités au cours de l'accueil	Ecole d'été sur la restauration des paysages forestiers tropicaux	
Salaire financé par AF ?	Oui ☐ou Non X	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => CHERCHEUR		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Navegantes Alves	
Prénom	Livia	
Genre	F X ou M ☐	
Nationalité	Brésilienne	
Adresse mail personnelle	lnavegantes@gmail.com	
Etablissement	UFPA/INEAF	Brésil
Date(s) de début de séjour	15/06/2018	
Date(s) de fin de séjour	01/07/2018	
Institution d'accueil	Cirad	
Unité d'accueil	Green	
Nature des activités au cours de l'accueil	Ecole d'été sur la restauration des paysages forestiers tropicaux	
Salaire financé par AF ?	Oui ☐ou Non X	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => DOCTORANT		
RAPPEL DU CODE PROJET : 1503-011		
Nom	Lima Resque	
Prénom	Antonio Gabriel	
Genre	F ☐ ou M X	
Nationalité	Brésilienne	
Adresse mail personnelle	gabrielresque@gmail.com	
Etablissement d'inscription en master ou équivalent	AgroParisTech	Pays : France
Date(s) de début de séjour	15/06/2018	
Date(s) de fin de séjour	01/07/2018	
Institution d'accueil	Cirad	
Unité d'accueil	Green	
Nature des activités au cours de l'accueil	Doctorat, analyse de résultats et rédaction d'articles	
Salaire financé par AF ?	Oui ☐ ou Non X	

DESCRIPTIF DU POSTE DU SCIENTIFIQUE ACCUEILLI => PRE-DOCTORANT (MASTER OU EQUIVALENT)	
RAPPEL DU CODE PROJET : 1503-011	
Nom	Gonella

Prénom	Gabriel	
Genre	F ☐ou M X	
Nationalité	Française	
Adresse mail personnelle	gabriel.gonella@agroparistech.fr	
Etablissement d'inscription en master ou équivalent	AgroParisTech	Pays : France
Date(s) de début de séjour	01/03/2019	
Date(s) de fin de séjour	20/06/2019	
Institution d'accueil	UFPA	
Unité d'accueil	INEAF	
Nature des activités au cours de l'accueil	Travail de terrain	
Salaire financé par AF ?	Oui X ou Non ☐ (sur le projet Stradiv)	