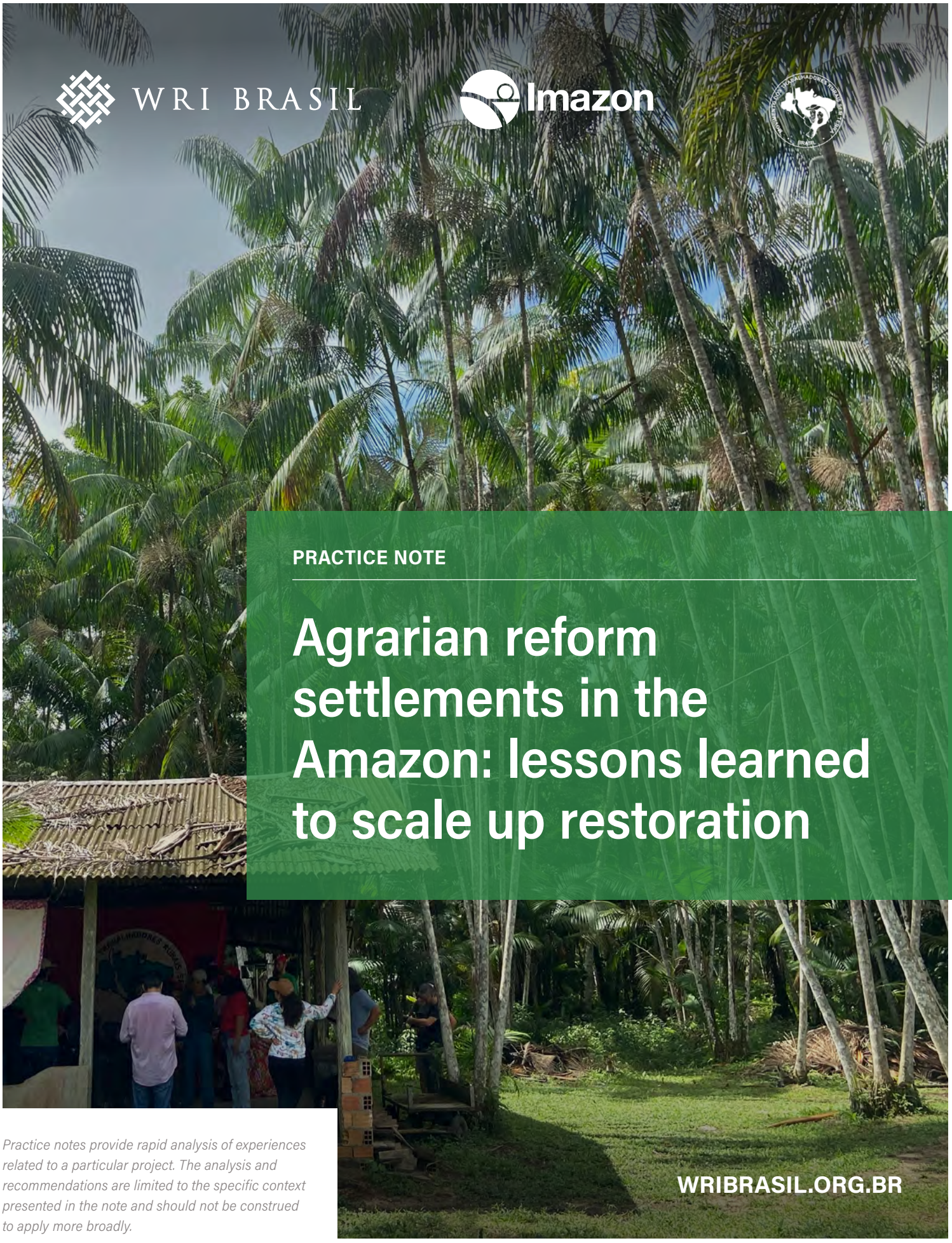

PRACTICE NOTE

# Agrarian reform settlements in the Amazon: lessons learned to scale up restoration

*Practice notes provide rapid analysis of experiences related to a particular project. The analysis and recommendations are limited to the specific context presented in the note and should not be construed to apply more broadly.*

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# HIGHLIGHTS

- The Amazon plays a key role in the restoration scenario, with great potential for natural regeneration.
- Agrarian reform settlements show favorable conditions to drive restoration through techniques such as Assisted Natural Regeneration (ANR), as they encompass 15% of the areas covered by secondary vegetation in the biome.
- This publication describes the planning, participatory knowledge building and implementation stages of restoration arrangements involving ANR and Agroforestry Systems (AFS) in five settlements in the state of Pará.
- The integration of social, environmental and economic benefits and the strengthening of local organizations were important drivers of community engagement and adherence.
- The accumulation of technical knowledge, combined with participatory planning, allowed for the structuring of an approach that is adjustable to the specificities of each settlement, enabling interventions with greater potential for autonomy and continuity.
- Experience has shown that agrarian reform settlements are strategic to scale up restoration, although the restoration process requires adaptation to the specific historical, ecological, sociocultural and organizational context of each settlement.
- In addition to local leaders and community organization, access to technical and material resources was essential to enable implementation, reiterating the importance of projects and policies that facilitate this access for small farmers in agrarian reform settlements.

# Executive summary

## Context

**Assisted Natural Regeneration (ANR) is a set of practices aimed at improving and accelerating the recovery of ecosystems** (Chazdon et al., 2023). To this end, techniques are employed to remove or reduce barriers to natural regeneration with minimal human intervention, such as the installation of fences or enrichment planting (Shono et al., 2020), positioning ANR as a promising solution for landscape and forest restoration at scale, especially in view of its low implementation cost.

**Agrarian reform settlements, with significant presence in the Amazon, emerge as key components of restoration efforts in the region, both in terms of challenges faced and potential solution.** These settlements concentrate about 15% of secondary vegetation areas mapped in the Amazon (Pinto et al., 2021; Guimarães et al., 2025), which highlights the strategic potential of these territories to boost natural regeneration through practices such as ANR.

**To ensure the success of restoration initiatives that provide lasting benefits for both people and nature, the restoration process must incorporate social and economic aspects, with a participatory approach that addresses local motivations** (Tedesco et al., 2023). With this focus, a partnership has been established between the project Promoting and Implementing Assisted Natural Regeneration in the States of Mato Grosso and Pará (*Promovendo e Implementando a Regeneração Natural Assistida no Mato Grosso e Pará)* and the Landless Workers' Movement (*Movimento dos Trabalhadores sem Terra - MST*), aiming to promote forest restoration in agrarian reform settlements. The project – jointly carried out by WRI Brasil, Instituto do Homem e Meio Ambiente da Amazônia (Imazon) and Instituto Centro de Vida (ICV), with support from Norway's International Climate and Forest Initiative (NICFI) – aims to restore degraded forests in the Brazilian Amazon through the implementation of ANR in selected municipalities in these states. Additionally, MST is already committed to planting 100 million trees by 2030 and strengthening the production of healthy food in agrarian reform settlements and camps in Brazil, as established by the movement's National Plan to Plant Trees, Produce Healthy Food (*Plano Nacional Plantar Árvores, Produzir Alimentos Saudáveis*), launched in 2020.

**With common objectives, the partnership is focused on promoting restoration in five settlements in the state of Pará (Figure ES1), adopting two approaches based on the specific conditions of each territory: Assisted Natural Regeneration (ANR) and Agroforestry Systems (AFS[1]).** These approaches, even when applied in different contexts, can complement each other in the promotion of social, economic and environmental benefits. The settlements already included several AFS areas before the beginning of the project, while natural regeneration (NR) areas, although numerous, lacked

Figure ES1 | **Location of the five settlements involved in the project**


*Source:* created by the authors.

systematic ANR actions, such as enrichment with native species, protection against external interference and management aimed at accelerating ecological succession. Thus, the settlements showed potential for expansion of productive agroforestry arrangements and dissemination of ANR, enhancing these areas with technical and material contributions — such as training, inputs and infrastructure (fences, nurseries, etc.) — generated by the project. The partnership prioritized the adoption of a participatory approach that promoted an efficient and sustained restoration process, incorporating local objectives and motivations and integrating national or subnational restoration goals with benefits for local actors.

## About this Practice Note

**This Practice Note describes the three steps undertaken under this partnership — planning, participatory knowledge building and implementation.** It also presents the key success factors for restoration identified throughout the process, as well as lessons learned about the implementation process of the AFS-ANR approach. The initiative involved five agrarian reform settlements located in the state of Pará, in the municipalities of Belém, Santa Bárbara do Pará and Castanhal, in the Belém Metropolitan Mesoregion, and in the municipality of Irituia, in the Northeast Pará Mesoregion**.** The intention is to inspire other settlements and actors engaged in the restoration of landscapes and forests, contributing to the construction of viable paths adapted to the Amazon reality.

Throughout this publication, the term *AFS-ANR approach* is used to refer to the joint experience of implementing these two strategies in the five settlements studied, regardless of whether both have been applied in an integrated manner in the same area.

The results reflect practical experiences, challenges faced, and solutions built collectively in the selected settlements, thus reinforcing the importance of proposing restoration models that consider the social, economic, and environmental dynamics of each agrarian reform territory in the Amazon.

## Implementation of the AFS-ANR approach

**Following data collection and systematization, the information was organized into three stages of implementation of the AFS-ANR approach in the five settlements: (i) restoration planning; (ii) participatory construction of knowledge on ANR and AFS and (iii) implementation of ANR and AFS areas.**

Data collection took place through participatory workshops with farmers, developed in accordance with the Pedagogy of Alternation[2], including technical visits, community meetings and practical activities, such as participatory mapping, field training and implementation of local structures (such as nurseries and AFS demonstration areas), in addition to the enrichment of AFS and ANR areas already existing in the territories.

In the planning stage, working in collaboration, the project's technical team and community members developed a supervised classification model to identify ANR and AFS areas within the settlements. For this purpose, a georeferenced database with land use and cover maps was created for each settlement. This material was subsequently validated through a field survey, conducted by a collective of young community members trained to collect georeferenced points with the support of drones.

The ANR and AFS knowledge construction stage was carried out through ten 3-day workshops held in two cycles. The first cycle addressed theoretical aspects, while the second discussed the construction of agroforestry arrangements and included a practical AFS implementation activity. The workshop program was built jointly with the settlers, which ensured the inclusion of their knowledge, experiences and demands. Easy access to the training spaces and adaptation to the families' daily activities were important to ensure participants' adherence. By understanding the principles of the ANR and AFS approaches, families were able to adapt them to their traditional cultivation practices, strengthening local ownership of restoration strategies. Following this stage, 147 families were engaged in the project.

The implementation stage oversaw the restructuring of five nurseries. The inclusion of these nurseries in the project, ensuring the supply of inputs to expand production, and the participation of farming families, were strategic contributions for the implementation of AFS and ANR. The identification of potential points for seed collection in the planning stage, as well as the work of an organized association or cooperative that legally represented the group and mediated access to financial resources, were essential factors that contributed to this stage. The project also provided in-depth training for nursery workers. The families involved in the project participated in the nurseries' activities through joint efforts, contributing to the production of 88,186 forest and fruit seedlings in the five settlements over a period of nine months.

A visit to the plots of 120 participating families, carried out 2 years after the beginning of the partnership, identified 114 AFS areas (253 hectares) and 62 ANR areas (99 hectares) supported by the project. Enrichment techniques were applied in these areas, contributing to the maintenance and expansion of restored areas. The extreme and atypical drought that occurred during the project hindered the implementation of new AFS and ANR areas, leading to a focus on the maintenance and enrichment of existing areas. The settlements adopted different strategies in the establishment of ANR areas, influenced by their territorial characteristics, including the distribution and size of plots and strategic areas, such as springs and water bodies.

## Key factors in the AFS-ANR approach

**The systematization of key factors was based on the Diagnostic Framework developed by Hanson et al. (2015), which proposes an analysis under three major themes: (i) Motivate – investigates what drives people to get involved in restoration; (ii) Facilitate – refers to the conditions of surrounding areas, enabling or hindering restoration (iii) Implement – refers to the practical resources required for the execution of actions.**

Motivational factors for restoration include social, economic and environmental aspects and awareness of them, all of which were discussed in the workshops and participatory processes carried out in the planning stage. Restoration actions strengthen MST's culture and commitments, increase the commercialization of products resulting from the expansion of productive areas, and promote improvement in soil quality, protection of water resources and increased biodiversity, especially in settlements with a history of degradation.

Enabling conditions include social, market, ecological and political aspects. Social mobilization and community participation in the project's stages engaged people in the process and strengthened the organizational arrangements used to execute the actions, including the nurseries, which also played an important role in the supply of seedlings and inputs. Trade and value chain structures and the alignment of different policy guidelines committed to achieving restoration goals – such as the National Plan for Native Vegetation Recovery (Planaveg), the Native Vegetation Recovery Plan of the State of Pará (PRVN-PA) and MST's National Plan to Plant Trees and Produce Healthy Food – were also identified as enablers of restoration in the context of the partnership. Different ecological conditions in the settlements (greater or lesser availability of water, forest fragments and soil degradation) enable or hinder different restoration practices.

The factors that influence the implementation of restoration include the presence of committed local leaders, access to material, financial and technical resources and dissemination of results, publicly recognizing the efforts of the communities and sharing lessons learned with other territories.

## Lessons learned

**ANR proved to be a flexible technique that can be adapted to the settlements' different realities and contexts. Participatory processes at all stages strengthened community autonomy**, with people playing a leading role in the planning and monitoring of areas undergoing restoration.

The workshops played a key role in knowledge building on ANR and AFS and community engagement. The application of the Pedagogy of Alternation, integrating theory and practice, generated benefits such as coordination of the families' daily routine with training activities, exchange of knowledge between technicians and the community, continuous adaptation of the methodology and alignment with the reality and dynamics of each settlement. Active listening in all processes was also crucial to adjust the approach and ensure greater effectiveness in execution and community engagement.

The strengthening of community movements, combined with local capacity building at all stages of the process, proved to be a promising path to ensure the continuity of restoration in the territories. The participation of young people in the planning stage showed that activities involving technological tools can be used strategically to engage this portion of the settlements' population in restoration initiatives.

The experience revealed climate adaptation challenges, as most of the plots suffered significant seedling losses due to the intense drought observed in recent years in the Amazon. Thus, future efforts should include monitoring of ecological aspects, and new projects should consider water availability to ensure the feasibility and sustainability of restoration processes.

The project has shown that, while the restoration process must be adapted to each agrarian reform settlement's historical, ecological, sociocultural and organizational context, these territories offer strategic opportunities for scaling up restoration, especially when pre-existing community goals, community engagement and technical and material contributions are integrated. The accumulation of technical knowledge, combined with participatory planning, allowed for the structuring of an approach that is adjustable to the specificities of each settlement, enabling interventions with greater potential for autonomy and continuity.

## Conclusions and recommendations

**The lessons learned from this experience reinforce the idea that restoration in agrarian reform settlements in the Amazon should be understood as a social and ecological process, in which collective mobilization, knowledge acquired through dialogue and local adaptation are as important as technical aspects.** Accordingly, the following recommendations are provided to inform future initiatives:

- Strengthen local social organizations to support the implementation and continuity of restoration actions;
- Adapt methodologies, such as the AFS-ANR approach, to the context of each settlement;
- Integrate social, environmental and economic benefits to strengthen local engagement and outcomes over time;
- Develop participatory training processes to empower local leaders on restoration and enable greater integration with pre-existing community agendas;
- Create collectives to monitor areas, enhancing community involvement in the actions.

Considering the potential for large-scale restoration in the Amazon and broader ANR adoption, the alignment between a pre-existing MST plan, community engagement and technical and material contributions proved to be a powerful path to promote the adoption of techniques with local legitimacy.

Sustaining this initiative will require additional efforts to expand access to markets, attract financial resources and develop mechanisms that enable the advancement and continuity of actions over time. Therefore, monitoring the success of this initiative and understanding the factors that contributed to the continuity of the approach is essential to strengthen restoration in the long term, in environmental, social and economic terms.

Finally, this case contributed to the growing experience in the implementation of restoration practices in Brazil, reinforcing that agrarian reform settlements are part of this equation – especially in the Amazon, where they encompass 15% of the areas covered by secondary vegetation mapped in this biome, with high potential for natural regeneration.

# Introduction

Landscape and forest restoration is a key Nature-Based Solution (NBS) to address the climate and biodiversity crises. Several public policies and agreements establish goals to promote restoration and reduce the emission of greenhouse gases (GHGs), such as the Paris Agreement, the principles of Nationally Determined Contributions (NDCs), the Bonn Challenge, and the UN Decade on Ecosystem Restoration by 2030 (Messinger, 2021; UNFCCC, 2020; UN, 2022). In Brazil, the National Native Vegetation Recovery Plan (Planaveg) is a prominent policy instrument. In addition to the goal of restoring 12 million hectares of forests by 2030, it includes provisions to scale up restoration, such as governance structures, financing instruments and innovative monitoring systems (Brazil, 2024).

Different strategies can be considered for forest restoration, depending on the level of soil degradation, land use history, objectives, distance and conservation status of nearby forest areas, and available financial resources (Pinto et al., 2021; Alves et al., 2022). Innovative, economically viable methods that provide large-scale forest benefits are urgently needed to achieve global restoration and climate goals (Wilson et al., 2022). In this sense, Assisted Natural Regeneration (ANR) is an important set of practices with the potential to promote large-scale forest landscape restoration at lower costs compared to alternative methods (Chazdon; Guariguata, 2016; Shono et al., 2020).

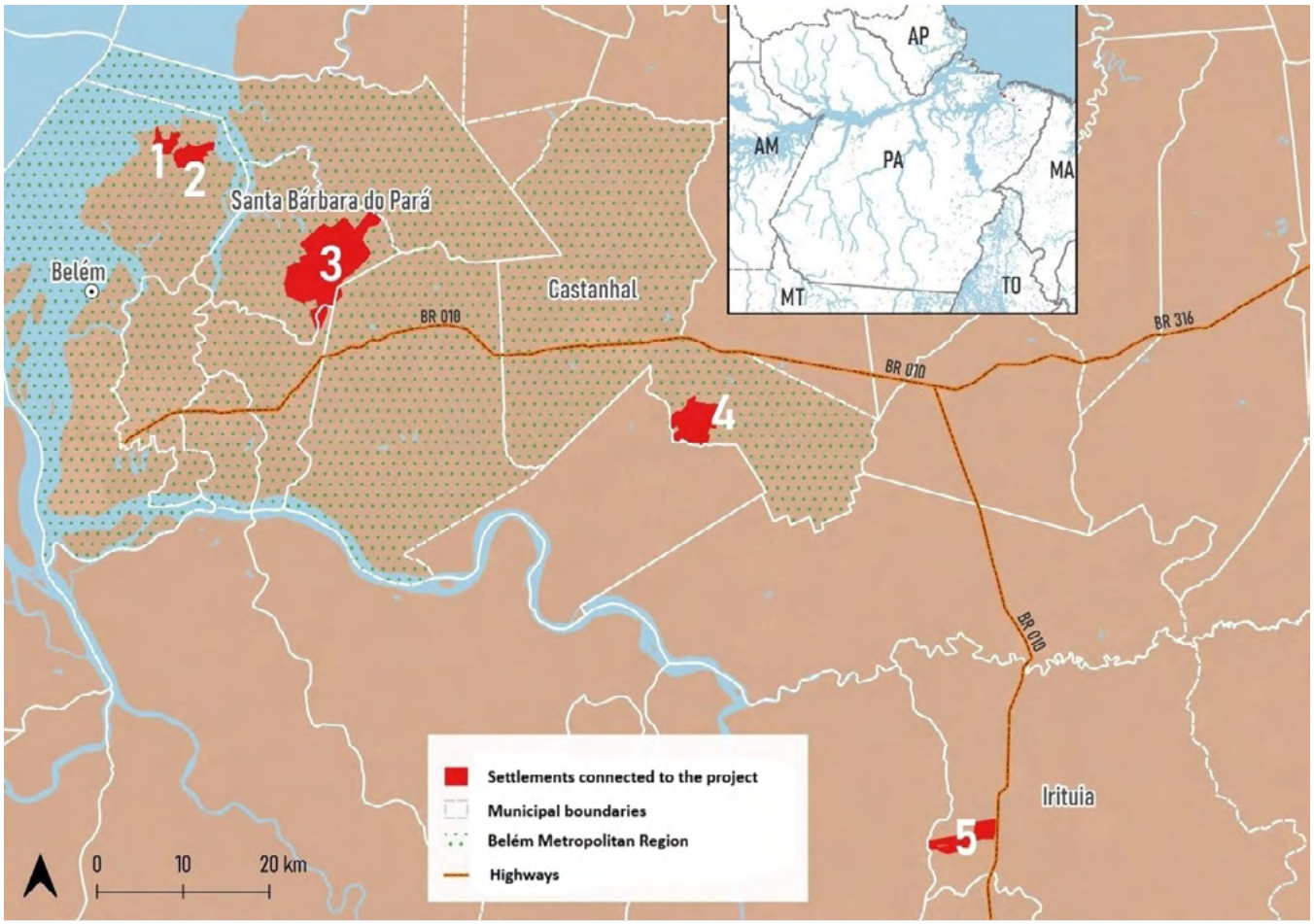
Rather than replacing them, ANR accelerates natural successional processes by removing or reducing barriers to natural regeneration with minimal human intervention, such as fencing or enrichment planting (Shono et al., 2020). Its success is linked to several factors, such as each landscape's natural regeneration potential, land tenure context and community engagement to support protection, monitoring and integration with local forest product value chains (Alves et al., 2022). Therefore, restoration planning and implementation should be approached as a process that incorporates not only ecological concerns but also social and economic aspects that ensure equity and participation to promote broader transformation (Tedesco et al., 2023).

Agrarian reform settlements play an important role in restoration in the Amazon, with a strong presence in the region and accounting for 15% of the secondary vegetation areas mapped in the biome (Pinto et al., 2021; Guimarães et al., 2025). Additionally, considering the importance of social engagement for restoration initiatives and their potential generation of socioeconomic benefits for local communities, the Landless Workers' Movement (MST) was identified as a relevant partner for the implementation of restoration actions in the Amazon, under the scope of the project "Promoting and Implementing Assisted Natural Regeneration in Mato Grosso and Pará".

Supported by Norway's International Climate and Forest Initiative (NICFI)[3] and implemented by WRI Brasil in partnership with Instituto do Homem e Meio Ambiente da Amazônia (Imazon) and Instituto Centro de Vida (ICV), the project aimed to promote forest restoration in degraded areas in the Brazilian Amazon, focusing on the development and implementation of ANR techniques and approaches in municipalities in the states of Pará and Mato Grosso. MST, on the other hand, is already committed to planting 100 million trees by 2030 and producing healthy food in agrarian reform settlements and camps in Brazil, under the movement's national plan entitled "Plant Trees, Produce Healthy Food" (MST, 2022).

Thus, a partnership was established with five agrarian reform settlements, located in the Metropolitan Belém and Northeast Pará mesoregions in the state of Pará, and distributed across the municipalities of Castanhal, Santa Bárbara do Pará, Ilha de Mosqueiro and Irituia (Figure 1). Together, these five settlements cover an area of approximately 11,000 hectares.

Figure 1 | **Location of the five settlements in the state of Pará**




*Notes:* 1 –Mártires de Abril Settlement; 2 –Paulo Fonteles Settlement; 3 –Abril Vermelho Settlement; 4 –João Batista II Settlement; 5 –Luís Carlos Prestes Settlement.
*Source:* created by the authors.

Two restoration approaches were adopted based on the specific conditions of each territory: ANR and Agroforestry Systems (AFS). Although applied in different contexts, they proved to be complementary in terms of the social, economic and environmental benefits produced. Throughout this publication, the term "AFS-ANR approach" is used to refer to the joint experience of implementing these two strategies in the five settlements located in the Belém metropolitan region (PA), even though they were not applied in an integrated manner within the same area.

This publication describes the three stages of restoration – planning, participatory knowledge building and implementation – carried out under the partnership with five MST settlements, and aims to answer the following questions:

- How were the different stages of restoration – planning, participatory knowledge building and implementation – carried out, and what was stakeholders' participation in the process?
- What were the key success factors identified in the AFS-ANR approach in each of the five rural settlements involved in the project?
- What are the lessons learned, so far, from the implementation of this AFS-ANR initiative in terms of stakeholder engagement in restoration efforts and the potential of AFS-ANR in agrarian reform settlements to contribute to the expansion of restoration in the Amazon?

# Context

## The relevance of forest landscape restoration in the Amazon: natural regeneration and rural settlements

The Amazon is the largest biome in Brazil, occupying almost 60% of the country's territory and spanning nine states. It is home to the largest and most biodiverse forest in the world, playing a fundamental role in climate regulation (Nobre et al., 2023). According to MapBiomas data, the Amazon lost approximately 55 million hectares of native vegetation between 1985 and 2023, corresponding to about 14% of its original cover. The main causes of this scenario include illegal deforestation, fires and forest degradation, a process in which the forest retains part of its structure but loses ecological functionality[4]. These factors also contribute significantly to the country's $CO_2$ emissions (Alliance for Restoration in the Amazon, 2020).

The forest's regeneration potential is directly impacted by these various factors, reinforcing the need for restoration strategies. In this context, the Amazon plays a fundamental role, encompassing both degraded areas, which still show remaining vegetation and recovery potential, and deforested areas, where natural regeneration can be promoted (Nunes et al., 2020; Pinto et al., 2021; Barlow et al., 2023; Alliance for Restoration in the Amazon, 2020).

Agrarian reform settlements, with a significant presence in the Amazon, emerge as key components of restoration efforts in the region, both in terms of challenges faced and potential solution. Guimarães and colleagues (2025) identified that approximately 7.2 million hectares of secondary vegetation, at least 6 years old in 2019, were distributed across the nine Amazon states, and that 15% of this total is located within rural settlements. Thus, these territories show potential for driving restoration in the Brazilian Amazon through techniques such as ANR, as secondary vegetation areas reflect ecological succession processes after disturbances, which can be strengthened by adopting this approach (Chazdon, 2014). Additionally, studies show that young forest ecosystems tend to capture more carbon per square meter than mature ones due to the higher ratio of photosynthesis to respiration in growing trees, reinforcing the importance of these areas for climate change mitigation strategies (Albert et al., 2018; Green et al., 2020).

Currently, there are 2,599 settlements in the Legal Amazon, representing 45% of the total area occupied by rural settlements in the country, totaling approximately 34.7 million hectares and home to approximately 400,000 families (Mourão et al., 2024). Although rural settlements represent an essential part of Brazil's strategy to democratize access to land and promote food production and social justice, settled populations and farming families in the Amazon region are among the most vulnerable in the country (Souza et al., 2022). This vulnerability is shown, among other aspects, by low access to public policies such as rural credit. There are profound inequalities in access to credit among family farmers in the country, with the North region accounting for the lowest per capita financing rates, which compromises these communities' productive capacity and socioeconomic resilience (Souza; Alburquerque, 2023). Furthermore, the climate impacts resulting from deforestation and forest degradation threaten crops and families' food security, creating a challenging scenario for the sustainability of settlements (Mourão et al., 2024; Souza et al., 2022).

The food security and sovereignty of these families directly depend on their ability to reconcile agricultural production with forest conservation (Silva et al., 2024). Integrated arrangements, such as AFS and ANR, have the potential to restore degraded areas, increase productive diversity and ensure access to healthy food, revitalizing springs and enhancing local biodiversity. However, the scarcity of expert technical assistance and lack

of infrastructure limit the large-scale adoption of these models, perpetuating dependence on monocultures that are more vulnerable to climate crises (Gonçalves; Lima, 2022). Finally, production for self-consumption is an important strategy to enhance food security, but faces challenges such as pressure for commodity production and fragmented public policies (Loiola; Maciel, 2015).

Thus, reflecting on the role of agrarian reform in the restoration of the Amazon involves acknowledging both the complexity of the Amazon territory as a non-homogeneous region (Josse et al., 2021) and the peculiarities of rural settlements, with all their differences in land use, agricultural practices, external pressures and forest cover (Souza et al., 2022).

## The need for social engagement for successful large-scale restoration

While most restoration projects have focused on meeting ecological goals, several studies point to the essential role played by social dynamics in restoration and conservation outcomes (Löfqvist et al., 2023; Fischer et al., 2021). Incorporating the complex social dynamics of the different sectors, practices and actors related to restoration can enhance social and ecological impacts (Tedesco et al., 2023). Thus, restoration projects not only influence but also depend on transformations in socioecological systems, which call for transformative changes and new approaches to planning, implementing and monitoring restoration initiatives. (Tedesco et al., 2023).

Despite its lower costs, ANR is a technique that requires community engagement and investment in social capital to ensure its success, as it often demands intense physical labor in the maintenance, management and conservation of regenerating areas (Alves et al., 2022; Chazdon, 2016). Alves et al. (2022) investigated successful ANR cases and showed that local community involvement is a relevant factor in the successful maintenance and permanence of these areas.

Community organizations and smallholders are considered potential actors for ANR expansion because they favor the use of lands with species diversity and are highly capable of adapting to biodiverse planting (Soriaga, 2011). Another notable characteristic of these groups is their strong ability to disseminate and exchange technical knowledge among themselves, enhancing the capillarity of the ANR approach in convergence with other established techniques. Additionally, the strength of local community mobilization and the level of trust in the institution proposing the restoration model are highlighted as relevant factors in the effort to engage these communities in ANR activities (Soriaga, 2011).

In this sense, despite the importance of global goals to stimulate restoration projects, identifying local motivations for engagement in these initiatives through inclusive decision-making processes is essential to ensure the sustainability of results over time (Tedesco et al., 2023).

## Connection between MST's "Plant Trees, Produce Healthy Food" national plan and the project

The MST is a peasant movement that advocates for agrarian reform, social justice and the production of healthy food. It also exposes violence in rural areas and supports the development of public policies for family farming. It emerged in Brazil with the aim of occupying unproductive or underutilized lands

that do not fulfill their social function – that is, that do not meet the criteria established by the Federal Constitution, such as proper land use, rational use of natural resources and environmental protection. According to Article 184 of the 1988 Constitution, the government has the right to expropriate these lands for agrarian reform purposes, ensuring their productive use by rural workers (Brazil, 1988; Caldar, 2001).

Formally created in 1984, the MST expanded its activities throughout the country, establishing settlements, cooperatives and schools, and producing food in occupied areas (Caldar, 2001). Currently present in 24 Brazilian states, the movement brings together approximately 450,000 peasant families, promoting sustainable production methods based on agroecology. Its mission includes advocating for a new rural development model based on solidarity and social, environmental and economic justice (MST, 2024).

Playing an essential role in settlers' education, the MST broadly promotes agendas focused on agroecology and environmental protection. Training activities on agroecology[5] are provided in different territories and adapt production practices to local realities, transforming peasant agriculture into an ally of forest restoration efforts. Among these practices, polyculture farming, for example, enhances biodiversity and promotes sustainable production systems.

In 2020, MST launched its "Plant Trees, Produce Healthy Food" national plan, committing to plant 100 million trees by 2030 and strengthen the production of healthy food in agrarian reform settlements and encampments in Brazil. In this context, the combination of Assisted Natural Regeneration (ANR) with the implementation of Agroforestry Systems (AFS) constitutes an integrated restoration strategy, reconciling social, economic and environmental perspectives. The AFS-ANR arrangement emerges as a restoration solution capable of creating diverse landscape mosaics and incorporating the knowledge and objectives of all actors involved.

MST has a historical and consolidated presence in the state of Pará, and plays a central role in coordinating state initiatives that integrate social justice and environmental preservation (MST, 2010). Thus, the established partnership strengthens forest restoration efforts while promoting the production of healthy food, aligning environmental sustainability and social development.

## Context of the selected agrarian reform settlements

The project's five partner settlements have specific historical contexts, political situations and forms of social organization, with distinct challenges and potential. Therefore, some local specificities must be considered when analyzing the project's results.

- **João Batista II Settlement**: located in Castanhal, approximately 96 km from the state capital, Belém, the João Batista II settlement was established in 1998 and occupies an area of 1,762 hectares. With a history of livestock production, this area was initially home to 800 families, but after the settlement's consolidation and demarcation of available land, only 157 remained. Land use and occupation primarily include pasture, secondary forest, AFS, Natural Regeneration, and infrastructure such as houses, schools, churches and public health centers. The settlement is notable for the natural occurrence of *murici* (*Byrsonima crassifolia*) and cashew (*Anacardium occidentale*), species adapted to the region and resilient to extreme weather events. These species are frequently incorporated into AFS or present in ANR areas, representing an important source of income for families.
- **Luís Carlos Prestes Settlement**: the Luís Carlos Prestes settlement covers an area that was occupied in 2007 and officially declared a settlement in the following year by Incra/SR-01 Ordinance No. 94, as of December 30, 2008. Currently, it is home to approximately 47 families and is located in the municipality

of Irituia, approximately 176 km from the capital, in the northeastern region of the state of Pará. Previously, the area was used for livestock farming and consisted solely of degraded pastures. The settlement occupies an area of 1,274 hectares and features diverse land uses, including pasture, secondary forest, AFS, Natural Regeneration and infrastructure (houses, schools, churches and public health centers), similar to other settlements in the region. In addition to climate impacts, the settlement faces conflicts that occasionally lead to fires, negatively affecting ongoing restoration efforts.

- **Mártires de Abril Settlement**: located on Mosqueiro Island, in the municipality of Belém, the Mártires de Abril settlement is 70 km from the city center. The territory's occupation began in 1999, but was only officially recognized as a settlement in 2001 by Incra/SR-01 Ordinance No. 27, dated October 30, 2001. Prior to occupation, the area was dedicated to coconut monoculture, resulting in highly degraded soil with low natural regeneration potential. Currently, the settlement is home to approximately 92 families in an area of 408 hectares. Land use and occupation include pasture, secondary forest, AFS, natural regeneration and infrastructure (houses, schools, churches and public health centers). However, the predominant sandy soil poses challenges to restoration and agricultural production. The settlement is part of the Casulo Project of the National Institute for Colonization and Agrarian Reform (Incra), a decentralized agrarian reform program developed in partnership with the municipal government through the Municipal Secretariat of Economy (Secon). As an agroecological strategy to restore degraded soil, the settlers adopted banana and inga trees as service plants to improve soil fertility, adapting to the territory's adverse conditions.
- **Paulo Fonteles Settlement**: located on Mosqueiro Island, approximately 75 km from downtown Belém. The area was covered by a rubber plantation prior to occupation, with sandy soil and low productivity. The initial occupation occurred on October 6, 2003, and the settlement was officially created by Incra/SR-01/PA Ordinance No. 17 as of July 13, 2006, as published in Diário Oficial da União No. 137 as of June 19, 2006. Currently, the settlement is home to 65 families and encompasses 849 hectares. Land use and occupation include pasture, secondary forest, AFS, Natural Regeneration and infrastructure (houses, schools, churches and public health centers). However, due to low soil fertility, many settlers face difficulties in agricultural production. Species such as *murici* and cashew are used to support the cultivation of *açaí*, enriching the soil with nutrients and strengthening the resilience of restored areas.
- **Abril Vermelho Settlement**: located in the municipality of Santa Bárbara do Pará, approximately 53 km from Belém. The occupation took place on April 16, 2004, in an area previously used for oil palm (*Elaeis guineensis*) monoculture, but considered unproductive. The settlement was officially established in November 2009, including 370 families in a total area of 6,803 hectares. Over the course of 20 years, settlers protected and managed secondary vegetation, enabling ANR in several areas. Currently, the restored areas within the settlement are largely the result of this process.

# Methodology

The five agrarian reform settlements selected by the project were identified by MST's national and state coordinators as promising locations for implementing the planned actions. This assessment considered factors such as geographic proximity between the settlements and prior engagement with agroecology. The WRI Brasil team subsequently assessed the presence of natural regeneration areas in these territories, and the feasibility of AFS-ANR implementation.

The mobilization of settled families began in late 2022 through the project's presentation at community meetings and invitations to participate in training workshops, territorial assessment and participatory mapping activities. These actions were designed to disseminate knowledge on restoration and its application in local contexts, prioritizing participatory methodologies aligned with local realities (Chambers, 2006; Nunes et al., 2021; Ribeiro, 2008; Gonçalves et al., 2024).

These initial activities resulted in the direct involvement of 147 interested families, willing to continue the implementation stages. The families were selected in collaboration with the settlers, based on criteria such as interest, prior experience with agroecological practices, especially AFS and ANR, and prior engagement with other MST training programs.

These criteria aimed to ensure greater engagement and participation in the activities, optimize training and increase implementation effectiveness. They also considered the project's operational capacity, including workshop logistics, technical support and the feasibility of monitoring results over time.

The data collected during project execution were systematized and organized into three main stages, corresponding to the actions that culminated in the implementation of restoration through the AFS-ANR approach in the settlements:

1. **Restoration planning:** this stage involved data collection on the socio-environmental context and conditions enabling the implementation of restoration in the settlements. Participatory mapping activities (Chambers, 2006; Nunes et al., 2021) were carried out, through community meetings and interviews with settlers to gather perceptions about land use, challenges and opportunities for restoration. Additionally, after training provided by the WRI Brasil and Imazon teams, community members collected geographic points to map and monitor areas undergoing restoration.
2. **Participatory knowledge building on ANR and AFS:** during this stage, six in-person workshops were held in each settlement between March 2023 and January 2024, strengthening knowledge on ANR and AFS and promoting community engagement. WRI Brasil, Imazon and the MST jointly developed a Political-Pedagogical Project for this purpose. Guided by the project, the workshops were based on the Pedagogy of Alternation, a pedagogical approach that integrates theory and practice by alternating learning spaces between the school environment and the communities, thus promoting a continuous exchange of knowledge (Ribeiro, 2008; Gonçalves et al., 2024). An invitation to participate in the workshops was extended to the entire settlement community, encouraging family participation, including women and youth. Workshop programs respected local routines, and were held in the settlements to facilitate logistics for participants. Throughout this stage, the results of the workshops were systematized, allowing the identification of challenges, opportunities and strategies regarding ANR and AFS implementation.

3. **Implementation of ANR and AFS areas:** this stage involved participatory planning, with participants defining the locations for the practical implementation of AFS-ANR on participating families' plots. Participants recorded data on the seedling nurseries' structuring and maintenance processes in each settlement, as well as information on the area, number and diversity of species in the AFS and ANR areas implemented on the families' plots two years after the beginning of the project. This information was documented in monitoring forms and photographic records.

Participatory practices at each project stage aimed to encourage stakeholder engagement, as described above. This engagement was assessed based on the results of engagement and mobilization actions. The factors considered in the assessment included participation in training sessions, organization of collectives for joint work (seedling production and data collection), implementation of AFS and ANR areas on families' plots and local leaders' efforts towards community mobilization.

The main success factors associated with the AFS-ANR approach in the settlements were assessed, considering a context of joint implementation of AFS and ANR, even though these two strategies were not applied in an integrated manner in the same area. This analysis was based on systematized data produced throughout the three implementation stages, including the settlements' socio-environmental context, perceptions of settled families, records of implemented production arrangements, georeferenced location of the areas, workshop results and technical monitoring records. This analysis was guided by the Restoration Diagnostic (Hanson et al., 2015), a methodology that systematizes the key success factors for restoration, grouped into three fundamental dimensions: Motivate, Facilitate and Implement. This analytical framework allowed for systematic interpretation of the data and identification of the factors that contribute to the effectiveness of restoration implementation in each settlement.

The study also systematized the main lessons learned throughout the implementation of the AFS-ANR approach, describing how agrarian reform settlements can strategically contribute to the expansion of restoration in the Amazon. These lessons were drawn from the project's practical experience, based on the perceptions of participating families, the technical team's observations, and data collected during the three implementation stages. Reflections were organized based on the challenges faced and the opportunities identified during the process, and adapted to the context of the partnership and the region's socio-environmental specificities.

# Implementing assisted natural regeneration and agroforestry systems in agrarian reform settlements

Before the project's beginning, the partner settlements already had AFS areas implemented on several lots. This is partly due to the fact that this production model is a political and technical priority for MST. However, potential was identified for expanding productive agroforestry arrangements, which depended on technical and material support that the project could provide, including training, inputs and infrastructure (fences, nurseries, etc.

Numerous natural regeneration (NR) areas also existed in the settlements, but lacked the systematic actions involved in ANR, such as enrichment with native species, protection from external interference and management aimed at accelerating ecological succession. Before the project, the concept and practice of ANR were little known among families and were not applied in these areas. The initiative also worked to disseminate this practice and enhance these areas, increasing their effectiveness.

In this context, once the partnership with MST was established, mobilization and technical planning activities began in the five settlements. These included the study of agroforestry arrangements, technical planning for workshops, forecasting the number of participants by territory and analysis of each settlement's local characteristics. The specific conditions for the performance of activities in each area (locations, mobilizing leaders, material conditions and potential areas for AFS and ANR interventions) were assessed, as well as the workshops' didactic structure, considering each settlement's social and ecological aspects.

The implementation of restoration actions considered the specificities of each settlement, including the history of land use and occupation, ecological characteristics and social organization processes that influence the productive profile and adherence to restoration initiatives. Although participation occurred at the family level, the collective context was key for activity engagement and dynamics, with community organization enabling the implementation of actions, with support from MST.

The 147 families involved belonged to the five settlements, as shown in Table 1. The difference in numbers in each settlement reflects the number of families settled in each location and the criteria used in the selection, as described in the methodology.

Table 1 | **Number of families participating in the project by settlement**

| SETTLEMENT | NUMBER OF PARTICIPATING FAMILIES |
|---|---|
| João Batista II | 24 |
| Luís Carlos Prestes | 10 |
| Mártires de Abril | 15 |
| Paulo Fonteles | 24 |
| Abril Vermelho | 74 |
| **Total** | **147** |

*Source:* created by the authors.

The process was structured in three main stages, carried out in the period from 2022 to 2024, as described below.

## Restoration planning

This stage aimed to promote the exchange of knowledge on the territories with the communities, and foster community involvement in the planning process. Thus, incorporating participatory processes into the various planning activities leveraged the potential of mapping tools, strengthening ties with the territories and reaffirming the role of community organization in restoration initiatives.

## Participatory mappings

In October 2022, a workshop was held by WRI Brasil's and Imazon's technical teams, where they proposed a participatory mapping activity, validated by the attending families. The activity aimed to provide a space for participants to recognize the territory and express their perceptions of the landscape in which they live. The activity was based on methodologies that value local knowledge and promote the collective construction of spatial information (Chambers, 2006; Nunes et al., 2021). This type of approach has been widely used in territorial governance contexts, especially in restoration initiatives and community management of natural resources, as it strengthens the connection between communities and their territories and encourages autonomous decision-making regarding land use (Chambers, 2006; Souto, 2022).

The workshop took place in the Abril Vermelho settlement and brought together representatives from the other territories, except for Paulo Fonteles settlement, which was unable to send representatives due to internal community issues.

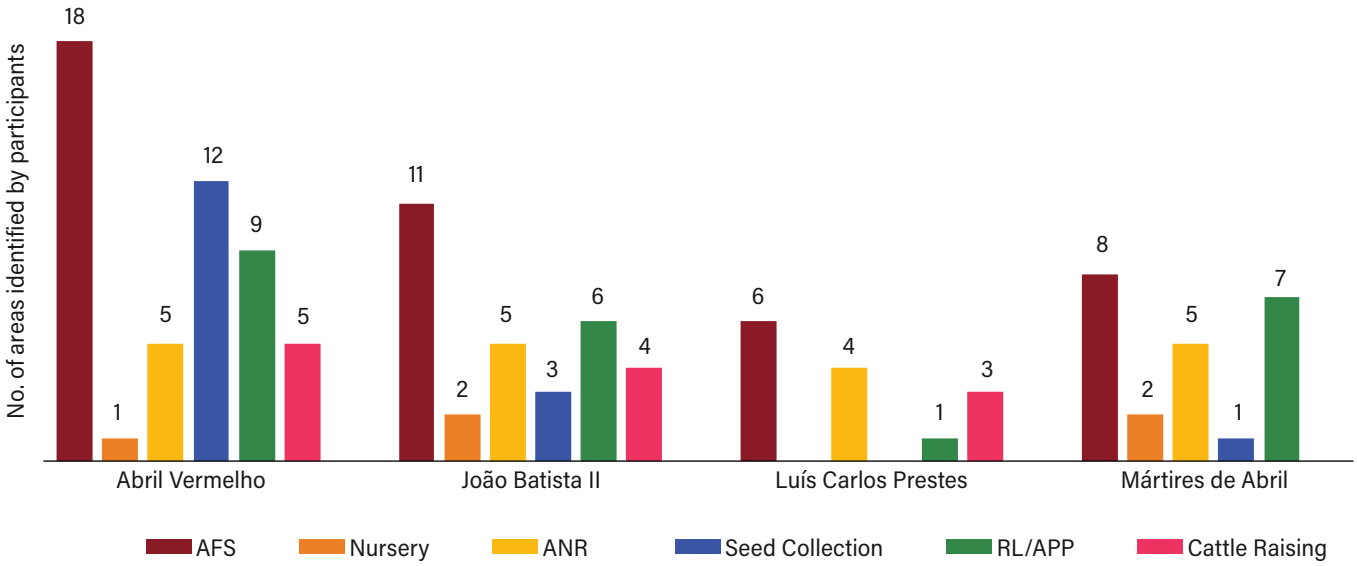
During the activity, participants were organized by settlement and used printed maps to identify and demarcate different areas, such as assisted natural regeneration, AFS, nurseries, seed collection, Legal Reserve (RL, in the Portuguese acronym), Permanent Preservation Areas (APP, in the Portuguese acronym) and other land uses (Figure 2). The results obtained for each settlement are shown in Figure 3 and represent the areas identified by participants under each classification. However, it is important to note that the numbers presented do not accurately reflect the number of areas existing in the settlements, as the activity depended on territory knowledge, the number of participants and each group's cartographic skills. Furthermore, participants did not identify or demarcate areas where AFS, ANR or seed collection overlapped RL and APP areas.

Figure 2 | **Participatory mapping carried out in the Abril Vermelho settlement**


*Notes:* A. Result of the identification of settlement areas by participating families. B. Color code used to identify the areas. Breakdown by land use: AFS; Nursery; ANR; Seeds; RL/APP; Cattle raising.

*Source:* WRI, 2023. Institutional archive.

Figure 3 | **Number of areas identified by use category in the participatory mapping activity carried out with four project settlements**




*Source:* created by the authors.

The participatory mapping exercise allowed the creation of an initial profile for each settlement, in terms of existing areas and enabling conditions for restoration through AFS and ANR. These areas were considered strategic because they were already established in the settlements, facilitating their expansion or improvement and serving as examples for the implementation of new AFS and ANR areas on the plots.

Many participants visualized the entire settlement through cartographic tools for the first time, an experience that broadened their understanding of the territory, sparked reflections on land use and strengthened their sense of belonging. By connecting families' traditional knowledge with broader and more systematic spatial representations, the activity fostered a collective understanding of the space and supported the planning of restoration actions.

The Abril Vermelho settlement stood out, identifying a greater number of AFS, seed collection and Legal Reserve areas, possibly due to its larger territorial extension and greater number of plots compared to the other settlements.

The Luís Carlos Prestes settlement showed a limited number of areas available for seed collection, likely reflecting its history of intensive land use and frequent fires. These variations across territories helped establish an initial profile of areas for restoration implementation efforts.

Importantly, a greater number of AFS areas were identified in all settlements compared to livestock production areas. These results reinforce the opportunity, identified within the project, to concentrate restoration efforts on agrarian reform territories, where a predisposition for productive practices aligned with ecological restoration is already present (MST, 2010).

## Mapping through satellite images

Satellite images were used to map land use and land cover, complementing the participatory mapping exercise and meeting settlers' interest in mapping and quantifying existing AFS areas. This process allowed participants to differentiate AFS and natural regeneration (NR) areas within the settlements, and

generated a georeferenced database with territorial classification maps and their respective quantification in hectares. These maps can be found in Appendix A.

### Field data collection with local training for greater mapping accuracy

Using satellite imagery as starting point, field data collection was carried out to refine the land use and land cover mapping and validate the mapped areas against the territories' realities. Data collection began with the use of geographic location tracking equipment (GPS)[6] by an MST technician and was later optimized with the acquisition of a drone, which allowed for more efficient plot surveys in just a few minutes, increasing mapping accuracy.

Given the challenges of conducting field surveys in all settlements and limited execution time, community participation emerged as an opportunity to build local capacity and autonomy. A youth collective was thus formed in the Abril Vermelho settlement, comprising five men and three women, responsible for collecting georeferenced data. They were already members of a youth collective in the settlement and participated in AFS and ANR training workshops.

The mobilization of young people was strategic: their greater interest and familiarity with technology increased the accuracy of territory mapping and fostered their engagement in the project.

The youth group received training by means of instructional videos developed by WRI Brasil and, together with a local technician, organized a schedule for point collection in the five settlements. Despite the lack of time to form and train youth teams in the five settlements, young residents of each settlement and those interested in the topic followed the activity in their respective territories, alongside the team formed in the Abril Vermelho settlement. The community kept the drone by the end of the activity, enabling them to maintain and expand monitoring activities.

The group also collected AFS and NR points from all five project settlements and a higher number of georeferenced points than initially expected (values detailed in Appendix A). Community engagement was crucial to mapping success, given the settlers' familiarity with the territories. Using the collected points, a supervised classification model was developed based on satellite image segmentation, and NR and AFS areas were identified with the use of Geographic Object-Based Image Analysis (Geobia). This identification methodology can be replicated in other settlements, contributing to the development of a community monitoring protocol.

Thus, the mapping process not only generated vital data for the project, but also strengthened the communities' connection to their territories and encouraged their autonomy in planning and monitoring restoration.

## Participatory knowledge building on ANR and AFS

The ANR and AFS knowledge-building stage aimed to consolidate theoretical and practical knowledge on these approaches and promote community engagement by encouraging collective responsibility towards the territories' conservation. A Political-Pedagogical Project was jointly developed by WRI Brasil, Imazon and MST for this purpose, guiding the workshops according to the Pedagogy of Alternation method. (Ribeiro, 2008).

This approach is characterized by integrating theory and practice, alternating learning spaces between the school environment and the community and thus promoting a continuous exchange of knowledge. Thus, technical knowledge is integrated with local experiences, making learning more relevant and applicable to the daily lives of those involved (Gonçalves et al., 2024).

### Workshop planning and participation

The workshops' program was developed jointly with the settlers, ensuring the inclusion of individual knowledge, experiences and needs. The topics discussed included the relationships between restoration and different forms of land occupation, as well as different ways of relating to the land from agroecological perspectives, including the reconstruction of fair social relations in rural areas and the guarantee of food sovereignty. The meetings contributed to improving organizational, productive and environmental awareness planning.

The workshops were held between March 2023 and January 2024, in two cycles per settlement, totaling six meetings in each location and involving 346 participants across the five settlements (details in Appendix B). Participation was open to the entire community. To foster participation, the workshops took place in the settlements and/or participating families' plots, facilitating access for farmers to the training spaces. This choice sought to overcome the logistical barriers often faced by settlers in training sessions held outside the settlements. Additionally, collective agreements established workshop schedules compatible with family routines and allowed for rescheduling flexibility when necessary, such as in cases of bereavement or scheduling conflicts with MST's national activities, fostering participation.

Participation numbers varied between settlements proportionally to the number of families supported by the project. According to an assessment of the number of participants in each settlement's workshops relative to the number of families supported, the relative participation rate ranged from 2.2 (Luís Carlos Prestes settlement) to 2.4 (Mártires de Abril settlement), demonstrating a similar result across all five settlements and reflecting the importance of providing easy access to training spaces, as the workshops were held within the territories.

## Workshop implementation and content

The first cycle of workshops, held over three days in each settlement, addressed a series of important topics for the theoretical and practical foundation of ANR principles. The ANR workshops were led primarily by WRI Brasil's and Imazon's technical teams, while MST technicians led those covering AFS principles, including the history of agriculture, bioinputs and soil health. This theoretical content was interspersed with practical activities, always adapted to local circumstances. This cycle achieved 170 participants, 79 women and 91 men, reflecting gender balance and demonstrating the engagement of participating families.

The second cycle of workshops, also three days long, was structured into three phases: theoretical concepts, design of agroforestry arrangements (Figure 4), and practical AFS implementation activities. During this stage, experimental units were implemented in three settlements: one in a school area in the Abril Vermelho settlement and two on individual families' lots in the João Batista II and Luís Carlos Prestes settlements. Implementation was delayed by technical issues in Mártires de Abril and Paulo Fonteles settlements, hindering the practical application of concepts. Approximately 176 people participated in this stage, including 82 women and 94 men.

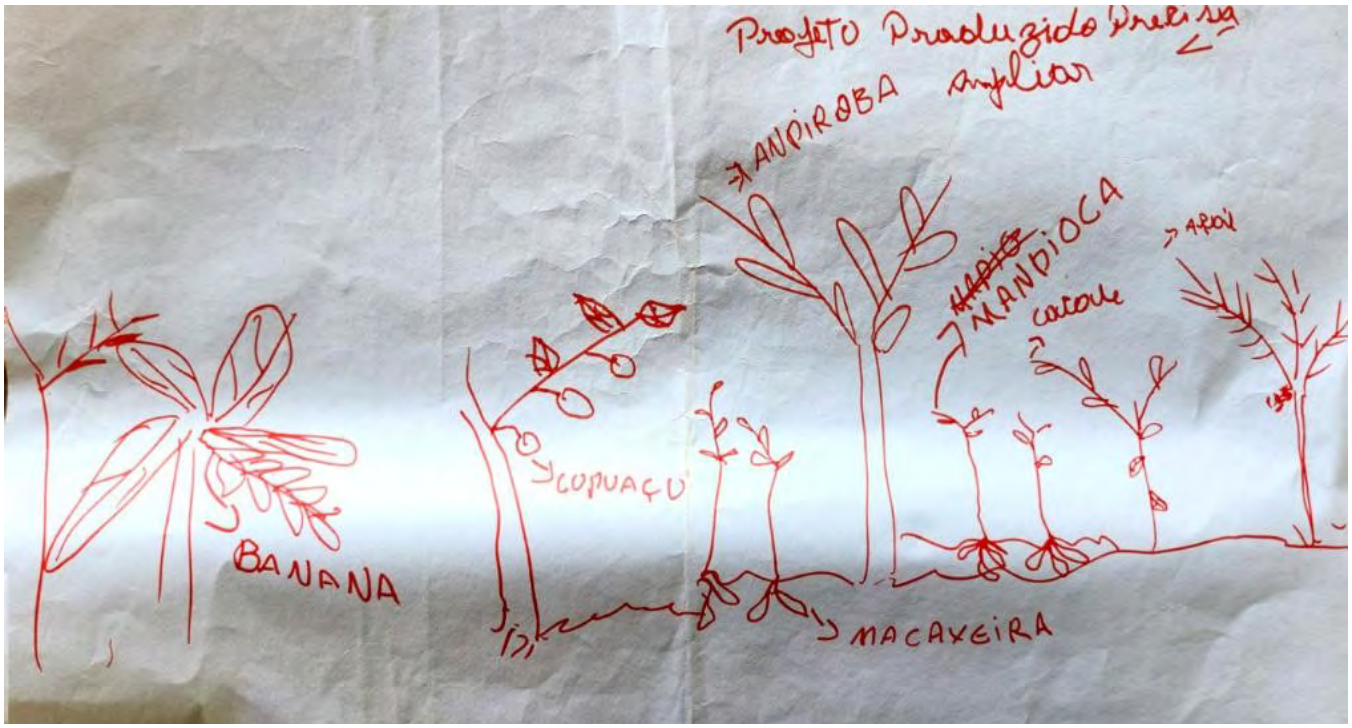
## Development of experimental AFS arrangements

The AFS arrangements were designed considering the specific characteristics of each settlement, such as plot size and configuration, history of land use, existing production and farmers' prior knowledge. Agroforestry principles were incorporated based on these factors, including species diversity and stratification, system sustainability, production autonomy, and forest succession.

The selection of the three areas for AFS implementation was guided by criteria agreed upon by the participants and workshop facilitators, prioritizing areas without the presence of regenerating vegetation (thus avoiding clear-cutting), or areas with a predominance of monoculture, which could benefit from the inclusion of diversity and soil improvement practices through fertilization.

The species and arrangements for these experimental units were analyzed and discussed in advance among MST technicians, considering the climatic aspects of each location and based on the land use experiences of each settlement.

Figure 4 | **Example of AFS arrangement design developed during the workshop, representing the consortia and strata**




*Source:* WRI Brasil, 2023. Institutional archive.

Training activities were thus integrated with implementation practices, aiming to promote voluntary adoption of ANR or AFS practices by families, fostered by the recognition of their environmental, social and economic benefits. Once ANR and AFS principles were understood, the families incorporated them into their traditional cultivation practices, strengthening local ownership of restoration strategies.

## Implementation of ANR and AFS areas

### Restructuring and operation of nurseries

The presence of nurseries in the project and their collaboration with farming families was a central strategy for AFS and ANR implementation in the five settlements involved. Seedling nursery structures were already present in all settlements, acquired through a partnership with Ideflor-Bio, maintained between 2018 and 2020. Under this partnership, Ideflor-Bio provided the structures, inputs and technical training for settlers, primarily in the preparation of compost for planting. When the partnership with WRI Brasil was established, four of these nurseries were inactive, except for the one in the Abril Vermelho settlement. The partnership enabled the restructuring of community nurseries that were deactivated or in need of maintenance, and ensured the supply of inputs to increase production and thorough training for nursery workers.

Six nursery workers were hired to implement this component. The workers were residents of the settlements, and in addition to ensuring seedling production, organized a collective responsible for nursery maintenance and autonomy. The nursery workers attended the project's training sessions, aligning production with the needs and vocations of each settlement, in direct interaction with the families.

Nursery activities included the participation of families involved in the project through monthly or weekly collective work, according to each settlement's internal organization. This involvement was an essential driver of restoration implementation efforts in the territories. In the Luís Carlos Prestes settlement, for example, the shortage of labor for nursery maintenance was resolved by creating a daily payment system for young people who helped with production.

Another important aspect was the identification of potential areas for seed collection, strengthening autonomy in seedling production. Furthermore, the existence of legal representation, through an organized Association or Cooperative, was essential to support the hiring of workers and mediation of financial resources.

The nursery activities included maintenance and repairs to structures, the production of 88,186 forest and fruit seedlings from October 2023 to June 2024 (including the five settlements), delivery of seedlings to families, as well as capacity-building for nursery workers and community involvement, which were essential to the success of the process. These results, along with training provided in the workshops, supported implementation at the family plot scale (Appendix C).

## Implementation, enrichment, expansion and maintenance of ANR and AFS areas

Of the 147 participating families visited by WRI Brasil's technical team two years into the project, data were collected from 120. Of this total, 114 had enriched or implemented AFS areas, and 62 had worked with ANR. This resulted in a total of 253 hectares of AFS and 99 hectares of ANR, encompassing techniques for enriching, expanding and maintaining restored areas (Table 2). Data collection was not possible for the remaining 27 families because their representatives were not available at the time of the visits.

Most of the visited lots implemented AFS (95%), while just over half implemented ANR. In many of these cases, AFS already existed before the project, but the partnership enabled their expansion, maintenance and enrichment. This difference between the number of AFS and ANR areas in the territories reflects the productive profile of MST settlements, which historically prioritize mobilization efforts for food production (MST et al., 2022), used both for subsistence and for commercialization in spaces such as fairs, small markets and production for the National School Feeding Program (Pnae), for example.

Table 2 | **Number of AFS and ANR areas supported by the project for 120 visited families**

| SETTLEMENT | Nº. OF SUPPORTED FAMILIES | Nº. OF VISITED FAMILIES | Nº. OF SUPPORTED AFS | AFS AREA (ha) | Nº. OF SUPPORTED ANR | ANR AREA (ha) | Nº. OF FAMILIES WITHOUT ACTIONS |
|---|---|---|---|---|---|---|---|
| Abril Vermelho | 74 | 58 | 56 | 177 | 23 | 49 | 4 |
| João Batista II | 24 | 20 | 23 | 39 | 12 | 15 | 1 |
| Paulo Fonteles | 24 | 20 | 14 | 10 | 13 | 16 | 3 |
| Mártires de Abril | 15 | 13 | 10 | 15 | 12 | 17 | 0 |
| Luís C. Prestes | 10 | 9 | 9 | 12 | 2 | 2 | 1 |
| **Total** | **147** | **120** | **114** | **253** | **62** | **99** | **9** |

*Source:* created by the authors.

Proportionally to the number of families visited, the Mártires de Abril settlement had the most ANR areas, followed by Paulo Fonteles, João Batista II, Abril Vermelho and Luís Carlos Prestes. The first three settlements have a history of significant soil degradation and already employed agroecological practices such as the use of banana and inga trees as service plants[7] to improve soil fertility, provide shade and accelerate environmental recovery. According to one settler, techniques that offer environmental benefits are highly valued in territories that require greater adaptation to adverse conditions, which may explain the higher proportion of structured ANR areas in these three settlements.

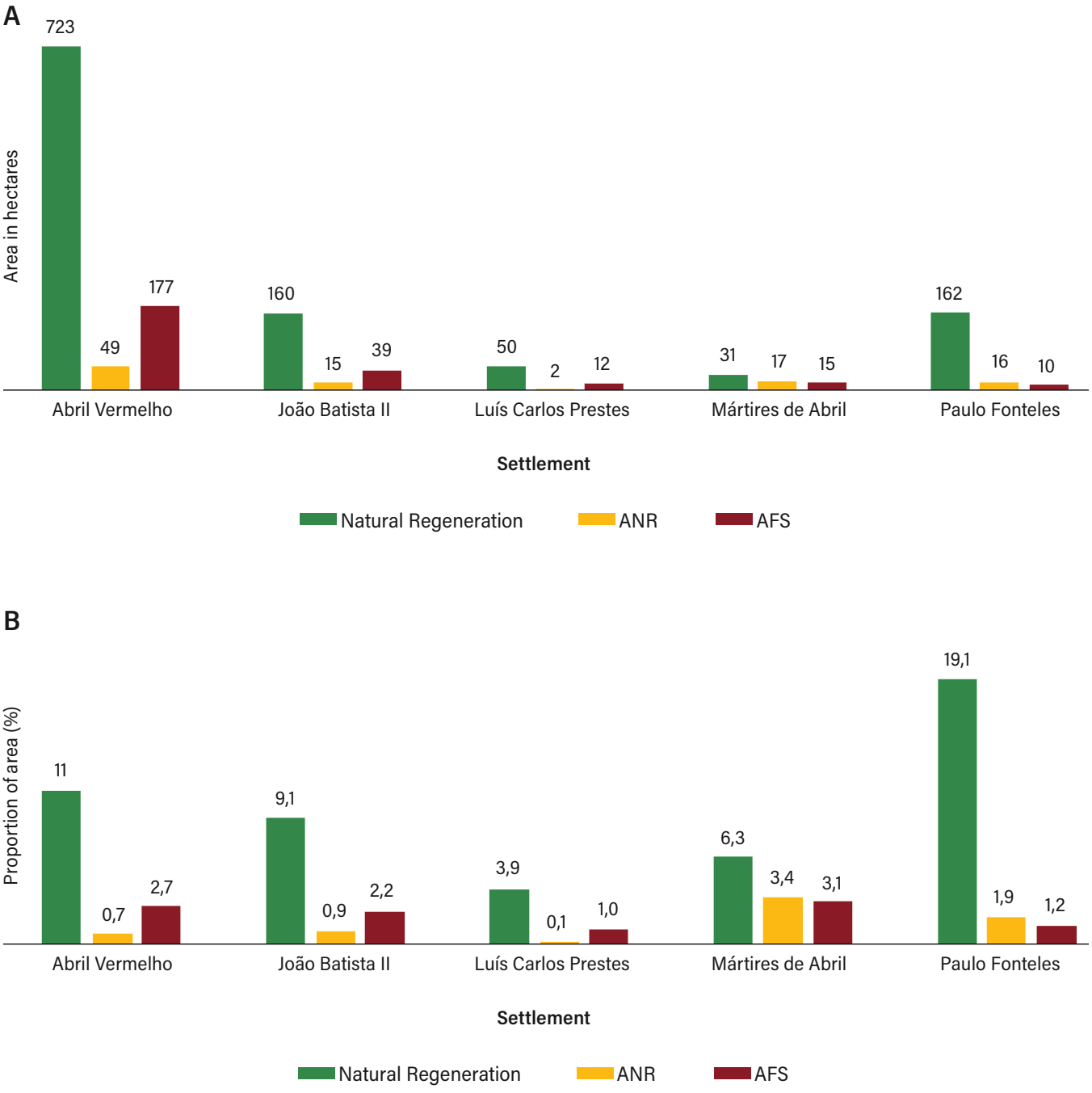
In the settlements located on Mosqueiro Island (Mártires de Abril and Paulo Fonteles), the territorial configuration of "agrovillages" – where homes are separated from cultivated areas – facilitated the adoption of natural regeneration practices in secondary forest areas, with specific interventions such as introduction of fruit trees and demarcation of protected areas.

In the João Batista II settlement, species such as *murici* and cashew were perceived as well adapted to local soil degradation conditions. This spontaneous growth of species that add economic value to ANR areas may also have driven the maintenance and support of regeneration areas. In the Luís Carlos Prestes settlement, the low availability of areas with natural regeneration potential, coupled with the occurrence of fires and the scarcity of forest fragments in the surrounding areas, compromised the viability of ANR.

On the other hand, a greater availability of seedlings positively influenced the adoption and expansion of AFS, according to residents. They highlighted how this availability strengthened families' resolve to implement and diversify the production systems on their lots. Although most of the families participating in the workshops made progress in implementing AFS, nine of them chose not to continue with the initiatives on their lots at that time. As the reasons for their withdrawal were not investigated in depth, further studies are recommended to help understand the factors limiting full engagement and improve future strategies.

The settlements with a higher proportion of implemented ANR areas do not necessarily correspond to the largest territorial extensions (Figure 5; Table 2). Each settlement adopted distinct strategies, influenced by its territorial characteristics. For example, on larger lots, ANR implementation is facilitated by greater land availability, while on smaller lots, priority is given to productive use. In the Mártires de Abril settlement, for instance, the total area adds up to 488 hectares and the lots are smaller (40 m x 1,000 m), which led to the prioritization of ANR in collective or strategic areas, such as springs and water sources. In Abril Vermelho, with 6,548 hectares and larger lots (200 m x 1,000 m), it was possible to implement both AFS and ANR on family properties, totaling 177 hectares of AFS and 48 hectares of ANR. In these areas, ANR included specific management and protection actions, such as isolating sensitive areas, special attention to regenerating species, and enrichment with economically valuable species, such as *cupuaçu*. Natural regeneration areas, on the other hand, comprise secondary vegetation areas existing in the settlements, but not assisted by direct management actions.

Figure 5 | **NR, ANR and SAF per settlement in hectares (A) and proportion in relation to the total area (B)**




*Notes:* 1. Natural Regeneration = secondary vegetation areas existing in settlements, but not assisted by direct management actions; 2. ANR = secondary vegetation areas assisted by specific management and protection actions, such as isolation of sensitive areas, special attention to regenerating species and enrichment with economically valuable species.

*Source:* created by the authors.

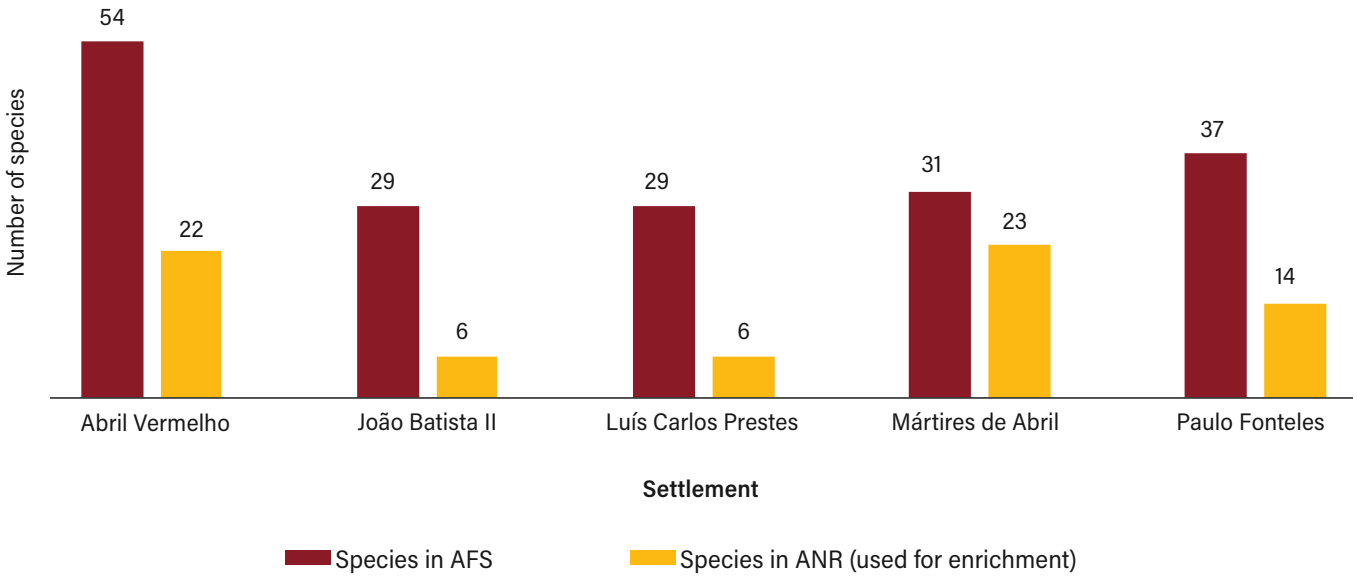
Testimonies from settlers highlighted that the extreme and atypical drought that occurred during the project period hindered the implementation of new AFS and ANR areas, leading to the prioritization of maintenance and enrichment of existing systems. Another challenge mentioned was the lack of adequate soil preparation machinery, especially in areas dominated by grasses such as *Brachiaria*, which significantly hindered the implementation of new AFS systems.

According to a nursery worker, the workshops helped expand the diversity of species used in AFS and ANR. He reported that the greater availability of seedlings and the understanding of the importance of biodiverse systems boosted this gain in diversity, recognizing its relevance in the face of the climate extremes faced in the Amazon (Kala, 2024). Figure 6 shows the total number of species used in the AFS and ANR areas (considering only those used for enrichment) of the 120 families visited in the field. A description of the main species found in the AFS and ANR areas can be found in Appendix C.

80% of the species found in the five settlements' AFS food, with the five most prevalent species being *açaí*, *cupuaçu*, cocoa, peach palm and banana (see Appendix C for more details). The ANR areas showed lower recorded diversity, as only the species used for enrichment were accounted for, not the spontaneously regenerating ones.

During the two-year project, the implementation stage enabled settlers to reactivate production in four settlements' nurseries and increase production capacity by over 8,000 seedlings in the Abril Vermelho nursery. Additionally, the greater availability of seedlings and inputs, combined with access to information through training, strengthened families' adherence to AFS and ANR techniques, resulting in an expansion of these areas and species diversity in the systems. The settlers have also established future goals, which include expanding the nursery production capacity, increasing the diversity of cultivated species and improving management practices.

Figure 6 | **Number of species planted, per settlement, in the AFS and ANR areas (considering enrichment actions) of the 120 families visited**




*Source:* created by the authors.

# Key factors in the AFS-ANR approach

In general, successful restoration projects share key success factors that include the motivation of those involved, enabling conditions for restoration, and availability of resources for its implementation (Hanson et al., 2015). These factors were analyzed for the AFS-ANR approach in the five settlements, considering the context of the established partnerships and the results obtained throughout the project.

The key factors were systematized based on the Diagnostic Framework developed by Hanson et al. (2015), which proposes analysis under three broad themes:

- **Motivate:** investigates what drives engagement in restoration, such as perceived economic, social and environmental benefits, as well as awareness and appreciation of the process.
- **Facilitate:** refers to the surrounding conditions that enable or hinder restoration, including public policies, institutional support, legal frameworks and technical and financial incentives.
- **Implement:** refers to material resources needed to execute the actions, such as technical knowledge, infrastructure, labor, financial resources and coordination among stakeholders.

Based on this conceptual framework, the key factors observed in the five settlements were identified and organized, as shown in Table 3. The results are also detailed by theme and broken down by settlement in Tables 4, 5 and 6.

Table 3 | **Key factors identified in the implementation of AFS-ANR with the five settlements**

| THEME | ASPECT | KEY FACTOR FOR SUCCESS | DEFINITION |
|---|---|---|---|
| MOTIVATE | BENEFITS | Restoration generates economic benefits. | Restoring the candidate landscape is expected to generate economic benefits (e.g., economic diversification, damage prevention, new marketable products) with positive financial impacts (private benefits) and/or positive economic impacts (public benefits) compared to conventional land use. |
| | | Restoration generates social benefits. | Restoring the candidate landscape is expected to generate social benefits, including the promotion of cultural ties and political achievements. |
| | | Restoration generates environmental benefits. | Restoring the candidate landscape is expected to generate environmental benefits. |
| | AWARENESS RAISING | The benefits of restoration are made known to the public. | The benefits arising from restoration of the candidate landscape have been clearly identified and communicated to land managers, the public, and other stakeholders. |
| | | Opportunities for restoration are identified. | Candidate areas for restoration were identified and quantified. |
| FACILITATE | ECOLOGICAL CONDITIONS | Conditions related to soil, water, climate and fires are favorable for restoration. | Soil, rainfall and temperature conditions in the candidate landscape are suitable for forest regeneration, and the fire regime does not harm tree growth or recovery. |
| | | There is immediate availability of seeds, seedlings or source populations. | The candidate landscape has source populations (e.g., sizable remaining native tree populations), underground root systems, seed-dispersing animals or low-cost sources of native tree seeds and seedlings that could support forest regeneration. |
| | POLITICAL CONDITIONS | Policy guidelines for restoration are aligned and optimized. | Relevant public policies are aligned, simplified and mutually reinforcing to support forest restoration in the candidate landscape. |
| | MARKET CONDITIONS | There are value chains for products from restored areas. | As forest restoration in the candidate landscape generates marketable products, there are value chains in place that allow products to reach end consumers. |
| | SOCIAL CONDITIONS | The local community has decision-making power over restoration. | People living in or around the candidate landscape are empowered to engage in the design of the forest restoration program, help set restoration goals and participate in management. |
| | | The local community will benefit from restoration. | People living in and around the candidate landscape are able to reap or enjoy the benefits generated by restoration (e.g., improved water quality, increased availability of forest products) or obtain alternative livelihoods. |
| IMPLEMENT | LEADERSHIP | There are regional and/or national advocates for restoration. | There are charismatic individuals (or influential institutions) that can effectively inspire decision-makers to pursue restoration, mobilize support, and sustain restoration efforts in the candidate landscape over time. |
| | KNOWLEDGE | There is relevant restoration know-how for the candidate landscape. | Local experts are familiar with or conduct research on restoration techniques (e.g., natural and assisted regeneration, traditional knowledge) that are ideal for the candidate landscape. |
| | | Restoration know-how is disseminated by farmers themselves or extension services. | Technical advice and rural extension ("extension services"), mutual visits among producers, and/or other methods of knowledge exchange and training for restoration are present and are adequately used in the candidate landscape. |
| | FINANCE AND INCENTIVES | Incentives and financial resources are quickly accessible. | Incentives and funding for restoration in the candidate landscape are made available, without obstacles or excessive bureaucracy, to land managers or the communities. |
| | OPINIONS AND CONTRIBUTIONS | Effective performance evaluation and monitoring systems are in place. | There is a system to monitor progress and assess the impact of restoration on the candidate landscape. |
| | | Achievements are reported from the beginning. | Early successes in the candidate landscape are achieved and communicated to stakeholders. |

*Source:* adapted from Hanson et al. (2015).

## MOTIVATE

The aspects involving the motivating factors for restoration in each project settlement are described in Table 4.

Table 4 | **Key motivating factors identified for each settlement**

| THEME | ASPECT | ABRIL VERMELHO | LUIS C. PRESTES | MÁRTIRES DE ABRIL | PAULO FONTELES | JOÃO BATISTA II |
|---|---|---|---|---|---|---|
| MOTIVATE | BENEFITS | **Economic benefits:** expansion of productive areas for commercialization. | | | | **Economic benefits:** expansion of productive areas for commercialization; ANR with *murici* and cashew. |
| | | **Social benefits:** strengthening MST's culture and political achievements. | | | | |
| | | **Environmental benefits:** increased diversity and resilience to extreme climate events; protection of water resources; improved soil quality. | | **Environmental benefits:** history of soil degradation — importance of ANR for protection of water resources and improvement in soil quality. Increased diversity. | | |
| | AWARENESS RAISIN | The benefits of restoration were shared with families through ANR and AFS workshops with the participation of local leaders. | | | | |
| | | Opportunities for restoration were identified through participatory processes during the planning stage. | | | | |

*Source:* created by the authors.

During the project, participants expressed a desire to expand the collective production of sociobiodiversity products, implementing crops on a larger scale and developing more structured organizational processes, such as the establishment of cooperatives or associations. Thus, the opportunity to expand production areas through AFS and the management of species of interest in ANR areas stood out as an economic benefit for the communities, increasing the volume and diversity of products.

Beyond the economic aspect, social benefits also played an essential role in driving the adoption of the approach. MST's "Plant Trees and Produce Healthy Food" national plan has a strong political component, embedded in the struggle for agrarian reform and search for an alternative food production model, in opposition to the hegemony of large estates and monoculture. In this context, AFS have strengthened peasant culture and reaffirmed the movement's political achievements, becoming an agroecological and symbolic strategy of resistance.

Regarding the adoption of ANR practices, on the other hand, environmental benefits stood out as the main driving factors. According to one settler, the settlements with the greatest difficulty in planting, due to high soil degradation, were those that most adopted regeneration techniques, recognizing their importance. This was reflected in the higher proportion of ANR areas in the three settlements with the most degraded soil conditions and the lowest water availability. Overall, in all five settlements, there is a clear need to protect natural resources, especially regarding water resources and the recovery and improvement of soil quality, which are essential to ensuring the long-term viability of family farming.

Participatory knowledge development proved essential in communicating the environmental and socioeconomic benefits of the AFS-ANR approach. The restoration planning stage, with participatory mapping and data collection processes in the territories, was also an important factor in identifying potential areas for restoration and engaging farmers in the process. Furthermore, the MST's prior training of local leaders on topics such as sustainable production and

agroecology, combined with partnerships with strategic stakeholders in the territories, expanded the dissemination and territorial reach of knowledge and facilitated the appreciation of the benefits of restoration in agrarian reform territories. In this sense, the influence of local leaders in encouraging the organization of youth collectives, combined with participatory mapping processes during the project, was fundamental to the effective involvement of young people in restoration actions.

## FACILITATE

Enabling factors refer to the aspects that make restoration more feasible or challenging, including institutional support and technical, political and financial incentives. Ecological, social, political and market characteristics were identified as important enabling or hindering conditions for restoration actions in each of the territories. Table 5 presents a summary of these aspects in the five settlements.

Table 5 | **Characteristics of the settlements and factors that enabled restoration**

| THEME | ASPECT | ABRIL VERMELHO | LUIS C. PRESTES | MÁRTIRES DE ABRIL | PAULO FONTELES | JOÃO BATISTA II |
|---|---|---|---|---|---|---|
| FACILITATE | ECOLOGICAL CONDITIONS | Greater water availability. Larger lots with more NR areas and forest fragments. | Degraded soil. More frequent fires. | Sandy soil, not very fertile and very degraded. | Sandy soil, not very fertile and very degraded. | Low water availability. Soil degraded by pastures. |
| | | Important role of nurseries in seedlings and input supply, and strengthening community organizations. | | | | |
| | MARKET CONDITIONS | Located near Belém, facilitating the flow of products and access to consumer markets (mainly fairs and small markets). | There are value chains in place for products' distribution, mainly through fairs and small rural markets. | | | |
| | POLITICAL CONDITIONS | There are national (Planaveg), state (PRVN-PA) and MST ("Plant Trees and Produce Healthy Food" National Plan) policies aligned with restoration goals and commitments. | | | | |
| | SOCIAL CONDITIONS | Participatory processes at all stages and AFS planning according to stakeholders' interests. | | | | |
| | | Environmental benefits of restoration are important for the work and livelihoods of settlers: dependence on fertile soil, water resources and drought-resistant techniques. | | | | |

*Source:* created by the authors.

The settlements involved have distinct ecological characteristics. Two of them, Mártires de Abril and Paulo Fonteles, located on Mosqueiro Island, share similar ecological conditions, such as sandy and infertile soils due to their proximity to freshwater beaches, which limits the establishment and development of several plant species. The history of coconut monoculture has also contributed to soil degradation. In this context, the provision of inputs by nurseries was essential to enable the planting and maintenance of AFS and ANR areas. The community division of the territory into smaller lots also influenced the process, concentrating the implementation of ANR areas in strategic locations, such as collective areas or areas dedicated to the protection of springs and water sources.

The João Batista II settlement is marked by low water availability and soil degradation caused by the intensive use of pastures (Figure 7A). Despite these limitations, families expressed interest in including cattle in some production systems, which requires additional management in the areas under restoration. The implementation of ANR and AFS was driven by demand for environmental benefits and supported by the nurseries, which made seedlings and inputs available to families.

Figure 7 | **Ecological characteristics of the settlements and nursery in the Abril Vermelho settlement**

A) Degraded area due to intensive pasture use in the João Batista II settlement

B) Stream area in the Abril Vermelho settlement

C) Initial AFS for recovery of degraded area in the Luís Carlos Prestes settlement

D) Seedling production nursery in the Abril Vermelho settlement

*Source:* Viviane Sobral/WRI Brasil, 2025. Helen Ramos/WRI Brasil, 2024.

The Abril Vermelho settlement presented more favorable conditions, with greater water availability (Figure 7B) and proximity to Belém, facilitating product flow and access to consumer markets. The presence of nurseries with production aligned with the families' interests also supported restoration efforts in the territory. Land division into larger lots (200 m x 1,000 m) enabled the implementation of ANR in larger areas, typically not occupied by production.

Territorial organization and land division is still underway in the Luís Carlos Prestes settlement, which also has a history of soil degradation. Concern for water resources motivated the adoption of ANR and AFS, and the provision of seedlings and inputs through the nurseries facilitated implementation. However, the occurrence of fires hindered the maintenance of newly implemented areas (Figure 7C). Nevertheless, the project's implementation efforts helped strengthen community organizations by providing spaces for more frequent meetings among residents. Despite the differences in the settlements' ecological conditions, the nurseries were essential drivers of restoration processes (Figure 7D). Social mobilization and community participation throughout the project, from planning to implementation, demonstrate that social conditions are another key factor in the context of agrarian reform settlements, as they place people at the center of the process and strengthen the organizational processes that support action.

The appreciation of environmental benefits of restoration has been a key driver of peasants' work in the settlements involved, increasing participation in the initiatives, as previously described. In this regard, one settler highlighted the perception that more developed and biodiverse AFS demonstrated greater resilience during the dry season compared to less diverse areas in early stages. Similar conclusions have been reported in studies on the relationship between AFS and biodiversity (Udawatta, 2019; Kala, 2024).

Within the context of this partnership, political and market conditions also favored restoration. The alignment of different policy guidelines committed to achieving restoration goals, such as Planaveg at the national level, the Native Vegetation Recovery Plan of the state of Pará (PRVN-PA) at the state level, and MST's "Plant Trees and Produce Healthy Food" national plan, mutually reinforces and promotes restoration within the partnership. Regarding market conditions, initial chains and channels are in place to support the circulation and commercialization of restoration products, especially in rural markets and local fairs.

## IMPLEMENT

The factors that influence the implementation of restoration in the settlements involved in the project relate to material and organizational resources required to carry out the actions, such as technical knowledge, infrastructure, labor and coordination between local and external stakeholders. These aspects are systematized in Table 6.

Tabela 6 | **Key implementation factors identified in the five settlements**

| THEME | ASPECT | ABRIL VERMELHO | LUIS C. PRESTES | MÁRTIRES DE ABRIL | PAULO FONTELES | JOÃO BATISTA II |
|---|---|---|---|---|---|---|
| IMPLEMENT | LEADERSHIP | There are local advocates for restoration. | | | | |
| | KNOWLEDGE | The knowledge construction stage offered spaces for exchange and AFS planning. | | | | |
| | | Assistance was provided by MST technicians who are partners in the project and community meetings that promoted exchanges on the processes. | | | | |
| | FINANCE AND INCENTIVES | The project promoted access to financial resources and inputs for implementing restoration actions. | | | | |
| | OPINIONS AND CONTRIBUTIONS | Results announced in a series of videos and publication. | | | | |

*Source:* created by the authors.

During the implementation stage, the presence of local leaders committed to restoration proved a key factor. They demonstrated a strong capacity for mobilization and networking, encouraging engagement and promoting the continuity of actions in their territories. Collective knowledge building was another decisive factor: sharing information about the territory expanded restoration possibilities and paved the way for AFS planning aligned with families' interests. This process was enriched by the integration of traditional peasant knowledge with technical concepts disseminated throughout the process.

Access to the resources necessary for structuring nurseries, seedling production, training and supplying inputs to families was essential for implementation. As mentioned, one of the reasons for seeking new partnerships was access to material, financial and technical support for restoration actions in the territories. Thus, this experience underscores the importance of projects and policies that ensure facilitated access to resources, especially for small farmers in agrarian reform settlements, enabling restoration in the territories.

The dissemination of results also played a relevant role in implementation, publicly recognizing the communities' efforts and sharing lessons learned with other territories. In August 2024, WRI Brasil launched the video series "Regenerating the Forest and Producing Food in the Amazon", which systematizes the experiences undergone with the project and expands its reach. The videos add to this strategy and help disseminate lessons learned, inspiring and engaging other stakeholders interested in similar initiatives.

Finally, it is important to emphasize that many of the key factors are interrelated. Knowledge building, for example, is not only essential for implementation, but also acts as a motivating factor by expanding understanding of the social and environmental benefits of restoration. Likewise, strong leadership simultaneously represents a key implementation factor and enabling factor: local leaders organize collective processes, strengthen community engagement and favor territorial stewardship practices.

# Lessons learned

During the implementation of the AFS-ANR approach in the five MST settlements in the Amazon, important lessons were learned about the factors that strengthen restoration in diverse contexts and possible paths to scale ANR. These lessons reflect the results achieved at each stage of the process, as discussed in the previous sections.

Overall, the experience highlighted that restoration in rural settlements in the Amazon cannot be reduced to a single method. Considering local specificities is essential to developing restoration strategies aligned with socio-territorial realities. The process reinforced the importance of working together with local communities to develop solutions that are suited to their dynamics, challenges and vocations.

Thus, strengthening community movements, combined with local capacity building and the presence of engaged leaders proved essential for the continuity of restoration efforts in the territories. The appreciation of local knowledge, combined with the creation of technical and institutional support structures, sustains people's autonomy, guiding a restoration process that integrates established practices while incorporating new approaches.

## Community engagement and territorial planning

Community participation along the project's different stages was essential to ensure that social aspects were considered in the restoration process. The territorial planning stage significantly contributed towards:

- **Knowledge ownership:** mapping tools allowed participants to develop a new understanding of the territory, and young people gained familiarity with the technologies used in restoration monitoring.
- **Strengthening the sense of belonging:** participatory mapping proved to be a potential tool for expanding community participation in land use decision-making processes. Many participants reported that they had never had the opportunity to visualize and reflect on the territory through cartographic tools. Thus, the activity reinforced the community's sense of belonging to the territory and improved their understanding of the space, as described in the literature on the subject (Vergara-Asenjo et al., 2015; Malakar; Roy, 2024). Additionally, the experience corroborates studies that indicate that participatory mapping goes beyond technical aspects: it is a political and educational tool that promotes autonomous and informed land use planning and helps communities assert territorial rights (Neto et al., 2016).
- **Community autonomy:** experience has shown that training in field collection of georeferenced points, carried out by the youth collective, strengthened capabilities needed for monitoring restoration areas. The use of geoprocessing tools, such as GPS and drones, enabled communities to capture images of AFS and ANR areas. These capabilities allow the communities to capture and compare future images of the same areas to assess restoration progress. Capacity building in this area was vital to promote ownership of ANR knowledge and equipment, which remained in the settlements, facilitating their incorporation into local routines. Its continued use will be supported by a monitoring protocol currently under development.
- **Youth inclusion:** youth participation in the planning stage demonstrated that activities involving technological tools can be used strategically to engage this segment of the settlements' population in restoration initiatives. Youth engagement efforts highlight the importance of young people's active role in local development, encourage appreciation of the territory and create future opportunities in rural areas. These factors contribute to the retention of rural youth, strengthening generational succession (Valadares et al., 2016).

- **Effectiveness of data collection:** community involvement increased the effectiveness of data collection, as residents are familiar with the territory and have access to restoration areas, facilitating mapping and logistics.

## Education and local capacity building

The workshops were vital for knowledge building on ANR and AFS and community engagement. The application of the Pedagogy of Alternation, which integrates theory and practice and organizes the training process around the local reality, generated the following benefits:

- **Adaptation of training activities to families' routines:** the adoption of the Pedagogy of Alternation allowed the workshops to be organized around the families' daily commitments in the settlements, including their agricultural and domestic activities, with meetings held in the communities. This ensured easy access to training activities and produced similar participation rates across all settlements, creating an environment where theory and practice complement each other without overburdening the communities (Littig; Amaral, 2023).
- **Knowledge exchange between technicians and the community:** the workshops fostered an open dialogue between technicians and settlers. This exchange brought traditional local knowledge to the forefront while also introducing innovative tools and techniques, such as geoprocessing practices and ANR methodologies. Grassroots education and knowledge exchange processes strengthen community autonomy and are recognized as key elements of emancipatory training in rural areas (Santos; Araujo, 2020).
- **Continuous adaptation of the methodology, aligning it with the reality and dynamics of each settlement:** the success of the workshops was a result of the adaptability and flexibility of individuals and institutions. Throughout the process, adjustments were made to meet the specific needs of each community in terms of frequency of meetings, approach to content and pace of activities. The adaptation efforts reinforced the relevance of training activities to the families' daily lives and aligned them with rural education practices.

Active listening throughout the process was also vital to fine-tuning the approach and ensuring greater effectiveness in execution and community engagement, given the vast amount of technical information available on restoration, whether through AFS or ANR. Active listening is understood as an essential part of participatory methodologies for collective construction of local solutions (Moura; Brandão, 2024).

## Local context and implementation

The implementation of restoration in the five settlements was conditioned by social, ecological and institutional characteristics, demonstrating the need for and importance of territorialized and adaptive approaches in restoration processes (Borda-Niño et al., 2021; Chazdon et al., 2020).

- **Social and ecological history:** each settlement presented historical and ecological peculiarities that directly influenced the challenges and opportunities of restoration and the adoption of techniques. Settlements with more degraded soil or water scarcity required more inputs and specific techniques. Additionally, factors such as land division into lots and territorial context shaped the strategic selection of restoration areas. In some settlements, local fragmentation and the dispersion of production units hindered access, input delivery logistics and implementation of restoration practices. On the other hand, settlements with more compact territorial organization and existing collective areas facilitated joint actions.
- **Community organization:** the presence of organized forms of action in the settlements, such as collectives, associations and working groups, was an important enabler of restoration efforts. Despite the settlements' different forms and histories of social organization, collective mobilization

and coordination among settlers helped align interests and overcome implementation challenges. Attention to local particularities and existing arrangements was essential to adapt methodologies to the realities of each territory and ensure greater effectiveness of restoration processes.

- **Strengthened restoration chain:** the establishment of community nurseries and input provision fostered the development of a local restoration chain. In addition to material gains, these actions promoted the development of a self-management and shared responsibility culture, empowering participants to take a leading role in the conduction of long-term processes. The nurseries also established themselves as training and community engagement spaces, strengthening the involvement of settled families and promoting the exchange of knowledge. Despite the progress, the continuity of these structures requires planning, technical and financial support to ensure their sustainability. Studies indicate that investments in local capacity building and network development are essential for the long-term sustainability of restoration projects (Padovezi et al., 2024; Bloomfield et al., 2019).
- **Adaptation to climate conditions:** the project revealed challenges in climate adaptation, as most plots suffered significant (or total) seedling losses due to the intense drought experienced in recent years in the Amazon. Future efforts should consider monitoring ecological aspects, and new projects should consider water availability to ensure the viability and sustainability of restoration processes.

# Conclusions and recommendations

The experience of AFS-ANR implementation in agrarian reform settlements in the Belém metropolitan region and northeastern Pará highlighted the potential of these territories as strategic areas for landscape and forest restoration.

Based on the lessons learned from this experience, the following recommendations are outlined to inform future initiatives:

- **Promote the integration of social, environmental and economic benefits**: identifying concrete gains from restoration, such as strengthened food sovereignty, improved environmental quality and productive use of restored areas, has proven important for community buy-in. This integration of benefits is key to increasing local engagement with ANR and consolidating results over time.
- **Strengthen local social organizations**: organized collectives, such as MST, play a fundamental role in the implementation and continuity of restoration actions. This experience reinforces the role of these organizations not only as implementers but also as leaders of the process. Therefore, strengthening the self-management capacity of local leaders and collective structures is a strategic prerequisite for consolidating restoration processes in the territories.
- **Adapt methodologies to local contexts**: experience has shown that, although restoration requires adaptation to the historical, ecological, sociocultural and organizational context of each agrarian reform settlement, these variations do not represent an insurmountable obstacle to scale. On the contrary, the accumulation of technical knowledge, combined with effective and participatory planning, as seen in the AFS-ANR scheme, promotes the development of replicable and adjustable approaches capable of informing effective interventions.
- **Invest in capacity building**: the training processes developed throughout the experience combined technical, social and political dimensions, in line with agrarian reform collectives' tradition of critical education. This combination allowed for the introduction of ANR in a new context, strengthening local leaders' and agrarian reform territories' familiarity with the topic and promoting greater integration with the movement's agenda.
- **Strengthen initiative monitoring and continuity strategies**: encouraging the creation of community monitoring groups was one of the strategies adopted, with potential to strengthen community autonomy in monitoring initiatives and their results. The inclusion of participatory monitoring in existing groups proved promising, as it recognizes previously established community organizations and leadership.

Thus, the lessons learned from this experience reinforce the idea that restoration in agrarian reform territories in the Amazon must be understood as a social, ecological and political process, in which collective mobilization, dialogue-based knowledge construction and context adaptation are as important as technical aspects.

Beyond the desired ecological results, restoration has the potential to assume a structuring role in territorial organization, fostering the development of new leadership and appreciation of peasant culture. In this context, MST's role as articulator, educator and executor of actions reaffirms its importance for strengthened family farming and collective organization in the territories, facilitating the attraction of new partnerships.

Studies have described work with agrarian reform settlements, especially in the Atlantic Forest biome, where local communities were engaged in conservation and restoration activities, including the implementation of AFS (Shennan-Farpón et al.,

2022; Chazdon et al., 2020). They also highlighted the importance of working with local communities as a central element of successful restoration initiatives (Silva et al., 2024; Chazdon et al., 2020). In this sense, our case reinforces this understanding while highlighting ANR as a viable alternative for implementation in different contexts. Its low cost and the possibility of integration with other techniques, including AFS, make ANR a promising strategy for participatory planning adapted to the realities of rural settlements.

Considering the opportunity to scale up restoration in the Amazon and the potential for advances in ANR adoption, the combination of a pre-existing social movement plan, community engagement and technical and instrumental support has proven to be a powerful path towards the adoption of techniques with local legitimacy.

However, these are only the first steps. Sustaining this initiative will require additional efforts to strengthen market access, attract financial resources and develop mechanisms that enable the sustainability and reach of actions over time. Furthermore, efforts are still needed in terms of monitoring, adaptive management based on data collected by the communities, and greater clarity regarding who will be responsible for the continuity of actions and introduction of future innovations.

In this sense, the following aspects need to be considered to increase the chances of long-term success of restoration actions in the five project settlements:

- Promote continuous training spaces on restoration in the territories, wide-spreading knowledge and increasingly integrating the agenda with local demands;
- Ensure support for monitoring restored areas, at the landscape scale and focusing on biophysical aspects, through the effective implementation of public policies;
- Encourage cooperative and associative arrangements to expand production capacity and access to markets;
- Develop and implement participatory monitoring protocols with joint action between WRI, partners and communities, through permanent plots and the use of drones;
- Ensure that generated data is used to adjust practices and promote adaptive management of restored areas;
- Establish success indicators related to the improvement of ecosystem services, focusing on biodiversity, soil and production;
- Promote public notices and policies that guarantee continuous funding for maintenance, expansion and provision of technical assistance to restored areas.

The lessons learned thus reinforce the idea that restoration in agrarian reform territories in the Amazon must be understood as a process. Continued research and projects that highlight field experiences and clarify the costs involved in each stage of implementation, from initial mapping to area maintenance and evaluation of results, are essential. It is also necessary to establish indicators that measure the positive impacts on ecosystem services associated with restoration actions in the areas supported by the project. Together, these efforts have the potential to inform public policies and attract new funding partners to the restoration agenda.

These recommendations aim to ensure the continuity of results achieved in the five project settlements and support their replication in other agrarian reform territories in the Amazon and other Brazilian regions.

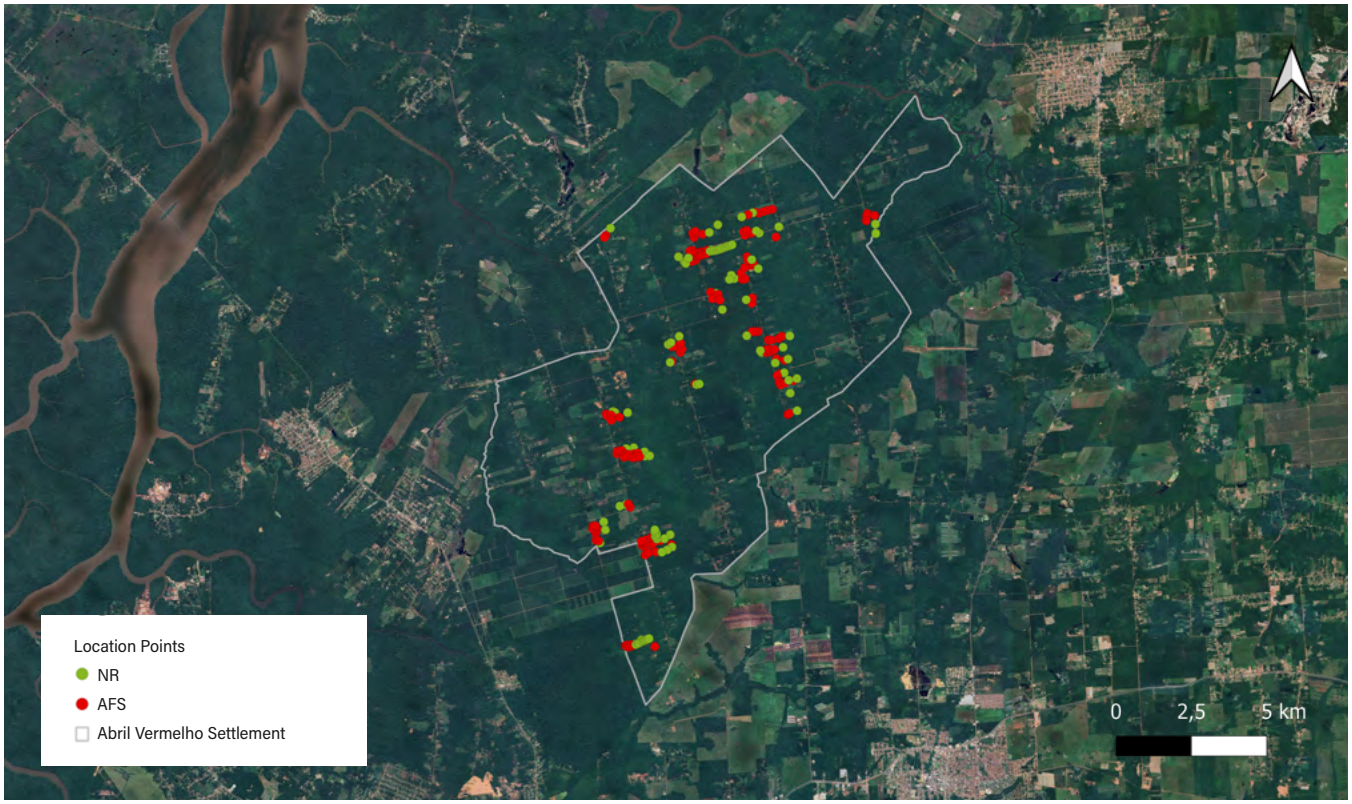
# Appendix A: Mapping of land use and occupation in five agrarian reform settlements

After the participatory mapping workshop, the need arose for field reconnaissance of the areas and collection of georeferenced points for AFS and natural regeneration (NR). This step enabled land use and cover mapping of the settlements through remote sensing and GIS. The idea was that the collection of points would enable an analytical segmentation of these areas. In addition to these points (AFS and NR), the WRI Brasil team identified the remaining land use and cover classifications present in the settlements, based on satellite imagery. The people in charge of the field collection of AFS and NR points were required to use a GPS tool to record latitude and longitude coordinates, in addition to completing a standardized form prepared by WRI Brasil with data for each lot, thus generating georeferenced points for AFS and NR areas (Figure A1).

The first version of the mapping exercise did not achieve significant accuracy, considering that good results for land use and land cover mapping stand above 80% accuracy compared to validation samples, while an accuracy below 50% was achieved. When assessing the reasons, we identified the need for more location points and differentiation of the areas' ages/stages. This information was then included in the field form, and the collections were repeated. In the initial version of the Abril Vermelho settlement, 28 AFS points and 46 natural regeneration points were used, not yet including age differentiation.

When resuming the field collection practice with the new form (Table A1), the MST team assigned a separate code to each field collection point. They were instructed that each area within a visited lot should represent a fairly homogeneous portion, under the same classification. The area code/name observed the following pattern: AALLLCNN A = settlement; L = lot; C = point classification; NN = point number. Thus, all images were assigned an 8-digit name. For example, the point in image AV012R01 is the first point in the first image (01) of Regeneration (R) in lot 12 (012) of the Abril Vermelho settlement (AV).

Figure A1 | **AFS and NR points collected in the field in the Abril Vermelho settlement**




*Source:* created by the authors.

Table A1 | **Example of the field form containing the new collection information for the points for each settlement**

| CODE | TYPE | AGE | SPECIES | OBSERVATIONS |
|---|---|---|---|---|
| AV121X28 | X<br>R | 15 years | Açai, pupunha, biribá, tangerine, mango, avocado | |
| AV121X29 | X<br>R | 15 years | Pupunha, rambutã, bacabi and banana | |
| AV121X30 | X<br>R | 7 years | Açai, pupunha, cupuaçu and piquiá | |
| aV121X31 | X<br>R | 7 years | Açai and cocoa | Cultivation in consortium with native secondary vegetation |
| AV212R14 | X<br>R | 20 years | Native | |
| AV123X32 | X<br>R | 6 years | Açai, cupuaçu, rambutã, bacabi and banana | |
| AV123X33 | X<br>R | 5 years | Banana, açaí and cupuaçu | Area surrounding the project nursery |
| AV123R15 | X<br>R | 7 years | Native | Post-fire regeneration |

*Source:* created by the authors.

Subsequently, the area-specific code was identified based on the vegetation classification present in the territory, categorizing it as Natural Regeneration (R) or Agroforestry System (X), as reported by the person in charge of the area. Information was then requested on the approximate age of the vegetation (e.g. 2 years) and the plant species present (such as ***açaí***, cocoa, ***cupuaçu***, among others). Finally, the document included an open field for inclusion of additional relevant information, such as a history of significant events (e.g., "the area caught fire in 2018").

The mapping activity was time-consuming and involved an ongoing learning process. Initially, field collections were conducted using GPS by a single member of the project support team. This method proved slow because it required traveling long distances within the plots to record AFS and natural regeneration points. Following a suggestion from the MST team and with WRI's financial support, a drone was purchased, significantly increasing process efficiency. The equipment covered the entire lot in just a few minutes and generated georeferenced photographs of the existing AFS and natural regeneration areas (Figure A2).

Figure A2 | **Example of aerial drone photography taken by the MST supporters' group. Area: Abril Vermelho Settlement**

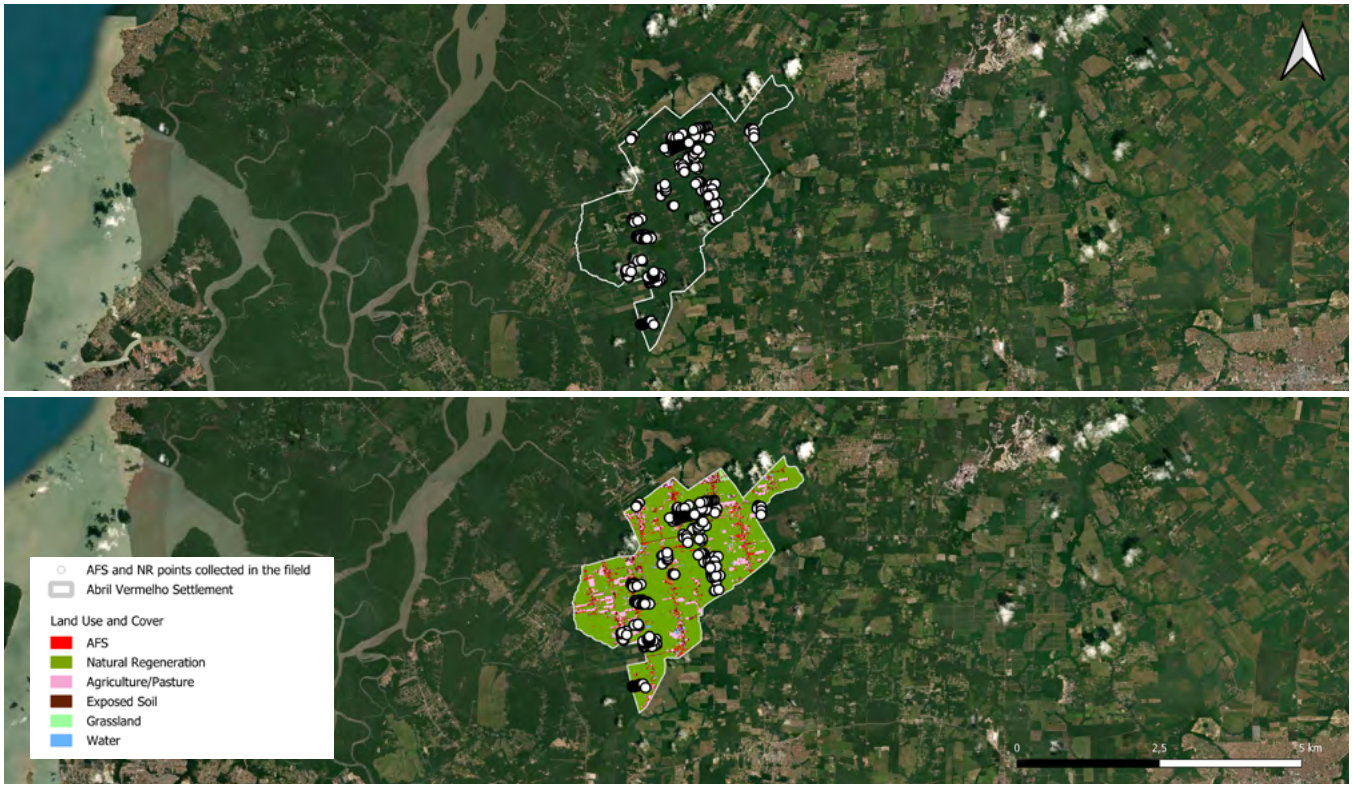
*Source:* WRI, 2023. Institutional archive.

Faced with the need for new field data collection, the MST once again took the lead. At this stage, the activity involved training university students from Instituto Federal do Pará — Belém Campus, residing in the settlements and key actors in MST's struggle. The students received guidance through videos made available by WRI in May 2024, enabling an increase in the speed and data collection areas for Abril Vermelho as well as the other settlements supported by the project. The videos explained how to conduct field data collection and fill out the forms with information about the areas visited. Subsequently, the students received practical instructions from one of the settlers on how to operate the drone and download the images to a computer, and finally submit them to WRI's technical team.

The goal was to collect at least 100 AFS points and 100 natural regeneration points in each of the project's settlements. The field point collection carried out by the new supporters accelerated the process, with at least 8 people (5 men and 3 women) working on the process, instead of a single representative in the previous mapping. The increased effort resulted in significant community involvement in land use and land cover mapping in the settlements, allowing the students to learn about, engage with, and take ownership of the ANR process.

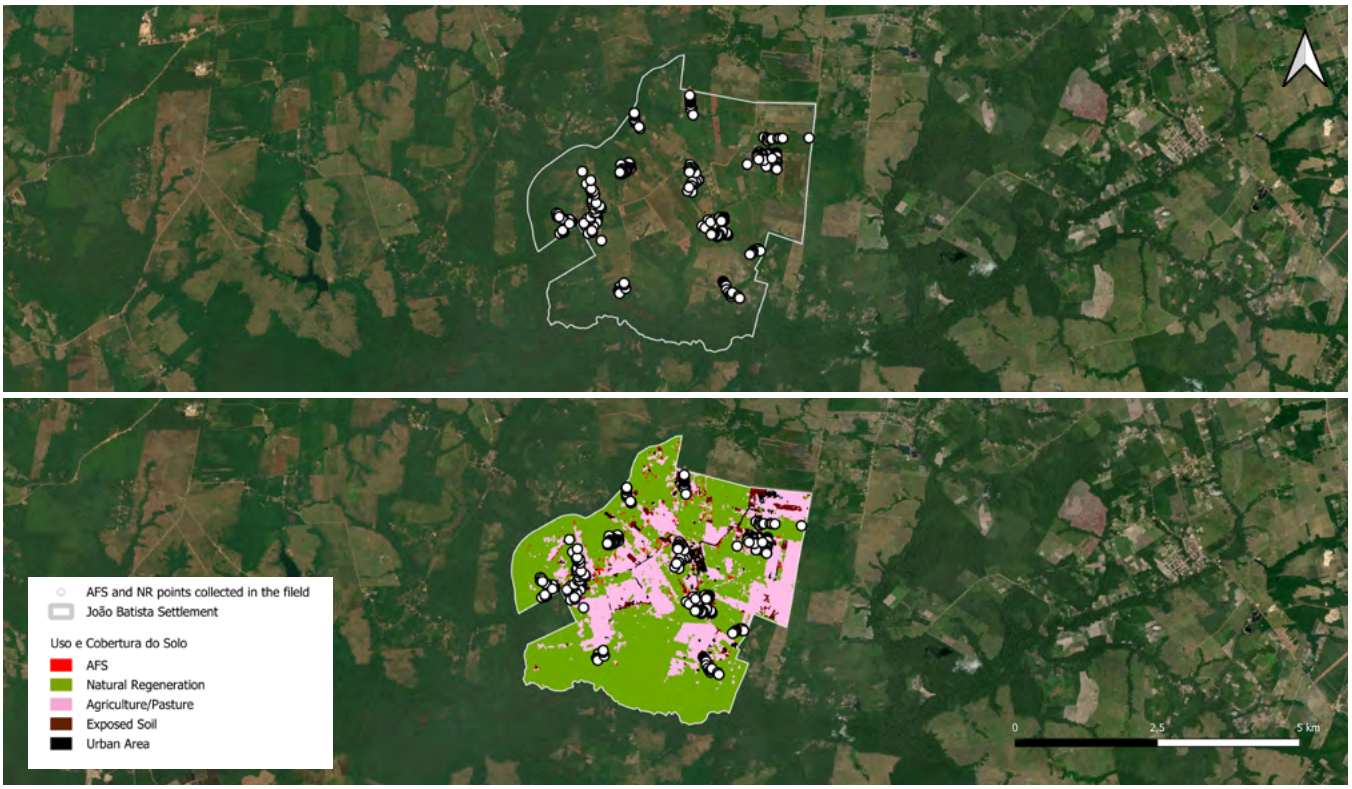
This step was crucial for the mapping exercise, as the more location points collected, the more effective the training of the machine learning-based computational model — a type of artificial intelligence used to predict or classify things based on data. Therefore, the more data we provide the model, the greater its accuracy in the prediction/classification process. Using the logic of analytical segmentation resulting from supervised classification, the field collection of points allowed the GIS-generated methodological model to map all the AFS and natural regeneration areas within the settlements' boundaries, as well as other use and occupation areas. These points are also essential for assessing the model's accuracy, verifying how closely the mapping matches the reality observed in the field. See figures A3, A4, A5, A6, and A7 for the mapping results for the five project settlements.

Figure A3 | **Land use and land cover mapping in the Abril Vermelho settlement**




*Source:* created by the authors.

Figure A4 | **Land use and land cover mapping in the João Batista II settlement**

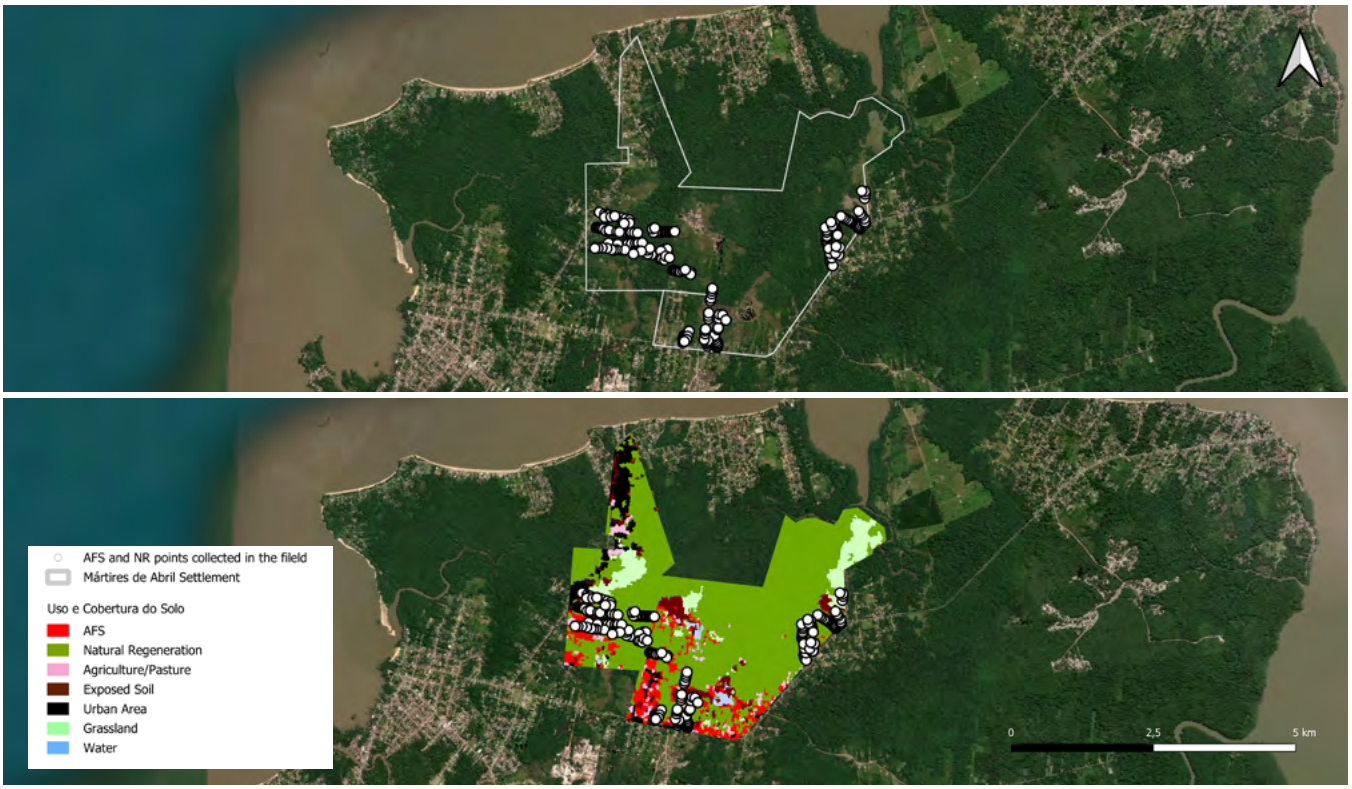



*Source:* created by the authors.

Figure A5 | **Land use and land cover mapping in the Luís Carlos Prestes settlement**

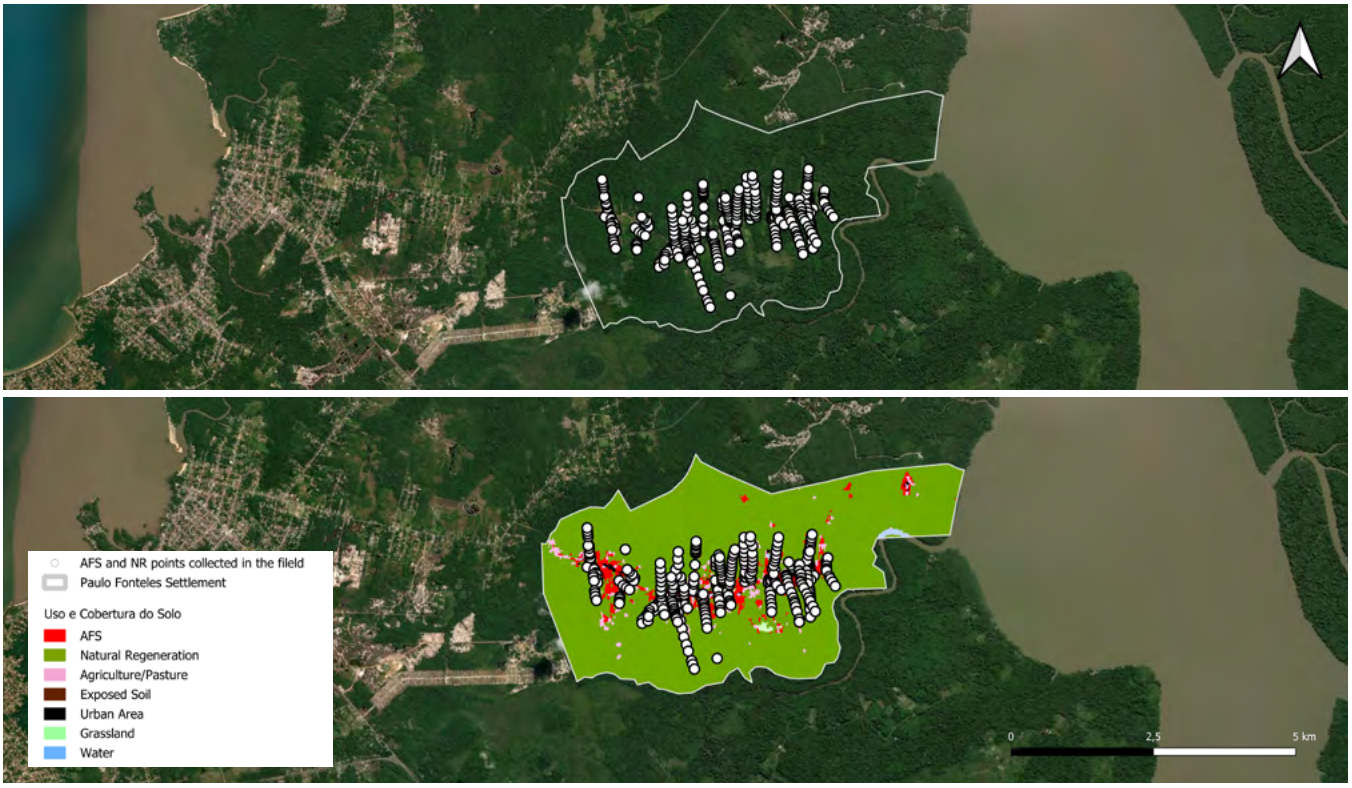

*Source:* created by the authors.

Figure A6 | **Land use and land cover mapping in the Mártires de Abril settlement**




*Source:* created by the authors.

Figure A7 | **Land use and land cover mapping in the Paulo Fonteles settlement**




*Source:* created by the authors.

The collection effort resulted in the establishment of a new level of recorded points. In the Abril Vermelho settlement, 160 AFS points and 93 natural regeneration points were collected. In the João Batista, Mártires de Abril, Luís Carlos Prestes and Paulo Fonteles settlements, the number of AFS points reached 109, 75, 106, and 104, respectively, while the NR points increased to 129, 126, 105 and 185, respectively. This improvement represented an increase of over 100% in the collection scale for both categories compared to the first survey.

The mapping results were as follows: for Abril Vermelho, a settlement with a total area of 6,548 hectares, 445 hectares of AFS areas and 4,957 hectares of natural regeneration were mapped. For João Batista II, with a total area of 1,761 hectares, 42 hectares of AFS areas and 1,365 hectares of natural regeneration were mapped. For Paulo Fonteles, a settlement with a total area of 848 hectares, 57 hectares of AFS areas and 756 hectares of natural regeneration were mapped. For Mártires de Abril, with a total area of 488 hectares, 48 hectares of AFS areas and 338 hectares of natural regeneration were mapped. Finally, for the Luís Carlos Prestes settlement, with a total area of 1,274 hectares, 65 hectares of AFS areas and 645 hectares of natural regeneration were mapped.

## Appendix B: Dialogical construction of ANR and AFS knowledge

The workshops held with the MST were mainly aimed at strengthening local engagement and capacity building in ANR and AFS techniques in the project's five settlements. The activities aimed to integrate low-cost social technologies and promote the use and management of natural resources that could bring benefits to farmers, regenerating the surrounding nature while also strengthening the MST's national policy.

The technical team visited the five settlements and held three-day workshops (Friday through Sunday) in each, with the same schedule and program. This replication aimed to reach the largest number of participants in each settlement, a strategy proposed by MST leaders to ensure proximity to settlers' homes and facilitated logistics.

The Mártires de Abril and Paulo Fonteles settlements held all three workshops of the two stages together due to their geographic proximity. The Abril Vermelho settlement, being the largest in terms of area and organized around four hubs, was divided into two groups, with hubs 1 and 4 carrying out the workshops separately from hubs 2 and 3. However, themes and activities were not changed, with the same content and format replicated in all hubs.

### First stage (2023)

The first stage of workshops consisted of three days of intensive activities, focused on training and raising awareness about sustainable agricultural practices. Each day covered a specific topic with theoretical and practical activities.

- **Day 1 –** evolution of agriculture and ecological alternatives: the first day's theme was the evolution of agriculture, from its beginnings to the present day, highlighting the transformations caused by industrial revolutions and the growing subordination of agriculture to financial capital. Discussions focused on ecological alternatives for agriculture and the importance of agrarian reform in the creation of a more just and sustainable agricultural system (Figure B1).

Figure B1 | **Presentation on the evolution of agriculture and sustainable ecological solutions**

*Source:* Igor Lopes/WRI Brasil, 2023. Institutional archive.

- **Day 2 –** Assisted Natural Regeneration (ANR): the second day was dedicated to the theoretical and practical aspects of ANR. Participants were able to observe ANR areas within the settlements and identify areas where Demonstration Units could be implemented, allowing them to have direct contact with ANR techniques and better understand their application (Figure B2).

Figure B2 | **Field observation and walk through the settlement for ANR study**

*Source*: Igor Lopes/WRI Brasil, 2023. Institutional archive.

- **Day 3 –** bioinput production: during the workshop, participants learned how to create agroecological and biological inputs, focusing on simple, low-cost practices. The use of social technologies was encouraged to ensure that farmers would be able to replicate the techniques on their own properties (Figure B3).

Figure B3 | **Workshop on bioinput production with MST technicians**

*Source:* Igor Lopes/WRI Brasil, 2023. Institutional archive.

### Second stage (2023 and 2024)

The second stage provided further knowledge on the planning and implementation of agroforestry systems (AFS). During this stage, participants were able to apply the knowledge acquired in the first stage in a more practical way.

- **Day 1 –** agroforestry arrangements and designs: the first day of the second stage addressed agroforestry arrangements and designs, with an emphasis on optimizing land use to increase productivity sustainably. Participants learned how to design agroforestry systems that integrate diverse crops and respect local ecological dynamics (Figure B4).

Figure B4 | **Practical workshop on agroforestry designs and arrangements**


*Source:* Igor Lopes/WRI Brasil, 2023. Institutional archive.

Participants were divided into groups by settlement or region to collectively create AFS designs, with tasks divided according to skills (such as calligraphy or drawing) and discussions facilitated by mediators (Figure B5). The participating families chose the areas for AFS implementation, with technical support from facilitators. Criteria such as avoiding advanced regeneration areas and prioritizing single-crop sites to increase diversity and improve soil quality were considered.

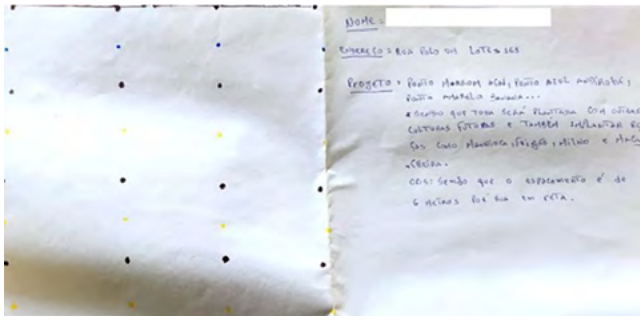
Figure B5 | **Workshop on designing AFS arrangements in the Mártires de Abril settlement**

*Source:* MST, 2023. Institutional archive.

The AFS designs served as planning for AFS locations and species to be included. For example, in the Abril Vermelho settlement, 44 designs were created, in which *açaí* was the most cited species (Figure B6), present in almost all arrangements. Banana, *cupuaçu*, cocoa and *andiroba* followed, with a high number of mentions.

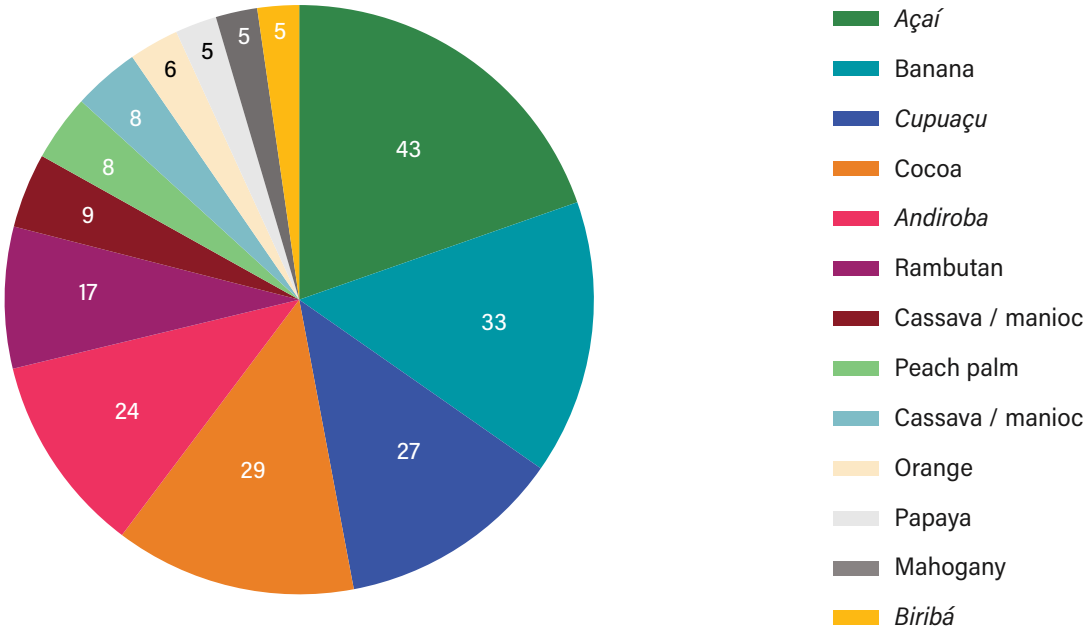
Some participants wrote detailed information on their drawings, such as the spacing between species (e.g., 6 meters), species names, plot address, and how they intend to carry out the planting (Figure B7).

Figure B7 | **AFS designs prepared during the workshop with detailed information accompanying the illustrations**



*Source:* WRI Brasil, 2023. Arquivo institucional.

Figure B6 | **Most cited species in the 44 AFS designs made in the AFS arrangement workshop in the Abril Vermelho settlement**




*Source:* created by the authors.

The AFS design workshop was designed to allow participants to visualize their AFS systems' organization on paper. The activity was conducted collectively, promoting interaction among participants.

- **Days 2 and 3 –** implementation of an experimental AFS and ANR unit: on the second day, farmers practiced planting agroforestry systems and ANR, implementing an experimental unit, and applying the knowledge on AFS and ANR management acquired in previous workshops. The activity aimed to enable participants to replicate the concepts learned on their own properties (Figure B8).

Table B1 shows the number of workshop participants and their gender distribution by settlement. Table B2 consolidates the total number of participants by stage, including technical teams from other institutions, such as WRI Brasil, Imazon and the Secretariat for the Environment.

Figure B8 | **Practical activity of implementing an experimental AFS unit**

*Source:* Igor Lopes/WRI Brasil, 2023. Institutional archive.

Table B1 | **Number of workshop participants with gender distribution**

| RESULTS OF PARTICIPATION IN WORKSHOPS | | | |
|---|---|---|---|
| **Settlements** | **Total number of people** | **Total number of women** | **Total number of men** |
| Abril Vermelho | 174 | 88 | 86 |
| Luís Carlos Prestes | 22 | 10 | 12 |
| Mártires de Abril | 36 | 13 | 23 |
| João Batista II | 55 | 22 | 33 |
| Fonteles | 54 | 32 | 22 |
| MST Nacional | 5 | 1 | 4 |
| **All participants** | **346** | **166** | **180** |

*Source:* created by the authors.

Table B2 | **Total number of participants in both stages, including the technical teams from WRI Brasil, Imazon, the Secretariat for the Environment and other institutions**

| ATTENDANCE LIST INCLUDING TECHNICAL TEAMS, WRI, IMAZON, MUNICIPAL GOVERNMENT, ETC. | | | | | |
|---|---|---|---|---|---|
| Total Participants | 361 | Women | 170 | Men | 191 |
| Total Participants - First Stage | 235 | Women | 119 | Men | 116 |
| Total Participants - Second Stage | 230 | Women | 106 | Men | 124 |

*Source:* created by the authors.

# Appendix C: implementation of restoration actions

The partnership with the MST settlements began in the second half of 2022, and the first actions to assess potential areas for AFS and ANR implementation took place in November of the same year. During this period, discussions started with the aim of mobilizing settlers interested in implementing AFS on their plots, and a budget for inputs for AFS implementation was presented. Reports from MST technicians briefly describe settlers' engagement with the project in the territory:

> *"We are eager to expand our capacity to include participants, as many people are excited to develop AFS and enhance their ANR areas. Apparently, envisioning healthy land use alternatives for producing healthy food appeals to all peasants. Recognition of the beneficial environmental services provided by regenerated areas is always unanimous; collective identity inevitably revolves around forest systems here in the Amazon Biome. Planting trees and producing healthy food is a common goal that needs to be made viable. (...) We need to understand how to facilitate the inclusion of interested parties exceeding those previously anticipated by the Project, how to include more than 150 families for a massive participation of settlers."*
>
> *Reported by an MST technician*

The establishment of seedling nurseries was a strategy envisioned in the project to support the achievement of ANR and AFS implementation goals, facilitating access to seedlings and inputs and ensuring the settlements' autonomy to maintain restoration efforts. In this process, Imazon acted as a mediator with the communities and the Association of Women Farmers (Amacampo), an MST organization responsible for resource allocation, management and reporting on activities.

In November 2022, MST technicians started gathering information on the materials and inputs needed for the nurseries. In January 2023, they started assessing production potential and identifying seed collection points. Amacampo facilitated the hiring of nursery workers. Continuous capacity-building efforts were reinforced to increase production gains and, most importantly, ensure decent working conditions in seedling production, strengthening the local restoration chain.

From October to December 2023, nursery activities focused on seed collection, selection, processing and sowing. The seedlings produced in the first stage were requested based on nursery demand and the intentions of the settlers involved in the project. Some of the native forest and fruit species sown during this period were distributed in early 2024.

Between April and June 2024, basic infrastructure installations were completed in the nurseries, along with rainwater harvesting and storage systems, seedling distribution in two settlements, and seedling planting and maintenance. The production of seedlings of native species with the greatest potential for environmental recovery and adaptability to local conditions was prioritized, including ***açaí***, ***cupuaçu***, cocoa, yellow ipe, ***acapu*** and ***angelim***. Seed germination was difficult during this period, especially for non-native species. Nevertheless, the production of 52,784 seedlings was achieved in the five project settlements during the period (Table C1).

Table C1 | **Number of seedlings produced in the settlement nurseries**

| SETTLEMENT | SEEDLINGS PRODUCED OCT-DEC/2023 | SEEDLINGS PRODUCED APR-JUN/2024 |
|---|---|---|
| Abril Vermelho | 5.618 | 13.015 |
| João Batista II | 4.102 | 9.372 |
| Luís Carlos Prestes | 6.130 | 8.205 |
| Mártires de Abril | 7.493 | 9.460 |
| Paulo Fonteles | 12.059 | 12.732 |
| **Total** | **35.402** | **52.784** |

*Source:* created by the authors.

Between October and December 2023, 35,402 seedlings of 24 species were produced, of which 5 are exotic and 19 are native to Brazil, as shown in Table C2. However, this survey of produced species was not carried out by the settlers for the production period referring to the year 2024.

Table C2 | **List of species produced by settlement nurseries from October to December 2023**

| POPULAR NAME | SCIENTIFIC NAME | FAMILY | ORIGIN |
|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | Malvaceae | Exotic |
| Hibiscus | *Hibiscus rosa-sinensis L.* | Malvaceae | Exotic |
| African mahogany | *Khaya ivorensis A.Chev.* | Meliaceae | Exotic |
| *Moringa* | *Moringa oleifera Lam.* | Moringaceae | Exotic |
| *Acerola* | *Malpighia emarginata DC.* | Malpighiaceae | Exotic |
| *Açaí* | *Euterpe oleracea Mart.* | Arecaceae | Native |
| White açaí | *Euterpe oleracea var. branco Mart.* | Arecaceae | Native |
| *Andiroba* | *Carapa guianensis Aubl.* | Meliaceae | Native |
| *Araticum* | *Annona crassiflora Mart.* | Annonaceae | Native |
| *Bacabi* | *Enocarpus mapora Miq.* | Rhizophoraceae | Native |
| Cashew apple | *Anacardium occidentale L.* | Anacardiaceae | Native |
| Cocoa | *Theobroma cacao L.* | Malvaceae | Native |
| *Fava tamboril* | *Enterolobium maximum Benth.* | Fabaceae | Native |
| Soursop | *Annona muricata L.* | Annonaceae | Native |
| *Ingá* | *Inga spp.* | Fabaceae | Native |
| Yellow ipe | *Handroanthus serratifolius (Vahl) S.O.Grose* | Bignoniaceae | Native |
| Purple ipe | *Handroanthus avellanedae (Raddi) Mattos* | Bignoniaceae | Native |
| Pink ipe | *Handroanthus heptaphyllus (Vell.) Mattos* | Bignoniaceae | Native |
| *Jatobá* | *Hymenaea courbaril L.* | Fabaceae | Native |
| *Maranhoto* | *Annona coriacea Mart.* | Annonaceae | Native |
| *Marupá* | *Simarouba amara Aubl.* | Simaroubaceae | Native |
| Brazilian mahogany | *Swietenia macrophylla King* | Meliaceae | Native |
| *Muruci* | *Byrsonima crassifolia* | Malpighiaceae | Native |
| *Paricá* | *Schizolobium amazonicum Huber* | Fabaceae | Native |

*Source:* created by the authors.

The production goal of 72,000 seedlings was set for the partnership. However, the settled families understood the potential to increase this volume and thus contribute to the goals of MST's "Plant Trees and Produce Healthy Food" National Plan. The stated priority was to fully meet the project's demand, without losing sight of the potential supply for MST's donations and initiatives, as well as potential sales.

During the partnership, the nurseries faced several challenges, including extreme weather variations, irrigation system failures and a lack of quality seeds for seedling production. Solutions included adjustments to irrigation systems, improved management techniques, collection and selection of seeds from the benefited territories to optimize the planting environment, and partnerships with research institutions. The intensity of challenges depends on the structural and ecological particularities of each settlement. However, collective mobilization and the strengthening of a self-managing culture proved decisive in overcoming the challenges involved in the implementation of restoration in agrarian reform settlements (Figure C1).

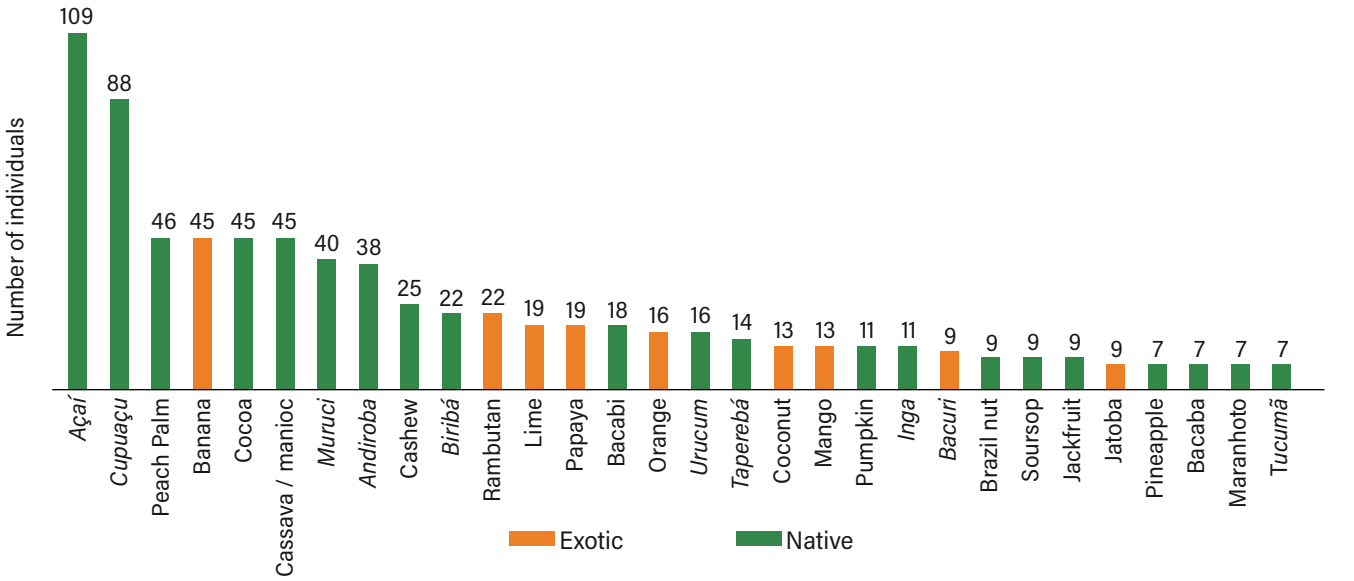
Figure C1 | **Collective work in nursery activities**

*Source:* MST, 2023. Institutional archive.

Future goals include expanding nursery production capacity, increasing the diversity of cultivated species and improving management practices. However, developing strategies to ensure continued community engagement, capacity building and community awareness are priorities to ensure the project's sustainability.

Two years after the beginning of the project, the results of visits to the supported families' areas indicated the identification of 76 different species in the 114 supported AFS areas across the five settlements. The Abril Vermelho settlement leads with 54 species, followed by Paulo Fonteles with 37, Mártires de Abril with 31, and João Batista II and Luís Carlos Prestes with 29 species each. Figure C2 presents the 32 most frequent species and indicates their origin (native to Brazil or exotic).

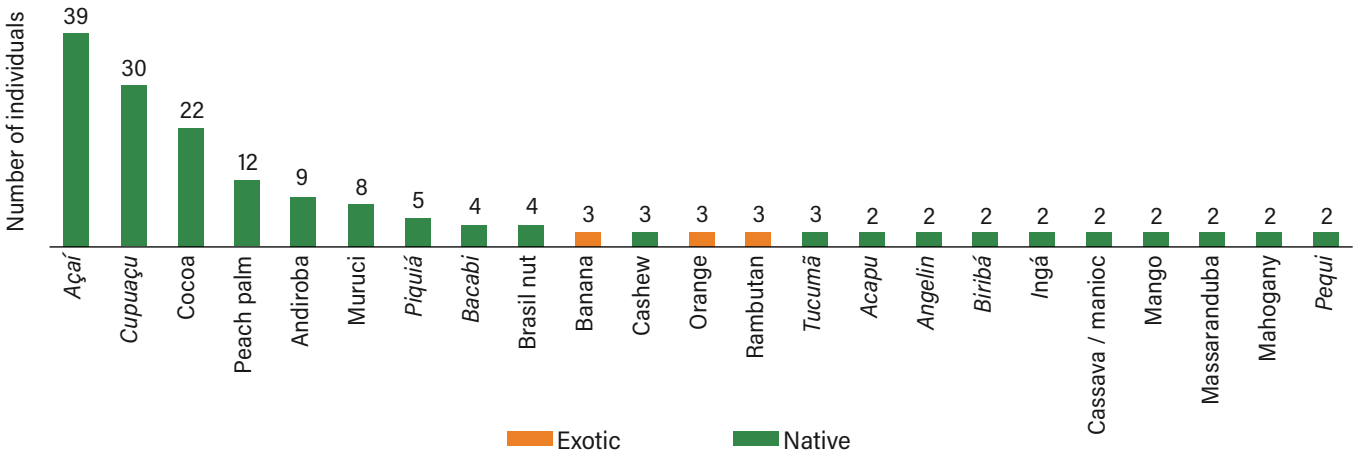
Figure C2 | **Main species identified in the AFS areas of the families visited in the five project settlements**




*Source:* created by the authors.

In the 62 ANR areas visited, 40 different species used for enrichment were identified. 23 different species were identified in the Mártires de Abril settlement; 22 species in Abril Vermelho; 14 species in Paulo Fonteles; and João Batista II and Luís Carlos Prestes with 6 species each. Figure C3 shows the 24 most frequent species and indicates their origin (native to Brazil or exotic).

Figure C3 | **Main species used for enrichment in the ANR areas of the families visited in the five project settlements**




*Source:* created by the authors.

## ENDNOTES

4. Agroforestry Systems (AFS) are forms of land use that synergistically integrate trees, crops and/or livestock, promoting ecological and economic benefits. These systems increase biodiversity, improve soil conditions and contribute to agricultural resilience (Gonçalves et al., 2021).

5. This approach is characterized by integrating theory and practice, alternating learning spaces between the school environment and communities, promoting a continuous exchange of knowledge. Thus, technical knowledge is integrated with local experiences, making learning more relevant and applicable to the daily lives of the people involved (Gonçalves et al., 2024).

6. The Norwegian International Climate and Forest Initiative – NICFI – is Norway's most important international effort to mitigate climate change by protecting the world's tropical forests. NICFI is administered by the Norwegian Ministry of Climate and Environment, in collaboration with Norad – the Norwegian Agency for Development Cooperation. The initiative supports bilateral agreements with forest countries, multilateral organizations and civil society.

7. In the context of this work, ecological functionality refers to the forest's capacity to maintain essential ecological processes, such as biodiversity, living biomass stocks, soil carbon sequestration, nutrient cycling, and the provision of fundamental ecosystem services for local communities and the economy, such as water regulation, soil fertility, and the supply of natural resources.

8. For the Landless Workers' Movement (MST), agroecology is understood as a practice, movement and science focused on promoting the production of healthy food and food sovereignty, integrating fair social relations and environmental stewardship, for the benefit of present and future generations.

9. This device allows specific points to be marked in the territory based on satellite signals, generating precise coordinates that can be used in maps and analysis.

10. Service plants are species cultivated to promote essential ecological functions in agricultural systems, with no harvesting or grazing purposes. They include herbaceous, shrub and tree species, and improve soil fertility, protect soil cover, control pests and enhance biodiversity. They also provide shade, produce organic matter and accelerate the natural processes of ecological succession (Jouhet et al., 2023; Götsch, 1996).

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## ABOUT WRI BRASIL

WRI Brasil works to improve people's lives, protect and restore nature, and stabilize the climate. As an independent research organization, we leverage our data, expertise and global reach to influence policy and catalyze change across systems like food, land and water; energy; and cities.

WRI Brasil is part of the World Resources Institute (WRI). Founded in 1982, our 2,000+ staff work on the ground in more than a dozen focus countries and with partners in over 50 nations.

## ABOUT IMAZON

Imazon is a Brazilian non-profit research institution whose mission is to promote conservation and sustainable development in the Amazon. The institute was founded in 1990 and is headquartered in Belém, Pará. Imazon's work is carried out through five programs: Protected Areas; Law and Sustainability; Amazon Monitoring; Policy and Socioeconomics; and Landscape Restoration. For more information: www.imazon.org.br.

## ABOUT MST

The Landless Rural Workers' Movement (MST) is an independent peasant social movement that unites and organizes rural workers and society to promote land reform and develop a project for the masses in Brazil. Present in 24 states, MST brings together approximately 450,000 families who have gained land tenure through collective struggle and organization.

The popular land reform project, which guides MST's actions, proposes a structural transformation of the Brazilian countryside. Its objective is to democratize access to land, oriented toward the production of healthy food, agricultural cooperation, food sovereignty and stewardship of natural resources – water, forests, seeds, biodiversity, minerals, among others. The movement also fosters the development of emancipated human relationships, enabling individuals who are capable of building new, solidarity-based relationships between rural and urban areas.

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