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Article *in* Agroecology and Sustainable Food Systems · August 2018

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Agroecology and Sustainable Food Systems

ISSN: 2168-3565 (Print) 2168-3573 (Online) Journal homepage: http://www.tandfonline.com/loi/wjsa21

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To cite this article: Leila Pires Bezerra, Fernando Silveira Franco, Vanilde F. Souza-Esquerdo & Ricardo Borsatto (2018): Participatory construction in agroforestry systems in family farming: ways for the agroecological transition in Brazil, Agroecology and Sustainable Food Systems, DOI: 10.1080/21683565.2018.1509167

To link to this article: https://doi.org/10.1080/21683565.2018.1509167

Published online: 28 Aug 2018.

AGROECOLOGY AND SUSTAINABLE FOOD SYSTEMS
https://doi.org/10.1080/21683565.2018.1509167

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Participatory construction in agroforestry systems in family farming: ways for the agroecological transition in Brazil

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ABSTRACT

This article aims to analyze the implementation of Agroforestry Systems (AFS) by family farmers, assessing their contribution to agroecological transition and understanding the process of knowledge construction. The study was carried out in family farming farms in the Sumaré Rural Settlement, and in the area of Family Farming and Agroecological Cooperative (Cooperacra), respectively located in the municipalities of Sumaré and Americana, São Paulo State, Brazil. The methodology was based on a case study, using Focal Groups and Field Notes as research instruments. On the basis of our analysis, there were social changes in the farmers' organization and in the decision-making process, as well as in the landscape in the areas of AFS and surroundings, where agroecological principles were also applied to production. In Sumaré, the four farmers participating in the project organized themselves to obtain organic certification. Cooperacra, which works with a group of 10 farmers advanced in the process of agroecological transition, starting from an intensive organic horticulture production system to a biodiverse agroforestry system. Despite the short time of the project, the construction of knowledge in relation to agroforestry systems was perceived through management techniques incorporated by the farmers in their agroecosystems. The arboreal component, which thus far the farmers had seen as something to be eliminated to realize agriculture, was introduced and became a relevant part of the process. The results demonstrate the feasibility and potential of AFS in the process of agroecological transition toward a more sustainable agriculture.

ARTICLE HISTORY
Received 27 November 2017
Revised 15 July 2018
Accepted 3 August 2018

KEYWORDS
Knowledge construction; sustainable agriculture; ecological restoration

Introduction

In the 1950s and 1960s, the process of industrialization started in Brazil, triggering increasing levels of urbanization and introducing the industrial

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/wjsa.

agriculture model in the field. Between the 1960s and 1970s, these processes intensified due to the support offered by the government for the adoption of Green Revolution technological packages. The modernization of agriculture encouraged industries to produce large amounts of agrochemicals, chemical fertilizers, seeds, vaccines, and medicines, causing significant societal and environmental impacts to both urban and rural areas (Mazalla Neto 2009).

In this context, a profound change that goes through levels of transition toward sustainable agriculture is required. It is crucial to propose and adopt a rural development model widely based on sustainability, and that considers various dimensions such as economic, social, environmental, political, ethical, and cultural. Agroecology offers a theoretical-methodological basis to support these transition processes of industrialized agriculture toward a more sustainable one (Caporal and Costabeber 2007).

According to Sevilla Guzmán, agroecology can be defined as "the ecological management of biological systems through collective forms of social action that represent alternatives to the current model of industrial management of natural resources with proposals arising from their endogenous potential. These proposals seek a participatory development from the production to the alternative circulation of their agricultural products, establishing forms of production and consumption that contribute to face the current ecological and social crises" (Sevilla Guzmán 2001, 11).

The agroecological transition can be defined as the gradual process of change in the forms of handling the agroecosystem,[1] with the goal of moving from systems highly dependent on the use of industrial inputs to systems relying on ecologically based principles, methods, and technologies (Costabeber 1998).

In this sense, the use of Agroforestry Systems (AFS) can be considered a valuable tool to support the agroecological transition. "Agroforestry System is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In AFS, there are both ecological and economic interactions between the different components" (Nair 1984, 2–3).

The active role of farmers through participatory processes during the elaboration and execution of processes of agroecological transition is a crucial component to promote the empowerment and autonomy of social actors. Thus, unlike the conventional rural extension where peasants play a passive role receiving knowledge from extensionists, the agroecological transition should be based on processes of collective knowledge construction that respects the peasant knowledge and stimulates their autonomy (Altieri and Toledo 2011; Holt-Giménez 2006). The process of knowledge construction should rely on collective and horizontal relations to facilitate the recovery

and co-creation of knowledge (Coolsaet 2016), and to provide a dialogue of knowledge between different cultures (Martínez-Torres and Rosset 2014).

Successional AFS with high biodiversity are considered highly sustainable not only from the environmental perspective but also from the social and economic point of view. They are based on complex ecological relations, traditional knowledge, and on the local culture, relying on the understanding that all species fulfill a function within a natural ecosystem (Götsch 1995; Silva 2002).

The process of agroecological transition is less complex for the farmer when it is based only on an input substitution model, replacing agrochemical inputs with more green ones, without challenging the monoculture structure. However, the challenges in AFS are more significant considering the need to introduce the arboreal element, made up of different vegetal strata, following ecological succession principles, and introducing plants fulfilling different functions in the system.

Thus, the elaboration and improvement of agroecological methodologies, instruments, and technologies for the implementation of AFS are in high demand. They must rely on a participatory approach that encourages the construction and reconstruction of agroecological knowledge through the exchange of knowledge between the different social actors (Bolfe 2003).

Another important aspect of AFS is its potential for ecological restoration of protected environments. The relevance of keeping protected areas within the farms is widely recognized since these areas have an essential contribution to preserving natural resources and biodiversity. In Brazil, farmers are required by law to keep a Permanent Preservation Area (PPA)[2] on their farms; however, the cost to introduce and maintain these areas is relatively high, and it must be covered by the farmers, who do not receive any economic incentive.

Furthermore, beyond the costs, part of the farmland is directed toward environmental preservation and restricted from agricultural activities. Thus, the farmers are doubly burdened since they must expend economic resources to restore the preservation area and cannot use part of their farm for agricultural production.

As a result, establishing alternative forms for the restoration of protected areas now is in demand, mainly for family farming. Family farmers may contribute to environmental conservation and at the same time maintain their agricultural crops while not being deprived of economic returns. In this context, AFS offer a possibility to reconcile agricultural production with environmental conservation.

The research presented here aimed to analyze how the implementation of AFS can contribute to agroecological transition and knowledge construction among family farmers.[3]

Research methodology

The method used in this research was the use of what is known as "multiple case study," with the purpose of analyzing and understanding the differences and the similarities between two or more cases. It is a comprehensive method in terms of planning, collection, and analysis of data (Yin 1989).

The multiple case study was carried out with two distinct groups of family farmers, allowing the investigation and analysis of how agroecological knowledge was constructed, and how it was reflected in different local dimensions.

As the data collection instrument, we used the focus group technique, which has been widely used by researchers. The use of focus groups is notably useful after intervention processes to study their impacts and side effects; thus, focus groups are extensively used in social research to understand the impacts of an intervention. (Gatti 2005). Research with focus groups aims to acquire concepts, feelings, attitudes, beliefs, experiences, and reactions that would not be possible through other methods (Morgan and Krueger 1993).

Therefore, this tool of data collection contributed to understanding the existing differences among farmers perspectives, ideas, feelings, representations, and behaviors, as well as to understanding the factors that influenced their decisions.

Four different focus groups were held during the research, two in each study area Sumaré rural settlement, and Cooperacra. In Sumaré rural settlement, four farmers that implemented AFS in their plots participated in each focus group meeting. In the focus groups performed in Cooperacra, 10 farmers took part in the meetings. During each focus group meeting, we performed collective interviews to gather information through group interactions. The focus groups helped to collect data in different stages, such as farmers' perception of agroforestry techniques before and after the project intervention, AFS planning, indicators for AFS monitoring, and labor assessment.

In addition to focus groups, Field Notes were used to record qualitative observations during the field research. This is a tool widely used for recording data based on the researcher's perspective on the situations that occurred in the field, then becoming a tool for the researchers to reflect on their perceptions (Lopes et al. 2002). After each field excursion, we recorded relevant observations on farmer's feelings, attitudes, experiences, and reactions, as well as farming practices that have changed the landscape. This practice was relevant to the data analysis.

Various field excursions to the study areas occurred in different periods, covering the AFS planning, implementation, maintenance, and monitoring activities. This continuous sequence of visits to the study areas enabled us to comprehend the processes of knowledge construction and agroecological

transition. Fifty-two field excursions were carried out to the study areas during the research period.

Semi-structured questionnaires were also given to farmers to collect personal and farm data, such as their age, occupation, educational level, farm history, initial and current AFS area, and information about the commercialization of their products before and after the implementation of AFS.

The data collection with the focus groups and Field Notes was carried out from July 2015 to July 2017.

Research context

The project "Agroecological Transition of Family Farming in the Region of Campinas, São Paulo State: the *praxis* of Teaching, Research, and Extension at Unicamp Agroecology Network," aimed to strengthen and deepen the teaching, research, and extension activities in agroecology in the region of Campinas/SP. Its goal was to support the sustainable local and regional development promoting agroecological transition processes. As a result, the project aimed to foster food and nutritional security among family farmers, increase their income generation, and support the recovery of degraded areas by implementing AFS (Oliveira 2014).

The project was structured in six thematic axes, and the case studies presented in this article refer to the axis "Organization of family farmers in the implementation of AFS for the agroecological transition." The objective of this axis was to promote and support the agroecological transition among family farmers, encouraging them to implement AFS; thus, promoting a new sustainable model of rural development (Oliveira 2014). The other axes are not detailed here since this research did not address their actions.

Participatory actions and practices to promote the agroecological transition were proposed by the project, integrating educational, research, and extension perspectives. These activities were carried out based upon the insights of Brazilian pedagogue Paulo Freire, who considered that in the rural extension process, the extensionist is a facilitator in the educational process, and both facilitator and learner can acquire, share, and exchange knowledge (cognitive subjects) intermediated by the object they both seek to know better (Freire 1983). Therefore, according to Freire, one cannot simply extend knowledge to other since "knowing is the task of subjects, not objects. And as subject and only as subject, a man may acquire knowledge".

Thus, while supporting the implementation of AFS, the project facilitators had also the role of collectively with the farmers developing methods and practices that could contribute to their own empowerment and autonomy.

Study area

AFS were implemented in four plots in the Sumaré rural settlement, located in the municipality of Sumaré, and in a single plot of the Family Farming and Agroecological Cooperative (Cooperacra), located in the municipality of Americana.

Figure 1 shows the location of the study areas, both part of the Metropolitan Region of Campinas in the São Paulo state – Brazil.

The Sumaré rural settlement is situated 3 km from the city center. It was established in 1984 when the State government designated 855.2 ha to meet the demands of landless farmers to produce their own food. The settlement was a result of the mobilizations of rural workers who lived in the outskirts of the city of Sumaré. They started meeting in 1983 to carry out biblical reflections, which resulted in discussions about the political and economic reality of the country. After several meetings, inspired by the idea of becoming small-holder farmers, these rural workers decided to occupy different public lands. As a result of the farmers' pressure, after several days of negotiations with the government, they were settled in the Sumaré (Bergamasco et al. 1996).

Currently, the Sumaré settlement is divided into three nuclei – Sumaré I, II, and III – where 67 settled families live and cultivate the land. In addition to families holding lots, there are several others mainly linked by kinship ties living and working in the settlement. A total of approximately 800 people – children, youth, adults, and elderly – depend directly or indirectly on agricultural activities in the settlement. Farmers are mainly engaged in growing fruit and horticulture with their production based on the use of agrochemicals and mechanization.

The other case study, the Family Farming and Agroecological Cooperative (Cooperacra), in Americana, was established in 1987 as an association, becoming a cooperative in 2008. Its headquarters and common production area are located in the municipality of Americana. The objective of Cooperacra is the sustainable production and commercialization of organic products.

The embryo of the cooperative was a farm family that came from the state of Paraná indebted due to the agribusiness model and settled in the Americana region searching for better living conditions. This family mobilized a group of 37 landless families and triggered a negotiation with representatives of the state government to cultivate a parcel of abandoned public land for the sustenance of their families. The negotiation process, which lasted 2 years, was finally endured by 12 families of these families who finally able to begin. At the present, 34 families are part of the cooperative (Castro 2014).

The area cultivated by the Cooperacra members belongs to the State of São Paulo. It includes 27.74 ha that are collectively cultivated by the families, and

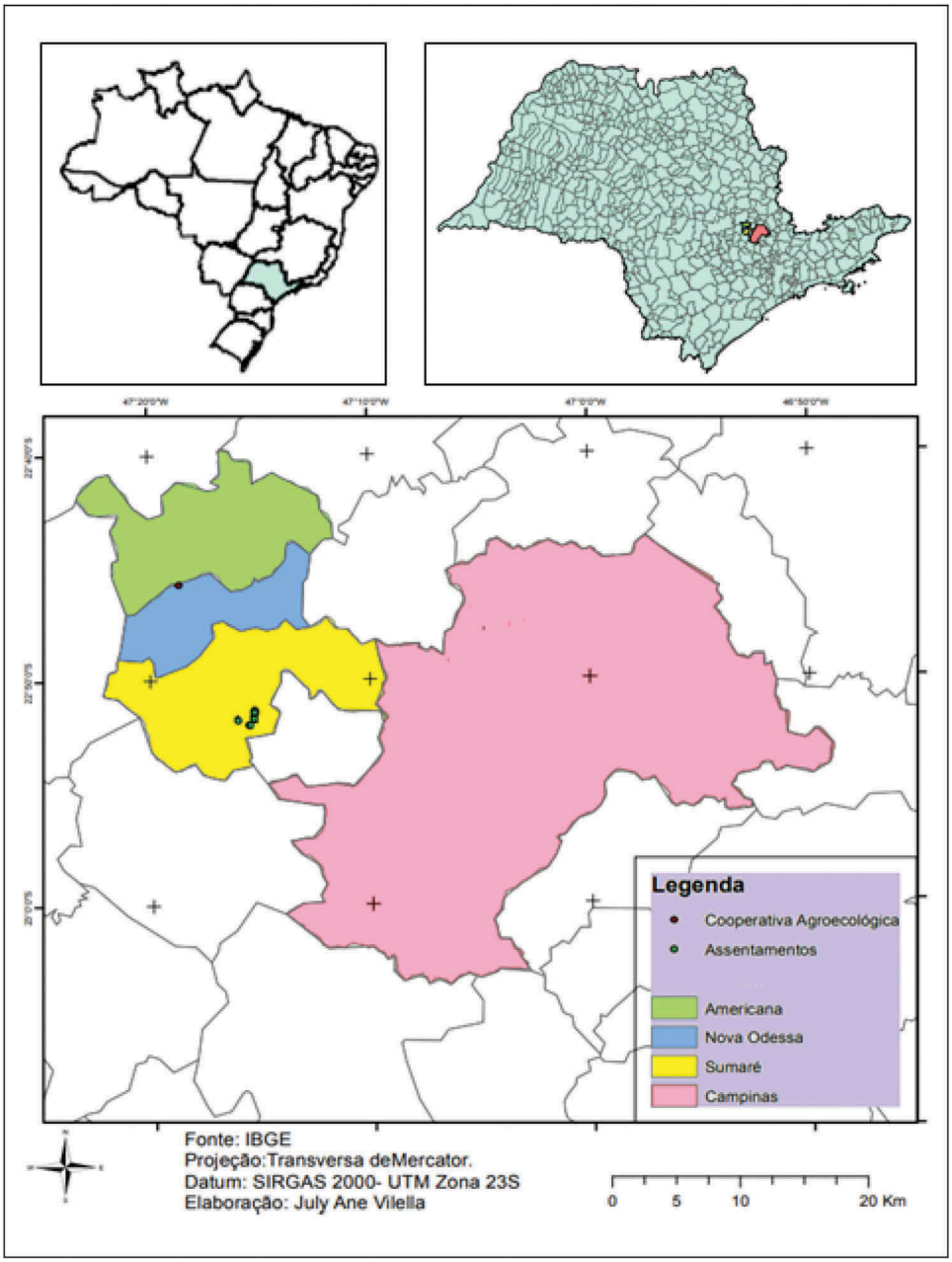

Figure 1. Location of the Sumaré II and III settlement reference units, and the family farming and agroecological cooperative (Cooperacra) in Americana. Source: Unicamp Agroecology Network (Rede de Agroecologia da Unicamp, 2017).

its use is regulated by an agreement signed by farmers and representatives of the State government.

Despite the significant progress of the group toward organic production, to advance in the agroecological transition, the farmers found it necessary to

use some external inputs. Their agroecosystems neither contained the necessary biodiversity for maintaining full system balance nor did they guarantee sufficient income for the farmers.

This research assessed the implementation of Reference Units (RUs) in AFS in both areas – Sumaré rural settlement and Cooperacra. In the Sumaré rural settlement, four RUs were implemented, in four different plots, with 500 m^2 each, totaling 2,000 m^2. In the Cooperacra one RU was implemented, which occupies approximately 1,000 m^2 and is managed collectively by 10 cooperative farmers belonging to 8 families.

Regarding the profile of our collaborators – four in the Sumaré settlement and 10 in the Cooperacra – the majority are relatively young with ages ranging from 30 to 64 years old and most of them are in their 40s. In the Sumaré settlement, three people responsible for AFS are men and one person is a woman. In Cooperacra, five are women, and five are men.

In Sumaré settlement, two farmers are carpenters, with agriculture being their secondary occupation. Two others have agriculture as their primary activity. In Cooperacra all farmers have agriculture as their main occupation.

Regarding the level of formal education, in the Sumaré settlement one farmer has graduated from college, two farmers have finished elementary school, and one has not finished elementary school. In Cooperacra one farmer has graduated from college and also attained a post-graduate degree, one farmer has a technical high school level education, and the others have not completed elementary education. Although some farmers do not have a high degree in formal schooling, many of them have extensive empirical knowledge about agriculture and natural techniques, which is of great value and has been acquired during years of practical experience

Construction of knowledge and the AFS development

The proposal for building a new rural development model no longer includes the use of ready-made recipes unrelated to local realities. Conversely, it relies on the prominence of local social actors, who should be empowered and aware of their citizenship condition. Thus, they can build their development based on solid foundations and proposals in tune with their reality (Vione 2002).

In this sense, all the activities of the project prioritize a systems approach, collective action, and the farmer's commitment as co-responsible social actors for the development of technologies and local solutions to their problems.

The project actions were organized according to the following actions: (1) Project Presentation; (2) Workshops to Exchange Knowledge; (3) Visits to

Exchange Experiences; (4) AFS Planning; (5) Implementation of AFS; (6) Monitoring Workshops; (7) Follow up; and (8) Assessment.

The first stage was the **Project Presentation** with meetings among the project members and farmers. The first stage sought to bring different social actors involved in the project closer together (farmers, researchers, extensionists, and students), as well as the discussion of the project proposals according to the interests of the farmers. The proposal to implement AFS in Permanent Preservation Areas (PPAs) was a way of respecting farmers' resistance to the introduction of AFS directly into productive areas.

In the Sumaré settlement, all of the 27 families of the area II were visited and invited to attend the Project Presentation meeting. The farmers defined criteria for selecting the plots where the AFS would be implemented since the farmers' interests were the primary goal of the project. The four selected farmers decided to implement AFS individually in their plots. Although the project intended to stimulate the AFS implementations in collective spaces, the farmers' decisions were respected. The farmers justified their decision due to the lack of social organization among them. In Cooperacra, the farmers decided to implement a collective AFS since all their land is cultivated in this way.

Subsequently, the **Workshops to Exchange Knowledge** were held seeking the construction of knowledge through dialogue, based on the Frerian perspective, which seeks to develop a horizontal relation between extensionists and farmers, encouraging the emergence of knowledge grounded in collective construction (Freire 1983). This perspective supported the group in building their comprehension about AFS, discussing its principles, dynamics, and functioning.

The workshops provided practical experiences of comparative observation related to preserved and degraded environments, raising ideas and sensations about different constituent elements of these environments, such as vegetation, soil, animals, solar radiation, temperature, and sound. These observations were useful in later debates about ecological processes driving AFS, as well as in understanding the importance of the arboreal element.

A striking moment of this stage was when the participants presented their perception of AFS through graphics and artistic representations. This technique was chosen since it is a more democratic form of expression, considering the possibility of having illiterate people in the group and as a way of releasing unconscious perceptions that could not be expressed through words. The graphics and artistic representations minimized that the speech of one participant influenced the other, and enabled the farmers to reflect over their ideal AFS, placing them in the space-time reference of productive possibilities of a new agricultural standard.

The third project stage was the **Visits to Exchange Experiences** when the farmers had the opportunity to visit some reference AFS in other locations, such as the Sepé Tiarajú settlement, the Mário Lago settlement, and the São Luiz Farm, all in the region of Ribeirão Preto in the state of São Paulo. The visits were an opportunity to share experiences among farmers, based on the "Campesino-to-Campesino" methodology, which is a participatory way of promoting and improving peasant production techniques. It is based on the principle that participation and empowerment are essential elements in sustainable development, focusing on self-initiative and the prominence of peasants. The methodology seeks to scale-out sustainable agriculture, reinforcing solidarity and mutual ties among peasants, as well as rescuing local knowledge and culture (PIDAASSA 2006).

This activity provided a leap forward regarding group learning since it enabled the farmers to observe implemented AFS and understand its functioning in practice, materializing and strengthening the knowledge about AFS. The opportunity of sharing knowledge with experienced farmers was essential for beginners becoming more confident, as well as bringing motivation and inspiration. Moreover, the visits also gathered people, grounded the identity of the group, and brought personal value from different experiences and realities.

After the visits, the farmers started **Planning** their AFS. This initially consisted of collecting and identifying surrounding plants as a way to retrieve and exchange their knowledge about plants. The possible role of each plant in an AFS was debated and farmers' identified the most known and used plants in their communities.

In a second moment of the **Planning** phase, farmers shared reflections on the types of AFS and the consortia of plants they intended to use. The application of the ecological succession concept was discussed in order to plant the species in the areas over time. The goal was to provide regular income to the farmer and the vertical occupation of the areas by different strata of plants, optimizing the land use, and the cooperation between plants to ensure the balance of the system.

To organize the work, the farmers listed the chosen species organized by categories on the basis of their functions in the AFS: (1) native forest[3] species Ingá *(Inga edulis)*, Ipê *(Zeyheria Tuberculosa)*, Jatobá (*Hymenaea courbaril*), Jequitibá Branco (*Cariniana estrellensis)*, etc. with the purpose of bringing diversity to the system; (2) fertilizer species with the function of bringing nutrients and biomass to the system (*Eucalyptus sp, Morus nigra, Gliricidia sepium, Musa sp*, etc.); (3) commercial fruit trees with the purpose of generating some income for farmers (avocado, acerola, mango, etc.); (4) agricultural species (cassava, yam, corn, beans, etc.) and vegetables (radish, lettuce, broccoli, etc.) with the purpose of generating income and bringing more diversity to the systems.

The consortia among plants were designed by the facilitators and farmers based on ecological succession and stratification concepts. Each plot had a specific arrangement of species, always considering that the AFS had the function of restoring the permanent preservation areas and generating income for farmers. Subsequently, the spacing and distribution of plants were determined, and the sketches with a schematic representation were drawn.

After planning, the AFS were **Implemented** through a collective effort that brought together the farmers responsible for the AFS, other farmers of the communities, facilitators, students, researchers, and project partners. First, the seedlings and cuttings of forest species were planted in lines, then the agricultural species and vegetables were planted between the those lines.

The project's resources enabled the acquisition of seedlings of native and exotic forest species and other required inputs for the AFS implementation, while farmers provided seeds and seedlings of agricultural species. The farmers were also in charge of the preparation of the areas, planting, and maintenance of the AFS.

The **Monitoring** workshops promoted the discussion about monitoring, its function, and how to carry it out. Considering the ideas of the group and the resources of the project, the environmental indicators selected were soil (soil moisture, soil cover, compaction, and soil analysis) and insects (quantity and diversity). Regarding the socioeconomic monitoring, questionnaires were applied to evaluate changes in income generation, food security, and social organization.

In soil monitoring, soil samples were collected in each of the five AFS areas, in three distinct periods, spaced 6 months apart. Chemical-physical analyses and Pfeiffer Chromatography tests were conducted on the samples to evaluate the evolution of the parameters over time. Pfeiffer Chromatography allows for the interpretation of qualitative and biological characteristics of the soil resulting in images with different colors, shapes, patterns, and zones. They are revealed on a circular filter paper sensitized with silver nitrate photo-reagent solution, where a soil solution of sodium hydroxide crosses and separates the different fractions by capillarity in these specific filter papers (Pfeiffer 1984; Restrepo and Pinheiro 2011).

The insect monitoring was carried out using the Pitfall Trap method. There are different shapes and models of this type of trap. However, it is basically a plastic container with bait and liquid to kill and preserve the insects (Favila and Halffter 1997). Four collections of insects were carried out in one year, allowing for the analysis of insects present in each plot throughout different seasons of the year.

Regarding socioeconomic monitoring, the socioeconomic status of those responsible for the AFS was analyzed at the beginning and the end of the project. The purpose was to verify whether AFS brought socioeconomic gains

such as an increase in income generation, new knowledge, and new socio-cultural relationships.

The farmers understanding and participation in monitoring, and in the analysis of its results brought meaning to their actions, leading them to reflect on the techniques adopted. Moreover, the data generated has been used in the decision-making processes related to production and commercialization.

In the **Follow-up** stage, the project technical team and farmers continued to meet systematically, discussing and deepening the knowledge on AFS, and performing the monitoring and management of the areas. In this stage, technical videos about experiences with AFS were used as a working tool, as well as publications on the subject. The farmers of the four reference units in the Sumaré settlement, who had not organized themselves into groups so far, started visiting each other to exchange experiences. The follow-up stage consisted of a field intervention, for planting or pruning the plants. The farmer responsible for the area shared how the management was carried out in his AFS, and other farmers and technicians presented suggestions to improve the system. Sumaré farmers also visited Cooperacra AFS for the same purpose.

The follow-up process was rich in terms of sharing and deepening knowledge about AFS. Moreover, it enabled the emergence of new social relations among the Sumaré farmers. The same happened in Cooperacra where the group met in the field to discuss the difficulties faced, and the advances achieved in AFS.

Finally, an **Assessment** of the work was carried out. In this stage, farmers reported everything they had learned with the implementation process of AFS and gave suggestions for continuing actions in future projects.

The agroforestry path to agroecological transition

After 2 years of practicing the construction of agroecological knowledge through participatory processes, several effective changes were observed since the beginning of the implementation of the AFS. Not only are the landscapes of the plots different but also the social actors who participated in the process have changed their way of seeing, thinking, feeling, and acting with agriculture.

According to farmers' assessments, they have acquired new knowledge about how to manage their agroecosystem; for instance, how to manage plant consortia, different vegetal strata, biodiversity in the agroecosystems, natural succession of different species, green manuring, microorganisms, cooperation among plants, pruning, and about the importance of keeping the soil covered. Moreover, beyond the technical aspects, they expressed that they evolved in the social dimension, learned to work collectively, coexist with

new people, and exchange experiences. They also expressed their happiness since they eliminated the use of pesticides.

The change in the way of seeing and thinking is portrayed in the testimony of a farmer from the Sumaré settlement:

"Along this time, I participated in workshops and implemented agroforestry, and my life changed a lot. It is with great satisfaction and joy that I say I have overcome some obstacles like working in groups, respecting the differences, and valuing other people's qualities. I have learned to be supportive and caring about other people. Getting rid of pesticides is a major victory".

A similar feeling can be perceived in the testimony of a Cooperacra farmer, who had already been working with organic production:

"My heart beats stronger when I hear about AFS. Organic farming is not a big deal for me after I have understood what an AFS is".

Similar results were discussed by Jalfim et al. (2013). They verified that the effective participation of the family farmers in all the stages of the project, especially in the planning, execution, monitoring, and assessment, is a fundamental condition to lead the actions more democratically and transparently.

The environmental evolution in most AFS is remarkable based on the observation of the soil cover, the presence of several consortia among plants, and on the biodiversity of the plots. Another relevant aspect is that the farmers started applying the agroecological principles in other areas of their farms, showing the appropriation and reproduction of the acquired knowledge. The farmers' speech demonstrates that they changed their vision regarding agriculture. They are concerned about soil preservation and fertility, and the system diversity and balance. The testimony of a farmer from the Sumaré settlement depicts her perception of the environment and agriculture:

"I have learned about green manure with the project. I didn't know that planting a certain type of vegetation would help the soil to nourish itself. I've also learned that plants do not compete, they cooperate with each other. I've learned that the land has a life. The soil has a life. I didn't know that. I thought only the plants were alive. Now I also understand that microorganisms are good".

Socially, the most important change in the Sumaré settlement is related to the farmers' initiative to organize themselves into groups. The change is a result of the learning and knowledge acquisition, which provide them autonomy and confidence to strengthen their work, and to change their production systems. The four farmers left conventional agriculture and the use of chemical inputs, to start the process of organic certification by the Participatory Guarantee Systems (PGS).[4]

This outcome of the project can be considered an important achievement since during the 33 years of the settlement's existence no area had been

certified organic. Moreover, in the municipality of Sumaré, there was only one farm with organic certification, according to the National Register of Organic Producers (MAPA 2017).

Sumaré farmers did not follow linearly the steps of the agroecological transition proposed by Gliessman (2000): (1) increase the efficiency of industrial practices; (2) substitute alternative practices and inputs; (3) redesign whole agroecosystems; and (4) (re)establish a direct connection among producers and consumers (Gliessman and Rosemeyer 2010). The construction of agroecological knowledge enabled farmers to leap some stages of the transition process, transposing stages 1 and 2 to stage 3. They redesigned their agroecosystems through diversified agroforestry techniques, performing an agriculture based on ecological and social processes.

Research with family farmers in the Alto Uruguai region demonstrated that the best results are achieved when steps 1 and 2 of the agroecological transition are almost immediate, and the focus is on an early redesign of the system. However, the situation of each production system at the beginning of the transition can interfere (Swiergiel 2007).

From a legal and commercial point of view, the transition occurs when there is no trace of synthetic chemicals in the products to be marketed for the last 1–3 years (Guzmán, González, and Sevilla 2000). However, from the ecological point of view, the period may be much longer.

Depending on the interest of the farmers, the agroecological transition may have different horizons, ranging from merely meeting standards of organic production, to replacing inputs, to creating truly sustainable agroecosystems (Khatounian 2001).

The process of reducing the use of chemical inputs and replacing them by ecological inputs is compulsory in larger scale monocultures and perennial crops already in production such as in fruit growing.

According to Guzmán, González, and Sevilla (2000), the way in which the stages of agroecological transition are introduced depends on several factors. Sometimes all agrochemicals are drastically eliminated based on the intention to sell the products in the organic market. On the other hand, the conversion often stops at the replacement of inputs, and never reaches the redesign of the agroecosystem. According to Guzmán, various factors can limit the progress of the transition, such as the high costs to acquire new machines and installations, but also because moving from monoculture to polyculture requires superior innovative management knowledge that implies risk. Therefore, Guzmán et al. propose that public policies must support initiatives of conversion and help to fund them.

The replacement of chemical inputs by ecological ones does not guarantee the sustainability of agroecosystems and often forces the farmer to get a new technological package based on organic inputs. In family farms, as shown in the case study presented here, farmers can develop a direct and more

sustainable way of management agroecosystems through the implementation of successional AFS with high biodiversity.

In one of the four properties in the Sumaré settlement, the AFS did not reach the expected development stage. According to the farmer assessment, it occurred because he was not responsible for the area and consequently did not have the autonomy to make decisions. Financial difficulties also prevented him from investing time and monetary resources in the area. This case stresses the importance of the farmer's autonomy to make decisions.

The implementation of AFS in Cooperacra has also levered several social, environmental and economic changes. Although this group of farmers has worked with organic production for 18 years, has had organic certification for 11 years, and has commercialized the production in several fairs and institutional markets,[5] they had no previous experience in AFS.

Some farmers have made new commitments to the AFS area, dedicating particular attention to the area, implementing several consortia among plants, generating ecological diversity, and improving fertility and soil structure. The results were motivating, and the agroecological techniques of AFS, such as soil cover and consortia among plants, were gradually transferred to the organic vegetable growing area. Finally, the group made the important decision to make the agroecological transition to AFS throughout the whole production area. The process is gradually progressing with Cooperacra's financial resources, and several beds have been intercropped with native and exotic forest species between vegetable species.

Although vegetables offer a fast economic return to farmers due to their short crop cycle, they also generate low profit and demand high labor. Thus, investing in fruit growing was a desire in Cooperacra for generating higher profits. However, investment in this area was not made due to the delay in the economic return of fruit production. After activities developed during the project, farmers understood that with the agroforestry system it is possible to produce vegetables between the fruit lines, and generate income with both crops in short and long-term.

At the beginning of the project, Cooperacra and the Sumaré Settlement presented different agricultural systems. Cooperacra farmers have worked with certified organic production for several years, while farmers in the Sumaré settlement worked according to conventional production. Considering this situation, it was a surprise to realize that Cooperacra farmers showed high resistance to change to AFS. It occurred because the Cooperacra group was not under as critical a situation as the farmers in Sumaré, who were exposed to pesticide contamination, insolvent, and with great market limitations. In this context, the Sumaré farmers were receptive to a new agricultural model. The fact that they had no confidence in agriculture based on the replacement of inputs made them receptive to a completely different and more complex system.

Also, we realized that the Sumaré farmers had more autonomy to make decisions related to the implementation and management of AFS since the AFS were installed in individual plots. The exception was the farmer who was not responsible for the area where he worked. In the Cooperacra group, some farmers were more convinced of the AFS benefits than others early in the beginning of the project, but they had to respect and wait until all the farmers were convinced to make more investments in the AFS.

When asked about their expectations for the future, farmers pointed out the need to deepen agroforestry techniques, mainly related to the management of AFS. They also pointed out the demand of funding to expand AFS areas, as well as the need of support to organize the farmers to sell their products in fairs, consumer groups, and CSAs (Community Supported Agriculture). Other expectations are related to training to multiply agroecological knowledge and the involvement of other farmers of the community in sustainable production. Summary characteristics of the plots that were involved in the study are presented in Table 1.

Table 1 shows the evolution of agricultural production from conventional to agroforestry in the Sumaré Settlement, and from organic to agroforestry in Cooperacra. It also presents the decision of farmers to expand the AFS areas in almost all production units, except Farmer 4. It also shows the marketing changes among the production units.

According to the soil chemical analysis and Pfeiffer Circular Chromatography, there was no significant evolution in soil quality in the AFS areas in the 18-month evaluation period, hence no data are presented with this study. However, the Cooperacra plot showed improvement in soil quality with an increase in organic matter content.

Regarding the insect monitoring, a great diversity of arthropods in the Cooperacra area and the areas of farmers 2 and 3 in the Sumaré settlement was noted. Also, an expressive number of arthropods of the *Hymenoptera* order was observed in all areas, mainly represented by ants. The high number is due to the ants' way of life, which is predominantly terrestrial, and organized in societies, which implies joint work and, consequently, many individuals are caught by the traps.

The research demonstrates that in both communities there were advances and significant changes after the experiences with AFS, especially considering the short time in which the changes occurred. However, according to the testimony of farmers, and due to the complexity of the system itself, continuous actions are required to deepen knowledge, mainly on AFS management, and over time, there is great potential for more obvious changes.

Table 1. Summary of some characteristics of the studied plots.

Farmers	Property history prior to project	Current history	AFS Initial size	AFS current size	Marketing prior to AFS	Current marketing
Farmer 1 -Sumaré Settlement	Conventional agricultural management	AFS biodiversity in PPA andsurroundings	500m^2	5.000m^2	Non-commercialization of agricultural production	Organic fair
Farmer 2 -Sumaré Settlement		AFS biodiversity in PPA and surroundings		2.000m^2	Conventional local market	Organic fair, consumption group, and conventional local markets
Farmer 3 - Sumaré Settlement		AFS in PPA		1.000m^2	Non-commercialization of agricultural production	Not yet started marketing
Farmer 4 - Sumaré Settlement		AFS in PPA		500m^2	Conventional local market	Organic fair
Cooperacra	Certified Organic Vegetables	AFS biodiversity in PPA and surroundings	1.000m^2	14.000m^2	PAA, PNAE and organic fair	PAA, PNAE and organic fair, including fruit production

Conclusion

We concluded that in both communities one aspect that favored the implementation of AFS was the proposal to introduce them in Permanent Preservation Areas (PPA), which are legally destined for restoration and cannot be used for conventional agriculture. Implementing AFS initially in PPAs, in small areas, may be a viable way to use these areas. Furthermore, farmers may learn about the system until they feel confident to reproduce it in areas already destined for agricultural use.

We believe that the proposition of an agroecological transition without planning the redesign of agroecosystems in the medium and long-term, and based only on the replacement of chemical inputs by others that are ecologically-based, may generate feelings of hesitancy and resistance among the farmers, preventing them from evolving their agricultural systems to more sustainable ones. It occurs when the comfort zone experienced by farmers grows, when they master the ecologically-based package, and they gain access to the market for certified organic products.

Our finding shows the potential of successive AFS with high biodiversity in promoting leaps in the agroecological transition process since they allow the direct redesign of agroecosystems. The redesign must be based on a collective construction and horizontal dialogue between farmers and extensionists, aiming to build a better understanding of the ecological and social processes and guaranteeing the independence of external inputs in the medium and long-term. Our results point out the viability of AFS based on participatory processes in promoting the agroecological transition.

The gains with the process are fundamentally attributed to the construction and acquisition of agroecological knowledge achieved by farmers. The understanding of agroecological principles allows farmers to abandon conventional technological packages and realize the importance of biodiversity in agroecosystems.

Notes

1. Agroecosystem is the fundamental unit of study, in which mineral cycles, energy transformations, biological processes, and socioeconomic relations are seen and analyzed as a whole. According to agroecological research, its objectives are not the maximization of production of a particular activity, but the optimization of the agroecosystem as a whole. Thus, it requires greater emphasis on knowledge, analysis, and interpretation of complex relationships among people, crops, soil, water, and animals (Altieri 1989).
2. According to the definition of Brazilian Law, Permanent Preservation Area is a protected area, covered or notby native vegetation with the environmental function of preserving water resources, landscape, geological stability, and biodiversity,facilitating the gene flow of fauna and flora, protecting the soil toensure the well-being of human populations (Lei n. 12.651 / 2012).

3. According to Secretaria do Meio Ambiente(Secretariat of Environment) that defines criteria and procedures forthe implementation of Agroforestry Systems (SMA - Resolução nº44, de 30 de junho de 2008).
4. Participatory Guarantee Systems are characterized by social control and joint responsibility, and can house different methods of credibility generation that are appropriate to different social, cultural, political, territorial, institutional, organizational, and economic realities, MAPA (2009).
5. Institutional markets are those where the State acts as the buyer of the products. They have rules that may be defined by members of civil society, social movements and, above all, by the State. The institutional markets that Cooperacra participates in refers to the Food Acquisition Program (PAA), and the National Program of School Feeding (PNAE).

Funding

This work was supported by the Conselho Nacional deDesenvolvimento Científico e Tecnológico e Ministério do Desenvolvimento Agrário (Edital MDA/CNPq 039/2014 - Process CNPq 472894/2014-15). Ricardo Borsatto was partially supported in this research by the grant #2017/04577-1, São Paulo ResearchFoundation (FAPESP).

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