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Forest and landscape restoration governance: Initiatives and the social actors' network in the São Paulo portion of the Paraíba Valley

Governança da restauração de paisagens e florestas: iniciativas e a rede de atores sociais do Vale do Paraíba paulista

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ABSTRACT: Tropical forests are historically affected by deforestation, environmental degradation and socio-environmental transformations, which turns these ecosystems into priority areas for biodiversity conservation and restoration of forests and landscapes. The *Mata Atlântica* region brings together social, environmental and institutional conditions for the implementation of restoration initiatives, particularly in the state of São Paulo portion of the Paraíba Valley. The article aims at describing the history of initiatives, the network of social actors and the interactions that shape Forest and Landscape Restoration (FLR) governance in the Paraíba Valley. Semi-structured interviews and social landscape mapping were used for data collection, as well as content and social network analyses. Forest and Landscape Restoration actions have been taking place in the Paraíba Valley for at least 15 years, currently involving around 92 local and regional social actors. It is understood that the Paraíba Valley social landscape offers favorable conditions for the advancement of Forest and Landscape Restoration initiatives given the multiplicity of actors and interactions between levels. The results suggest that project and program decision-makers should prioritize the social roles of intermediation, dissemination and change agents to integrate peripheral actors in the Forest and Landscape Restoration network.

Keywords: governance; forest and landscape restoration; social landscape; *Mata Atlântica*; social networks analysis.

RESUMO: As florestas tropicais são historicamente afetadas por ações de desmatamento, degradação ambiental e transformações socioambientais, o que faz desses ecossistemas áreas prioritárias para a conservação da biodiversidade e a restauração de paisagens e florestas. A Mata Atlântica reúne condições sociais, ambientais e institucionais para a implementação de compromissos pela restauração, em particular no Vale do Paraíba Paulista. O objetivo do artigo é descrever o histórico de iniciativas, a rede de atores sociais e as interações que configuram a governança da restauração de paisagens e florestas no Vale do Paraíba Paulista. Entrevistas semiestruturadas e o mapeamento da paisagem social foram utilizados para levantamento de dados, além de análises de conteúdo e de redes sociais. As ações de restauração de paisagens e florestas (RPF)estão ocorrendo no Vale do Paraíba Paulista há pelo menos 15 anos, envolvendo atualmente cerca de 92 atores sociais em diferentes níveis. Entende-se que a paisagem social do Vale do Paraíba Paulista oferece condições favoráveis ao avanço de iniciativas de RPF dada a multiplicidade de atores e interações entre níveis. Os resultados sugerem que tomadores de decisão de projetos e programas devem priorizar os papéis sociais de intermediação, disseminação e de agentes de mudança com o objetivo de integrar atores periféricos na rede da RPF.

Palavras-chave: governança; restauração de paisagens e florestas; paisagem social; Mata Atlântica; análise de redes sociais.

1. Introduction

Tropical forests are historically affected by deforestation, environmental degradation and socio-environmental transformations, which turns these ecosystems into a priority for policies and research into biodiversity conservation and Forest and Landscape Restoration (FLR) (Melo *et al.*, 2013; Ball *et al.*, 2014; Schweizer et al., 2019). Under the Paris Agreement, Brazil has made commitments to restoration and reforestation under its Nationally Determined Contribution (NDC), such as the target of restoring 12 million hectares by 2030 (Brazil, 2020). To this end, in 2017, the National Policy for the Recovery of Native Vegetation (Política Nacional para Recuperação da Vegetação Nativa, PROVEG) (Decree No. 8,972 of January 23rd, 2017) (Brazil, 2017) and its main implementation instrument, the National Plan for the Recovery of Native Vegetation (Plano Nacional de Recuperação da Vegetação Nativa, PLANAVEG) (Interministerial Ordinance No. 230 of November 14th, 2017), were instituted (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, 2017). PLANAVEG aims at promoting policies and programs to encourage the recovery of forests and all other forms of native vegetation, as well as the environmental regularization of Brazilian rural properties, under the terms of the Native Vegetation Protection Law (Law No. 12,651/2012) (Brasil, 2012).

The concept of Forest and Landscape Restoration (FLR) signals an advance from the small-scale forest restoration approach to the landscape scale, incorporating the provision of multiple livelihood functions and ecosystem services (Chazdon et al., 2016). FLR is a long-term process that seeks to rehabilitate the ecological functionality of ecosystems (production of goods, services and ecological processes) and to improve human well-being in degraded forest landscapes (IUCN, WRI, 2014).

For FLR objectives to be achieved, it is not enough for financial resources and technical projects to be available, as many of the challenges encountered in the successful implementation of restoration actions are directly related to social and institutional aspects (Mansourian, 2017). Gaining scale in forest restoration requires overcoming lack of technical assistance; simplifying legal bureaucracies that affect rural producers; improving planning and monitoring mechanisms (Interministerial Ordinance No. 230 of November 14th, 2017); and institutional adjustments between public organizations responsible for operationalizing FLR mechanisms (e.g., Environmental Regularization Plans, ERPs). Added to the involvement efforts by multiple social actors, all these aspects are necessary to establish favorable conditions for continuous and long-term FLR actions (Agrawal, 2007; Melo et al., 2013; Ball et al., 2014; Mansourian, 2017; Schweizer et al., 2019). The complexity of implementing successful FLR processes requires the development of FLR governance models capable of integrating the interests and legal requirements of public, private and civil society actors. Forest and landscape restoration governance1 can be understood as the connection and interaction of a broad set of social actors over time, in order to exert an influence on the implementation of FLR initiatives (Mansourian, 2017). Understanding these links involves identifying who the social actors in the network are and how they relate to each other, as well as how their position in the network defines their social roles (Borgatti *et al.*, 2009) in FLR governance.

The *Mata Atlântica* biome has received attention from decision-makers for being a priority area for ecological landscape restoration, and is considered one of the global "hotspots" for FLR opportunities in tropical areas (Brancalion *et al.*, 2019). The biome has accumulated a history of deforestation and environmental degradation (Dean, 1996); however, recent estimates show that 2.7 million hectares have already been naturally regenerated between 1996 and 2015 (Crouzeilles *et al.*, 2020). The Paraíba do Sul River Hydrographic Basin (HB-Paraíba do Sul River) is a representative example of the degradation history and of the biome's restoration potential. Located between the states of São Paulo, Rio de Janeiro and Minas Gerais, the Basin has drawn the attention of decision-makers across the *Mata Atlântica* areas as favorable factors for FLR. Biophysical factors contribute to this importance, such as the proximity of extensive areas of forest remnants, the diversity of terrain favorable to different restoration approaches, a climate with regular rainfall and the presence of degraded pastures suitable for restoration (IUCN & WRI, 2018). In addition to that, there are also economic factors such as the combination of the presence of commercial eucalyptus forest plantation activities, the low share of agricultural activities in rural employment (Silva *et al.*, 2016) and socio-technical factors, such as the presence of individuals and organizations working in the forest restoration chain in the region (Andrade et al., 2018).

In 2018, under the *Nascentes* Program and in partnership with the World Resources Institute – Brazil (WRI Brazil), the São Paulo State Government published the "Mapping of Opportunities for Forest and Landscape Restoration in the Paraíba Valley" (ROAM – Paraíba Valley), which presents

[1] For a systematic literature review on forest and landscape restoration governance in Brazil, see Adams et al. (2021).

the "Territorial Forest Development Plan for the state of São Paulo portion of the Paraíba Valley" (IUCN & WRI, 2018). Among the results, the importance of including the state of São Paulo portion of the Paraíba Valley (Paraíba Valley from now on) in the FLR governance analysis was highlighted, context in which this article was conceived.

This article aims at analyzing the FLR governance in the Paraíba Valley, in the state of São Paulo, by describing the history of local initiatives and the network of social actors related to forest and landscape restoration. The analyses made in this study seek to understand how these initiatives and connections between the social actors configure FLR governance in the Paraíba Valley. The results herein presented can act as support for decision-making in FLR programs and projects and for the articulation of the Paraíba Valley social actors.

2. Methodology

2.1. Study area

The Paraíba do Sul River HB supplies three large metropolitan regions São Paulo, Rio de Janeiro and the Paraíba Valley (Figure 1). The Paraíba Valley coverage area contained in the state of São Paulo consists of 35 municipalities distributed across approximately 1,400,000 hectares. This area has nearly 590,000 hectares of natural remnants (33% of its total area), distributed between the steep slopes of Serra do Mar and Mantiqueira, and approximately 80,000 hectares of forest cover deficit in permanent preservation areas and legal reserves (IUCN & WRI, 2018). In all, more than 420,000 hectares present high forestry potential, with 325,000 having high or average natural regeneration potential (IUCN & WRI, 2018).

The Paraíba Valley environmental degradation dates back to the economic cycles that have taken place since the 17th Century, related to natural resource exploitation (IUCN & WRI, 2018). Successive activities were developed in the region until the 18th century, especially gold and sugar cane (Devide *et al.*, 2014), turning the region into a strategic connection between the gold regions of Minas Gerais and Mato Grosso and the port regions of Rio de Janeiro. The coffee production expansion at the end of the 18th century marked the first deforestation cycle in the region (Silva, Batistella & Moran, 2016), associated with extensive livestock farming and deforestation to obtain valuable timber from the *Mata Atlântica* area. After the coffee production decline in the first half of the 20th century, rice cultivation and the use of its husk to manufacture cardboard gained prominence in the region, followed by the establishment of Eucalyptus and Pinus, plantations, encouraged by the forestry policy for timber, paper and pulp production (IUCN & WRI, 2018). From the second half of the 20th century, an intense industrialization and urbanization process was initiated in the region, motivated by the construction of the Presidente Dutra Highway, linking the cities of São Paulo and Rio de Janeiro. Currently, the urban area of the municipalities represents 4% of the entire Paraíba Valley and concentrates nearly 94% of its entire population. In the rural areas, there is predominance of low-productivity milk production, followed by rice cultivation on the Paraíba do Sul river banks. The small rural properties represent 93% of all rural farms in the Paraíba Valley (IUCN & WRI, 2018). The Paraíba Valley stands out among the *Mata Atlântica* coverage areas

with the greatest importance for FLR due to its rich potential for generating ecosystem services from the restoration of native forests (IUCN & WRI, 2018). In addition to that, it has spring areas decreed as a priority for native vegetation restoration (Decree No. 60,521 of June 5th, 2014), as well as favorable geographical, economic and institutional conditions for large-scale FLR actions (IUCN & WRI, 2018).

2.2. Data collection

The study adopted four data collection methods, which were applied during the 2018-2020 period:

a) Elaboration of the database including the social actors;

b) Mapping of the FLR social actors' network (Social landscape mapping from now on);

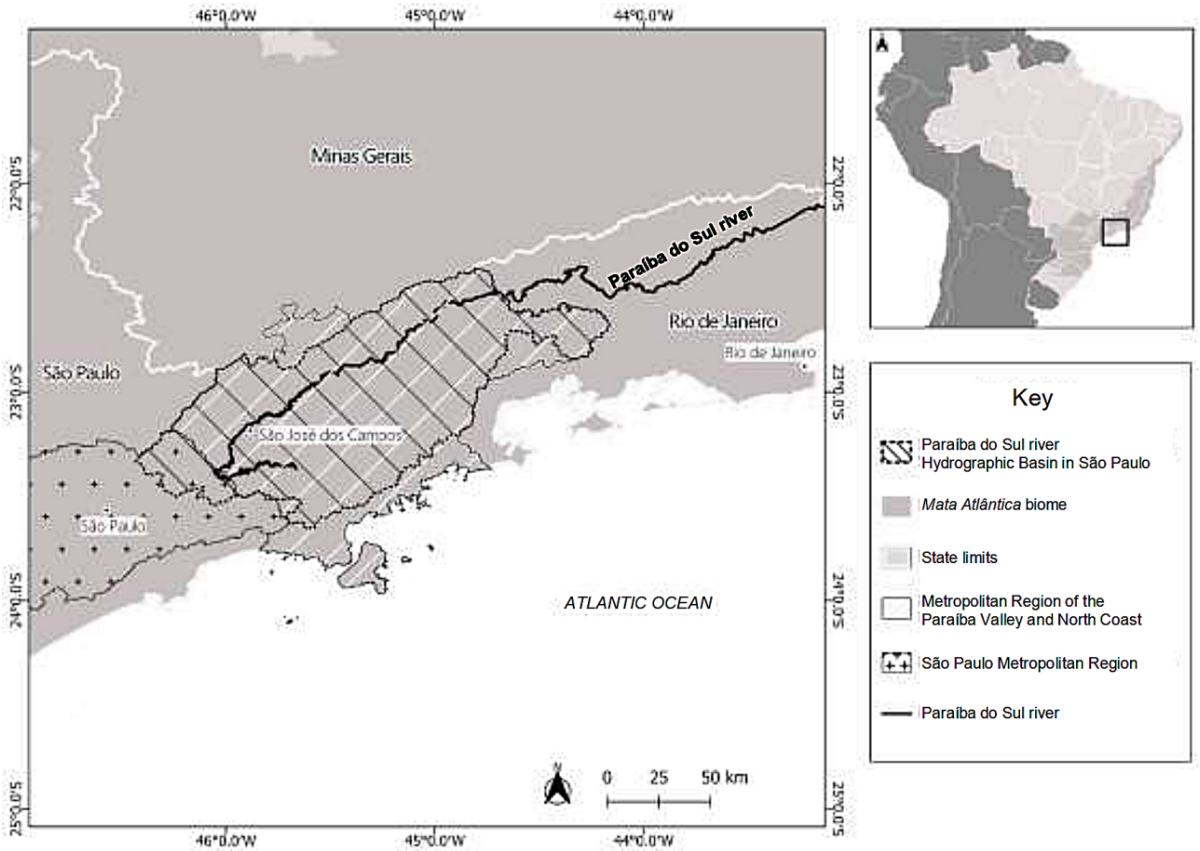

FIGURE 1 – Study are location encompassing the Paraíba do Sul river HB, state of São Paulo.
SOURCE: Prepared by Marcelo Matsumoto - WRI Brazil.

c) Validation of the preliminary results obtained in the social landscape mapping; and

d) Conduction of semi-structured interviews with key actors.

Preparation of a database of social actors in the Paraíba Valley was based on the collection of secondary data obtained through technical documents, consultation on the websites of organizations active in the Paraíba Valley and contacts of organizations provided by WRI Brazil. A total of 165 social actors with FLR-related actions were mapped in the SPPV. Based on the diverse information collected to prepare the database, attributes were defined for the social actors, such as type of activity carried out in the FLR chain, legal nature of the organization (referred to as category from now on), and level of activity of each actor's spatial scale of operation. Each category was assigned a color to guide the social landscape mapping activity (Table 1), which was the second method used for data collection.

The spatial scale (Cash *et al.*, 2006) was defined as the performance and/or influence (political, financial, articulation, technical assistance, commercial, knowledge production, etc.) geographical space of a given social actor. In turn, the scale was divided into performance levels (Table 2) with the objective of describing the FLR governance process both within and across performance levels and categories of social actors. The connections within levels are between actors classified in the same performance level (e.g., municipal), where those across levels are between actors at different performance levels (e.g., municipal and state).

The social landscape mapping was performed by means of the Net-Map method. Net-Map allows identifying how certain social actors relate to each other and exert an influence on a given landscape by exchanging different types of resources (Schiffer & Hauck, 2010; Buckingham *et al.*, 2018). The social landscape can be understood as the set of biophysical and sociocultural attributes of a landscape and their integrations (Field *et al.*, 2003). In this study, emphasis was given to the social actors articulated around resources for FLR. When applying the social landscape mapping, the social actors identified by the participants were individuals, organizations (public and private),

TABLE 1 – Categories used in the analysis of the networks and their definitions, by colors.

Category	Color	Definition
Public		Public administration entities, including councils and committees foreseen in legal certifications and/or in the governmental structure, public funds and foundations.
Private, not-for-profit		Entities that do not distribute assets earned through the exercise of their activities under any denomination (profits, operating surpluses, dividends, bonuses, shareholdings, etc.), applying the resources in full to achieve the respective social objective.
Private, for-profit		Company modality in which the owner is a natural or legal person, therefore being singular or individual if exploited by a physical person, or collective if organized and directed by a society.
Rural producers		Land owners or tenants, whose main activity is targeted at rural production (agriculture, forestry and/or animal breeding).
Social movement/ Network		A group of social actors or movements, not necessarily of a formal nature.

SOURCE: Prepared by the authors

TABLE 2 – Spatial performance scale levels used in the network analysis and their definitions.

Levels	Definition of the type of performance in each level
Community	Local, with the possibility of encompassing more than one municipality.
Municipal	In the municipality, encompassing the entire municipal territory in general.
Micro-regional	In a given region of the state, such as the area of a Hydrographic Basin.
State	In the state, encompassing the entire territory in general.
Sub-national	In a given Brazilian region. For example, the Mata Atlântica region, the Southeast region or an HB encompassing more than one state.
National	Internal to Brazil, encompassing the entire national territory in general.
International	In the country and abroad, encompassing more than one country.

Source: Prepared by the authors

networks and public policies. Mapping the social landscape made it possible to identify and describe the interactions between actors, that is, the flows of resources for FLR initiatives (financial, information, seeds, seedlings and other biological materials, authority and trade, monitoring). The mapping was performed in two participatory workshops. The first one was in the municipality of São José dos Campos on February 2019 with 26 representatives from 17 organizations. The attendees were representatives from universities, technical education institutes, non-governmental organizations, public bodies and private and private companies, in addition to rural producers. The list of invitees included two criteria: state, regional and local leaders and representatives from various categories (public and private, local social movements and rural producers) among the social actors linked to FLR projects and programs in the Paraíba Valley. Five networks of the Paraíba Valley FLR social actors were created in the workshop, namely:

1) General network comprised by all the actors that interact in any way around the Paraíba Valley FLR topic, regardless of the type of resource mediating the interactions;

2) Technical information networks;

3) Financial resources flow network;

4) FLR materials and inputs network; and

5) Audit, monitoring and supervision actions network.

As the objective is to present an overview of FLR governance in the SPPV, only the general network of the Paraíba Valley FLR social actors was used for data analysis in this article.

In the second workshop, conducted during June 2019 in the municipality of Guaratinguetá, the social landscape mapping data from the first workshop were validated. The social landscape maps drawn in the first workshop were analyzed by the participants, who were able to check for errors, inconsistencies and gaps to be corrected regarding the social actors and links mapped. The suggestions for corrections were presented in a plenary session format and the changes were implemented. The participants were 20 representatives from 18 organizations such as universities, non-governmental organizations, public bodies and private and private companies, in addition to two rural producers.

The fourth data collection method consisted in semi-structured interviews to characterize the FLR history and initiatives in the Paraíba Valley. The interviews were conducted in-person or via Skype, with 24 representatives from 23 organizations duly indicated and which are active in topics related to FLR in the Paraíba Valley. The interview script included questions about the following: existing FLR initiatives; the actors involved in these initiatives and their interactions; and the existing institutional arrangements (or governance arrangements) related to the initiatives surveyed (policies, councils, committees, programs, etc.).

2.3. Data analysis

The Social Network Analysis (SNA) allowed characterizing the FLR social actors' network in the Paraíba Valley. An SNA makes it possible to identify interaction patterns between nodes (e.g., individuals, organizations) based on their links, as well as to make inferences about the network profile and the characteristics of the nodes, based on their positions in the network (Borgatti *et al.*, 2009). The content of the connections between social actors involves any process to exchange material (financial and human) or immaterial (information, collaboration in projects) resources (Wasserman & Faust, 1994). In this study, the nodes represent social actors that are active in forest restoration initiatives The links represent the exchange of any type of resource for forest restoration, such as financial resources, inputs (e.g., fertilizers, seeds, and seedlings), technical information and plantation monitoring.

To describe the FLR governance network structure and the social actors' position in the network, network profile metrics (size, density, diameter, cluster coefficient, *Mean Degree*, mean path length) and node centrality metrics (degree centrality, proximity centrality, mediation centrality and eigenvector centrality) were calculated, respectively (Table 3). These metrics allow identifying the core actors of the network and their social roles in networking, in addition to the forest restoration governance network structure (Buckingham *et al.*, 2021). The network metrics were calculated in the Gephi open and free program (Bastian *et al.*, 2009).

During the social landscape mapping exercise, the participants were asked to identify the social actors in the Paraíba Valley FLR that they knew and to establish recognizable links between them. Some participants of the workshops mentioned projects and programs as FLR social actors, and the network mapping facilitators allowed such designation. For example, the *Conexão Mata Atlântica* Project, carried out by the São Paulo Infrastructure and Environment State Department (*Secretaria de Infraestrutura e Meio Ambiente*, SIMA from now on), was cited as an FLR social actor (a node). To delimit the types of social actors to individuals and organizations, in the data preparation stage for the SNA it was decided to join the nodes corresponding to projects and programs to the node corresponding to the social actor responsible for their execution or coordination, as in the example above. On the one hand, the effect of these transformations in the data was a reduction in the number of network nodes. On the other hand, it increased the indices corresponding to the centrality metrics of the social actors responsible for the projects and public policies identified in the social landscape mapping.

TABLE 3 – Description of the network profile and centrality metrics.

Network metrics	Description
Profile	
Size	Total number of actors and connections in the network
Density	Ratio between the existing number of connections and the maximum possible
Diameter	The largest distance between two nodes in the network
Clustering coefficient	Coefficient of small and cohesive clusterings along the network as a whole
Centrality (with social role)*	
Degree centrality (*Connector*)	Number connection an actor has
Proximity centrality (*Disseminator*)	Distance between each actor and all the others
Mediation centrality (*Mediator*)	Number of times an actor is in the shortest path among other actors
Eigenvector centrality (*Change leader*)	The extent to which an actor is connected with others with higher centrality degree

SOURCE: Adapted from Buckingham et al. (2018).

NOTE: (*) Based on the methodological guide proposed by Buckingham et al. (2018), definitions of social roles associated with each centrality metric were adopted with the objective of rendering the network analysis vocabulary more intuitive for decision-makers to assimilate.

The semi-structured interviews were transcribed and their content was organized in a database to describe the history of FLR initiatives in the Paraíba Valley between 2006 and 2019, the objectives, the actors responsible for them, and the predominant level at the spatial scale where the initiatives were implemented.

3. Results

3.1. History of FLR initiatives in the Paraíba Valley (2006-2019)

Since 2006, 22 FLR initiatives have been identified in the Paraíba Valley. These initiatives were partly motivated by the mandatory environmental regularization of rural properties; by Payment for Environmental Services (PES) contracts; by the economic potential of using native forest species; by recognition through certification of conservation practices in the market; and by training of professionals. All 22 initiatives can be grouped into 5 types of actions:

(i) PES programs and projects;

(ii) Forest restoration projects by means of resources coming from environmental compensations or mitigations arising from environmental licensing, public edicts and other sources;

(iii) Implementation of Agroforestry systems;

(iv) Research and people's training projects and soil use diagnoses;

(v) Creation of networks and mobilization of rural producers (Table 4).

The Paraíba Valley has a history of projects and programs (Figure 2 and Table 5) involving the participation of private not-for-profit organizations such as NGOs at the micro-regional level, which work on FLR-related issues (Figure 2) and are articulated to cover the entire Paraíba Valley. These organizations include the Paraíba Valley *Corredor Ecológico*, the Akarui Association (Akarui), the

Serracima Association (Serracima), and the Suinã Institute (Suinã), respectively headquartered in the municipalities of São José dos Campos, São Luiz do Paraitinga, Cunha and Guararema. In 2006, the Oikos Institute began implementing the *Ribeirão dos Macacos* Forest Restoration Project to restore the Permanent Preservation Areas (PPAs) of the *Ribeirão dos Macacos* HB and support the conservation of the forest fragments in this micro-basin, involving rural landowners in its actions. In 2007, following the initiative of a farmer and landowner at *Fazenda Coruputuba*, experiments were initiated with the implementation of Agroforestry systems with native species for economic exploitation, with the support of technical assistance and rural extension agencies in the Pindamonhangaba region. Currently, the Farm is the Coruputuba Institute headquarters.

In 2007, Serracima launched a Training course for young people and women on Agroecology and Healthy Eating topics. In addition to the training options in Agroecology and Agroforestry, Serracima has also supported creole seed exchange fairs in Cunha since 2010. In that same year Akarui launched the Chapéu River Basin Physical-Environmental Restoration Project in São Luiz do Paraitinga.

TABLE 4 – Forest and landscape restoration initiatives in the Paraíba Valley in the state of São Paulo, classified into five types of actions.

Category of forest and landscape restoration programs and projects	**Forest and landscape restoration programs and projects**
(i))Payment for Environmental Services (PEs) programs and projects	*Conservador da Mantiqueira; São José mais Água; Conexão Mata Atlântica*
(ii) Forest restoration projects by means of resources coming from environmental compensations or mitigations arising from environmental licensing, public edicts and other sources	*Ribeirão dos Macacos* Forest Restoration Project; Chapéu River Basin Physical--Environmental Recovery Project; Forest restoration projects through environmental compensation (Santander, Tamoios and Ecopistas); *Semeando Sustentabilidade* Project (ecology and management of Juçara palm trees and forest restoration); Nascentes Program.
(iii) Implementation of Agroforestry systems	Agroforestry Experience with Planting of Native Species for Economic Exploitation; Sustainable Rural Development Project (Preparation and implementation of Forestry and Agroforestry Systems study units); Agroecological Development of Family Farming in the Cunha Region (SP)
(iv) Research and people's training projects and soil use diagnoses	Training of young people and women in Agroecology and Healthy Eating; Sustainable Rural Development Project (training of rural producers); Opportunities for Landscape and Forest Restoration in the state of São Paulo portion of the Paraíba Valley - Territorial Forest Development Plan for the São Paulo portion of the Paraíba Valley (ROAM); *Recursos Hídricos na Bacia do Paraíba do Sul: Integrando Aspectos Naturais e Antrópico*s Project; Rural-Territorial Development Program (*Programa de Desenvolvimento Rural Territorial*, PDRT)
(v) Creation of networks and mobilization of rural producers	Paraíba Valley Forest Restoration Actors Network; Paraíba Valley Agroforestry Network; *Diálogos Roda D'água Project*; Mobilization of rural landowners to restore springs; Technical Chamber for Water Resources Conservation and Forest Restoration (CT-REF); Paraíba do Sul HB Committee (CBH-PS); Creole Seed Exchange Fair; Paraíba Valley Forest Hub Project.

SOURCE: Prepared by the authors

From 2011 onwards, *Corredor Ecológico* starts to be active in origin forest restoration projects in environmental compensation agreements for the implementation of works such as the Tamoios Highway. Another important actor that emerged that year was the Paraíba Valley Agroforestry Network, formed by local actors organizing joint efforts to implement Agroforestry systems on rural properties. In 2012, Akarui launched the *Semeando Sustentabilidade* Project focused on the management of Juçara palm trees in areas around the Serra do Mar State Park, *Santa Virgínia* Hub. In 2013, Akarui led the Rural-Territorial Development Project, conceived by the Suzano company. In 2014, along with other social actors, especially from the public sector, Akarui and *Corredor Ecológico* took part in the Sustainable Rural Development Project. The Project involved actions to train rural producers and implement demonstrative units of forestry and Agroforestry systems.

In the context of advancing national and international policies to reduce greenhouse gases, 2018 saw the creation of the *Conexão Mata Atlântica* Project, managed by SIMA, with the objective of increasing carbon stocks and contributing to the conservation of ecosystem services and biodiversity in priority areas of the Paraíba do Sul river HB. The Connection is based on the use of economic incentive instruments, such as PES, to guarantee other benefits for the rural producers involved, such

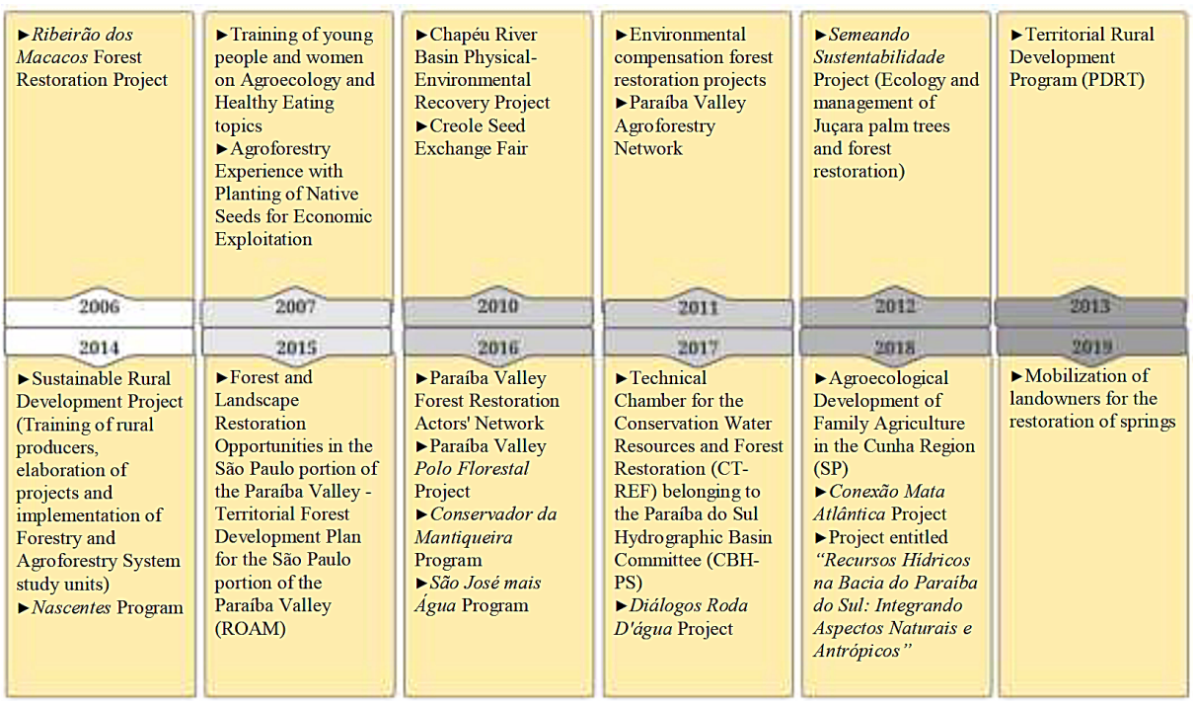

FIGURE 2 – Chronology of the FLR initiatives in the Paraíba Valley in the state of São Paulo.
SOURCE: Prepared by the authors

TABLE 5 – Main forest and landscape restoration initiatives in the state of São Paulo portion of the Paraíba Valley, by year of implementation, stage, coverage area, implementation level and main actors, from 2006 to 2019.

Initiatives	Start	Stage	Coverage area	Implementation level	Main actors
***Ribeirão dos Macacos* Forest Restoration Project**	2006	Finished	Ribeirão dos Macacos HB (municipalities of Guaratinguetá and Lorena)	Micro-regional	Rural producers; Oikos Institute; Ribeirão dos Macacos Association of Producers and Residents; Lorena City Hall (CH); Integral Technical Assistance Coordination Office (*Coordenadoria de Assistência Técnica Integral*[1], CATI); Rural Union; Milk Cooperative; Environmental Police; Green Initiative
Training on Agroecology and Healthy Eating topics for young people and women	2007	Finished	Cunha	Municipal	Rural producers; Serracima; Petrobras; CATI; Bolsa de Valores Sociais & Ambientais; Fundo Socioambiental CASA; Interamerican Foundation
Agroforestry experience with planting of native species for economical exploitation	2007	Ongoing	Pindamonhangaba	Municipal	Coruputuba Institute; São Paulo Agency for Agribusiness Technology (*Agência Paulista de Tecnologia dos Agronegócios*, APTA) - Pindamonhangaba; Rural Federal University of Rio de Janeiro (*Universidade Federal Rural do Rio de Janeiro*, UFRRJ); Agriculture Foundation (*Fundação para a Agricultura*, FUNDAGRI); researchers, carpenters and wood designers
Chapéu River Basin Physical--Environmental Restoration Project	2010	Finished	São Luiz do Paraitinga	Municipal	Rural producers; Akarui; Water Resources State Fund (*Fundo Estadual de Recursos Hídricos*, FEHIDRO)
Creole Seed Exchange Fair	2010	Ongoing	Cunha	Municipal	Rural producers; Serracima
Forest restoration projects via environmental compensation (Santander, Tamoios and Ecopistas)	2011	Ongoing	10 municipalities from the Paraíba Valley and 4 from the São Paulo North coast	Micro-regional	Rural producers; Corredor Ecológico; executing companies (*Ouro Verde, Crescente Fértil*); City Halls; Environmental Company of the State of São Paulo (*Companhia Ambiental do Estado de São Paulo*, CETESB); São Paulo Infrastructure and Environment State Department (SIMA)

[2] State Decree No. 64,131 of March 11th, 2019 (São Paulo, 2019), changes the name of the Integral Technical Assistance Coordination Office(-CATI) to Sustainable Rural Development Coordination Office (*Coordenadoria de Desenvolvimento Rural Sustentável*, CDRS) and incorporates some duties of the Infrastructure and Environment Department, specifically the job positions, functions-activities, rights and activities performed by the Biodiversity and Natural Resources Coordination Office (*Coordenadoria de Biodiversidade e Recursos Naturais*, CBRN), an organ of the Environment Department at that time. In this report, the name CATI will be kept until the structure of the regional offices is definitively reorganized in the Paraíba Valley.

Paraíba Valley Agroforestry Network	2011	Ongoing	Paraíba Valley (São José dos Campos, Cachoeira Paulista, Tremembé, Caçapava, Lagoinha)	Micro-regional	Rural producers; rural settlements; Coruputuba Institute; APTA-Pindamonhangaba; Land Colonization and Reform National Institute (*Instituto Nacional de Colonização e Reforma Agrária*, INCRA); volunteers
***Semeando Sustentabilidade* Project (Ecology and management of Juçara palm trees and forest restoration)**	2012	Finished	Municipalities of São Luiz do Paraitinga, Natividade da Serra, Ubatuba	Micro-regional	Rural producers; Akarui; Serra do Mar State Park (Santa Virgínia Hub); Suzano; Corredor Ecológico; Oikos Institute; Forestry Institute; Forestry Foundation; CATI; São Luiz do Paraitinga CH; Mata Atlântica Permaculture Institute (*Instituto de Permacultura da Mata Atlântica*, IPEMA); BNDES
Rural-Territorial Development Program (PDRT)	2013	Ongoing	Municipalities of São Luiz do Paraitinga, Redenção da Serra, Natividade da Serra, Salesópolis, Santa Branca and Guararema	Micro-regional	Rural producers; Akarui; Suzano; Mato Dentro Association; Minhoca Association--Agroecological partners
Sustainable Rural Development Project (Training for rural producers, elaboration of projects and implementation of Forestry and Agroforestry study units)	2014	Finished	São Luiz do Paraitinga and Natividade da Serra	Micro-regional	Rural producers; Akarui; Corredor Ecológico; CATI; São Luiz do Paraitinga and Natividade da Serra City Halls; SIMA; Forestry Foundation; Forestry Institute
Nascentes Program	2014	Ongoing	State of São Paulo	State	Rural producers; squatters; rural settlements; companies; NGOs; schools; City Halls; Conservation Units
Opportunities for Forest and Landscape Restoration in the São Paulo portion of the Paraíba Valley - Territorial Forestry Development Plan for the São Paulo portion of the Paraíba Valley (ROAM)	2015	Finished	Paraíba Valley in the state of São Paulo	Micro-regional	WRI Brazil; SIMA; Oikos Institute; Coruputuba Institute; Corredor Ecológico; Nascentes do Paraíba Movement; Forestry Foundation; Paraíba do Sul Springs Environmental Protection Area (Área de Proteção Ambiental Mananciais do Rio Paraíba do Sul, APA--MPS); Paraibúna CH; São José dos Campos Municipal Environment Department; Water and Electricity Department (Departamento de Águas e Energia Elétrica, DAEE); CATI - Pindamonhangaba; HB-RPS Pro-Water Management Association (Associação Pró--Gestão das Águas da BH-RPS, AGEVAP); HB-RPS Committee (CHB-PS); WWF;

					TNC; Family farming representatives; Paraíba Valley Rural Trade Union Association; Aeronautical Technology Institute (Instituto de Tecnologia Aeronáutica, ITA); Conciliation, Mediation and Arbitration Chamber (CIESP/FIESP).
Paraíba Valley Forest Restoration Actors' Network	2016	Ongoing	Paraíba Valley	Micro-regional	More than 100 organizations, including seed collectors, seedling producers, companies, NGOs, Universities, rural producers, City Halls, members of River Basin Committees and state and federal government organizations.
Paraíba Valley Forestry Hub Project	2016	In concept	Paraíba Valley	Micro-regional	SIMA – SP; Corredor Ecológico; Coruputuba Institute; WRI Brazil; TNC
Conservador da Mantiqueira Program	2016	Ongoing	An area of Serra da Mantiqueira that is home to the springs of the rivers that feed the Furnas (MG) reservoirs, in nearly 280 municipalities in the states of Minas Gerais, São Paulo and Rio de Janeiro.	Sub-national	TNC; state, municipal and federal governments; 19 hubs that bring together nearby municipalities; River Basin Committees in the three states; Conservation Units; NGOs; Research Centers and Universities.
***São José mais Água* Program**[3]	2016	Ongoing	São José dos Campos	Municipal	National Water Agency (*Agência Nacional de Águas*, ANA); AGEVAP; Forestry Foundation; CATI; Chico Mendes Institute for Biodiversity Conservation (ICMBio); Grupo Boticário Foundation for Nature Protection; TNC; WWF; Oikos Institute; *Corredor Ecológico*; SABESP; ITA; UNESP; São José dos Campos Municipal Environment Council (*Conselho Municipal de Meio Ambiente de São José dos Campos*, COMAM)
Technical Chamber for the Conservation of Water Resources and Forestry Restoration (Câmara Técnica de Conservação dos Recursos Hídricos e Restauração	2017	Ongoing	Paraíba do Sul River HB, in the state of São Paulo	Ongoing	City Halls (Caçapava, Cruzeiro, Cunha, Guararema, Pindamonhangaba, Santa Isabel); Agriculture and Supply State Department; SIMA; Education State Department; SABESP; DAEE; Environmental Entities; Agriculture, Fishing/Aquaculture and Mining Sectors; Representatives from the Engineering, Agronomy and Architecture Areas; Representatives from Service Clubs

[3] Available in: https://www.sjc.sp.gov.br/servicos/urbanismo-e-sustentabilidade/servicos-ambientais/ (Accessed on: 05/29/2021).

Florestal, CT--REF), belonging to the Paraíba do Sul HB Committee (CBH-PS)					
Diálogos Roda D´água Project	2017	Ongoing	Paraitinga River HB	Micro-regional	Municipal and State School Teachers; Akarui; São Luiz do Paraitinga Municipal Education Department; Serra do Mar State Park (Santa Virgínia Hub); National Center for the Monitoring and Alert of Natural Disasters (*Centro Nacional de Monitoramento e Alertas de Desastres Naturais*, CEMADEN); Alto Paraíba Sustainability Network (Suapa Network); Minhoca Association; FEHIDRO
Agroecological Development of Family Agriculture in the Cunha Region (SP)	2018	Finished	Cunha	Municipal	Rural producers; Serracima; Fundação Banco do Brasil
Conexão Mata Atlântica Project	2018	Ongoing	Areias, Silveiras, Lorena, Cachoeira Paulista, Guarantinguetá, Cunha, Lagoinha,Redenção da Serra, Paraibuna and Taubaté, São Luiz do Paraitinga, Natividade da Serra and the surroundings of the Bananal Ecological Station, Santa Virgínia Hub of the Serra do Mar State Park and the São Francisco Xavier Environmental Protection Area territory.	Micro-regional	SIMA; Forestry Foundation; rural producers private organizations devoted to technical assistance and rural extension (for example: Crescente Fértil)
Project entitled Recursos Hídricos na Bacia do Paraíba do Sul: Integrando Aspectos Naturais e Antrópicos	2018	Ongoing	Paraíba do Sul River HB	Micro-regional	Earth System Science Center (*Centro de Ciências do Sistema Terrestre*, CCST/INPE); Energy and Environment Institute belonging to the University of São Paulo (*Instituto de Energia e Ambiente/Universidade de São Paulo*, IEE/USP); Research and Development Institute belonging to the University

					of the Paraíba Valley (*Instituto de Pesquisa e Desenvolvimento/Universidade do Vale do Paraíba*, IPD/UNIVAP); Federal University of Itajubá (*Universidade Federal de Itajubá*, UNIFEI); State University of Campinas (*Universidade Estadual de Campinas*, UNICAMP); Brazilian Fund for Environmental Education (Fundo Brasileiro de Educação Ambiental FUNBEA); Valley Technological Institute (*Instituto Tecnológico Vale*, ITV); Coordination for the Improvement of Higher Education Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*, CAPES) (funding body); ANA
Mobilization of rural land owners for the restoration of headwaters	2019	Ongoing	Quatro Ribeiras HB (municipality of Jacareí)	Micro-regional	Rural producers; Suinã Institute; Akarui; Corredor Ecológico; TNC; SIMA; Fibria (currently Suzano); Jacareí City Hall

SOURCE: Prepared by the authors

as certification of products or production units, support for marketing and other incentive mechanisms for rural landowners. In the same year, Serracima implemented the Agroecological Development of Family Farming Project, which resulted in the creation of a Social Control Organization (SCO) comprised by agroecological family farmers. Also in 2018, under the coordination of INPE researchers and initiated by the project entitled *Recursos Hídricos na Bacia do Paraíba do Sul: Integrando Aspectos Naturais e Antrópicos*, with the objective of preparing a diagnosis of the HB-PS adaptive capacity, involving the modeling of biophysical aspects, governance and social control for water management. In 2019, Suinã, Akarui and *Corredor Ecológico* acted together in mobilization initiatives by rural land owners for forestry restoration of headwaters in the municipality of Jacareí.

This historical overview shows the diversity of social actors and projects in the Paraíba Valley, as well as the growing role of local organizations in forest restoration initiatives, with an emphasis on the concentration of initiatives at the micro-regional implementation level. To better understand the diversity of this social landscape, we will now analyze the FLR social actors' network of the Paraíba Valley in its several performance levels.

3.2. FLR social actors' network in the Paraíba Valley

The current FLR social landscape of the Paraíba Valley is represented by the network of interactions between its different social actors (Figure 3). This network is represented by 92 mapped social actors (Profile – Size metric) from different

categories (public organizations, private for-profit, private not-for-profit, work networks, social movements, groups and individuals) and operating at different levels on a spatial scale ranging from local to international, totaling 182 connections (Figure 3).

The micro-regional level concentrates the largest number of social actors in the network (25 [27%], n=92), and has predominance of private for-profit and private not-for-profit actors (10 and 11 network nodes per category, respectively). When the entire network is considered, the public actors category represents the largest group (31 nodes), with the highest concentration of these actors at the municipal level (32%). The diversity of categories of actors is higher at the municipal and micro-regional levels, with 4 categories in each (Figure 4).

The density of the Paraíba Valley FLR network (ratio between the number of existing connections and the largest number of possible links with zero as the minimum index and 1.0 as the maximum density index) is 0.03, which suggests low density. When comparing the connection density for each level, the highest value is at the state level (0.089), which indicates horizontal interactions between predominantly public actors (7 or 70%, n=10). The municipal level presents the lowest density (0.014), also with predominance of public actors (10 [52%], n=19). As for the existence of clusters in the network (*Clustering* coefficient), the mean index obtained was 0.28, which suggests an intermediate degree of community formation within the network, as in the case of the *Clustering* corresponding to the international NGOs: The Nature Conservancy (TNC), WRI Brazil and the World Wildlife Fund (WWF).

The greatest distance between two nodes in the network (diameter) is 7 connections, which gives an idea of how many links a social actor would need to make in order to get in contact with social actors who are further away from their close connections. In turn, the mean length (mean distance between the actors, calculated two by two) corresponds to approximately 3 connections, suggesting that, on average, the social actors are close to each other. Each actor in the network is linked to an approximate mean of 4 other actors (*Mean Degree* metric), with the number of connections for each actor varying between 0 and 48, the latter represented by *Corredor Ecológico*, which has the highest centrality degree in the network. There are 8 isolated social actors distributed in the different levels, with no connections with the others. They mostly represent the for-profit-private sector. There are 32 peripheral actors in the network, defined by their low centrality degree, equivalent to 1 connection. They are represented by actors from the following categories: for-profit private (11 [34%]), public (8 [25%]), rural producers (7 [21%]) and for-profit private (6 [18%]).

The central actors in the network, given by the centrality metrics, are as follows: *Corredor Ecológico*, TNC, the *Chico Mendes* Institute for Biodiversity Conservation (ICMBio), UNIVAP, São José dos Campos City Hall. The centrality of these actors indicates that the Paraíba Valley FLR network has among its most important actors organizations that operate locally, such as *Corredor Ecológico*, São José dos Campos City Hall and UNIVAP, respectively; government organizations that operate nationally, represented by ICMBio; and the TNC international NGO (Table 6).

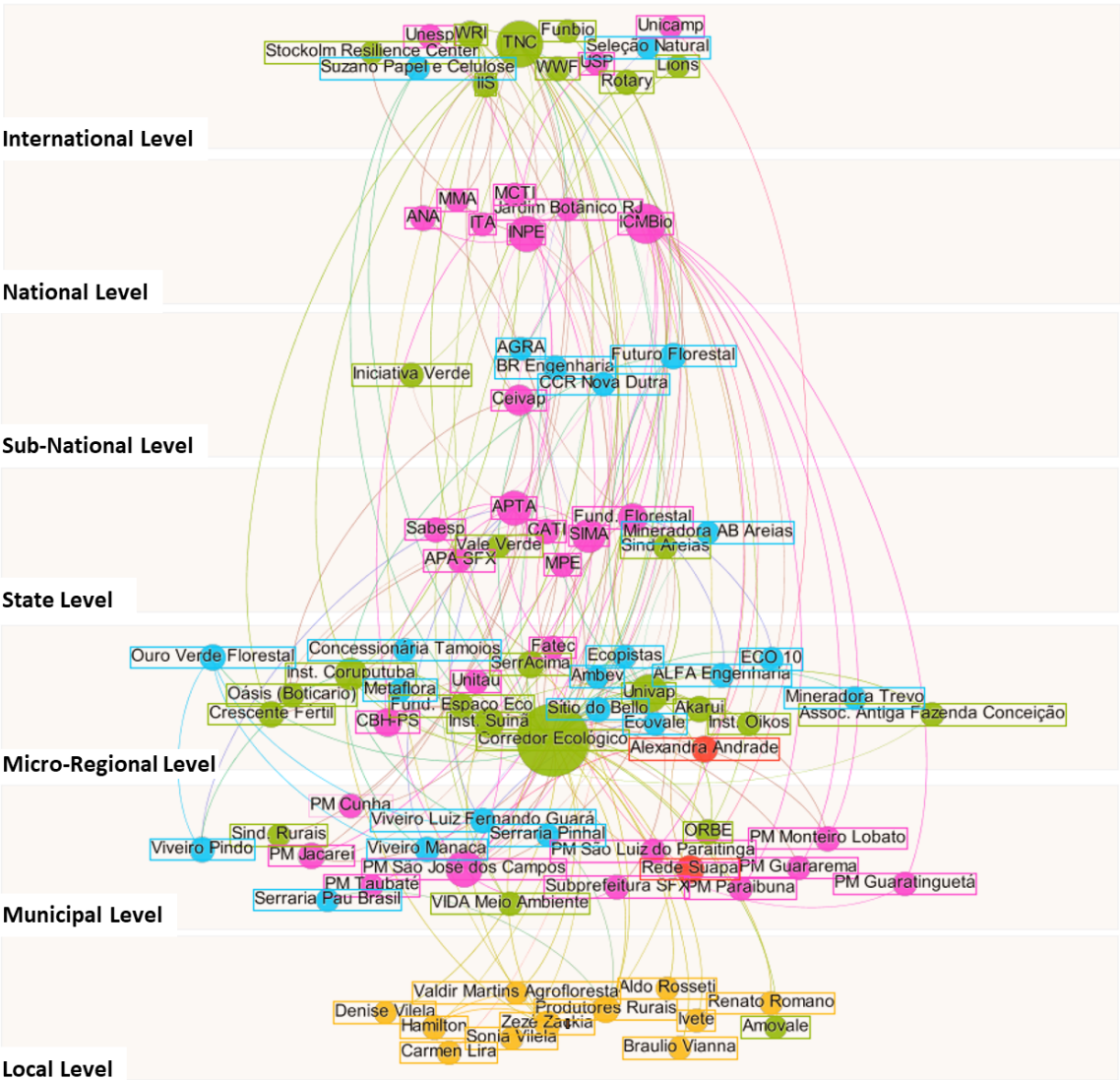

FIGURE 3 – Map showing the Forest and Landscape Restoration social actors' network in the Paraíba valley, distributed following a performance scale.

KEY: In the visual representation of the nodes and connections in the network, each node size corresponds to the number of connections it establishes with other network nodes (Degree Centrality - Connector). The connections have no specified direction. The color of each circle represents the actor's category (Table 2). Pink: public actors; green: private not-for-profit actors; blue: for-profit private actors; orange: individuals: red: social movement/network. The colors of the connections represent the color of the node originating each connection. The actors with no connections were included in the figure, namely: ISA, SOS Mata Atlântica, Dois Irmãos Nursery, Paulo Ferraz Nursery, São Gonçalo Nursery, Floresta Brasil, Arbovale Nursery and Agroforestry, and Paraíba Valley Forest Restoration Actors' Network (2019).

SOURCE: Prepared by the authors.

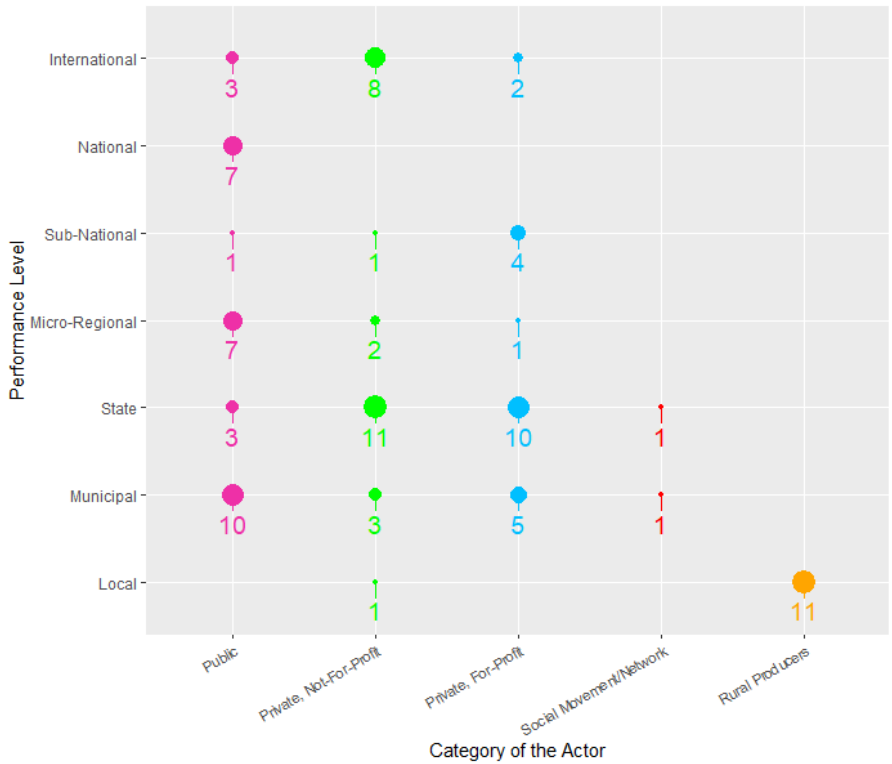

FIGURE 4 – Number of actors identified in the social landscape mapping, by category and by performance level.

KEY: Categories of social actors by colors: Public actors (pink); Not-for-profit private actors (green): For-profit private actors (blue); Individuals (orange); Social movement/Network (red)(2019).

SOURCE: Prepared by the authors

TABLE 6 – Ranking of the five main social network actors from the Paraíba Valley, according to their centrality metrics (the social role associated to the metric is indicated between parenthesis).

Position in the ranking	**Centrality degree (*Connector*)**	**Mediation degree (*Bridge organization*)**	**Proximity degree (*Disseminator*)**	**Eigenvector degree (*Change agent*)**
1st	Corredor Ecológico	Corredor Ecológico	Corredor Ecológico	Corredor Ecológico
2nd	TNC	TNC	TNC	TNC
3rd	ICMBio	São José dos Campos City Hall	São José dos Campos City Hall	ICMBio
4th	UNIVAP	ICMBio	ICMBio	São José dos Campos City Hall
5th	São José dos Campos City Hall	INPE	SIMA	UNIVAP

KEY: Public actors (pink); not-for-profit private actors (green).

SOURCE: Prepared by the authors

In addition to carrying out FLR projects in the Paraíba Valley, *Corredor Ecológico* plays an important role in articulating actors in the Paraíba Valley, as a bridge organization, for example, in the ROAM (2015) and *Polo Florestal* (2016) initiatives. The role of *Corredor Ecológico* in the approach and establishment of partnerships with the WRI Brazil and TNC NGOs deserves to be highlighted. The latter, which also stands out among the main actors, has been active in the Paraíba Valley since 2015, especially at the micro-regional (ROAM and *Polo Florestal*), municipal (*São José mais Água* Program) and sub-national (*Conservador da Mantiqueira* Program) levels. TNC has been playing an important role as a change agent by brokering various interactions with social actors at the municipal and local levels, as in the case of supporting City Halls in preparing municipal PES policies. In addition to acting as bridge organizations and change agents, TNC and *Corredor Ecológico* play important roles in disseminating resources and information to the other network actors.

The public actors contributing to FLR in the Paraíba Valley include public universities and research institutes (UNESP, USP, INPE, ITA) and environmental agencies linked to the state of São Paulo and the Federal Government (SIMA, São Paulo Agribusiness Technology Agency [*Agência Paulista de Tecnologia dos Agronegócios*, APTA] and ICMBio). These actors contribute to knowledge production, people's training, rural technical assistance, elaboration of regulations for FLR and provision of resources for forest restoration projects (Adams et al., 2021). São José dos Campos City Hall, ICMBio and SIMA stand out as disseminators capable of quickly reaching the other actors in the network, constituting important players for catalyzing new FLR projects. The City Hall and ICMBio are involved in FLR-related initiatives at the micro-regional (ROAM) and municipal (*São José mais Água* Program) levels. Although ICMBio's main role is to manage the *Mananciais do Paraíba do Sul* Environmental Protection Area (Área de Proteção Ambiental, APA), the management body of this Conservation Unit has sought to strengthen its social network in order to find opportunities for projects and partnerships that benefit the APA and the HB-RPS as a whole. SIMA, which ranks fifth in the bridge organization and disseminator metrics (Table 6), is involved in several FLR initiatives in the Paraíba Valley, such as forest restoration projects for environmental compensation (2011), the *Nascentes* Program (2014), in addition to preparation of ROAM (2015), the *Polo Florestal* Project (2016) and the *Conexão Mata Atlântica* Project (2018). SIMA has a significant track record of water and forest conservation and forest restoration projects in the region, currently represented by the *Nascentes* Program and the *Conexão Mata Atlântica* Project.

SIMA's work stands out in the social landscape of the Paraíba Valley FLR, with its 10-year track record of implementing programs and projects, as well as working with other social actors to develop new FLR governance models, such as the *Polo Florestal* Project. SIMA's work in the Paraíba Valley demonstrates a governance process centered on the action of this public actor as a disseminator of financial resources, inputs and technical assistance for FLR actions in the Paraíba Valley (Adams *et al.*, 2021). The centrality role of SIMA in the dissemination of diverse information and resources was also identified in a study about governance of water resources in HB-PSR (Marques et al., 2020).

4. Discussion

The Paraíba Valley has been accumulating FLR experiences for at least 15 years, with academic research initiatives, state programs for water conservation and native vegetation recovery, regularization of rural properties, diagnoses for land use planning, formation of work networks and actions to train people, and implementation of Agroforestry and rural development systems. Multiple social actors are working from the local to the international level, contributing to changing the historical path of deforestation and land degradation in the region and producing social, economic and environmental benefits through different FLR governance initiatives.

FLR is a strategy that involves multiple actors from different sectors and with sometimes divergent interests in relation to land use (Chazdon & Laestadius, 2016). The history of initiatives and the network metrics presented show a capacity for collaboration between social actors in the Paraíba Valley, from different categories and between different levels of the geographical scale of action. Based on the diagnosis about the forest restoration chain challenges in the Paraíba Valley, Andrade *et al.* (2018) states that it is important to promote better coordination and communication between the social actors involved in restoration, given that the network includes 141 organizations, including public bodies, companies, civil society organizations, universities and consultants.

Based on the history of initiatives and the current FLR network in the Paraíba Valley, it is possible to note the prevalence of private not-for-profit actors at the micro-regional level (Figure 4), where there is a greater density of connections. Based on the association between a greater number of civil society actors at the level with the highest density, it is plausible to assume that these actors are responsible for bridging the social actors in the forest restoration network in the Paraíba Valley, creating links and thereby increasing cohesion of the network. This assumption is reinforced by the results of the centrality metrics, which highlight the leading role of these actors as bridge organizations, disseminators and change agents (Table 6). One of the expected results of increasing network density is greater cohesion between the social actors, which can benefit collaboration between different players, strengthen trust between them and ease access to diverse information. However, a possible risk of a dense network for leading FLR governance is overlapping of various projects, actions and knowledge (Bodin et al., 2006; Buckingham et al., 2018).

The centrality of private not-for-profit actors in the social network indicates the importance of representatives from this category, such as NGOs, in FLR governance in the Paraíba Valley and, specifically, in the articulation between actors in the network and dissemination of resources and information on forest restoration. Contributing to the coordination between sector actors and between different levels is the presence of bridge organizations, which are also central to the dissemination of resources and information in the forest restoration network (Table 6). Bridge organizations connect multiple social actors from different sectors acting in different areas, with different jurisdictions and which represent different values, interests and perspectives. These organizations can ease local actors' links with others at different levels or external to the existing network, both to promote access to and sharing of information, knowledge and financial resources and to promote engagement between actors with little connection

to each other (Berdej & Armitage, 2016). *Corredor Ecológico*, TNC, São José dos Campos City Hall, ICMBio, and SIMA are the central actors capable of easing interactions with actors at the same level and other levels of the spatial scale of action, as well as between actors working in different sectors. The different natures of these five actors suggests that they can complement themselves in their roles as bridge organizations, according to their resources and capabilities In the Paraíba Valley FLR network, *Corredor Ecológico*, TNC, ICMBio and the São José dos Campos City Hall are central actors in the position of a link with the most connected actors (eigenvector degree/change agents, Table 6) and building bridges that connect different components of the network (intermediation degree/bridge organizations, Table 6).

The centrality of civil society organizations has also already been identified by Pinto *et al.* (2014) when analyzing a broad network of social actors, the *Mata Atlântica* Restoration Covenant, who work on forest restoration initiatives in the biome. However, the authors recognize that under- or over-representation of certain categories of actors, representatives of sectors and geographical areas, can negatively affect representativeness and legitimacy of FLR initiatives.

The NGOs acting in the Paraíba Valley are active in different geographical areas and are concentrated at the local (Akarui, *Corredor Ecológico*, Suinã and Serracima, among others) and international (WRI, TNC and WWF) levels. Currently, these NGOs seek to work in an integrated way in partnerships to capture and distribute resources and elaborate projects. The local NGOs stood out for implementing projects side by side with the local producers. The main challenge for local NGOs is to raise more funds for their projects, which has mobilized at least one of these organizations to work in partnerships and seek funds outside the country, as well as from other sources in the private sector that have not yet been prospected. Some of the funders of the local NGOs have used the expression "institutional strengthening" in the sense of "helping" NGOs by offering them training, rather than directly providing them with financial resources to carry out their action plans. Local NGOs are small organizations and their continued actions, mainly those related to mobilizing and involving social actors in restoration projects, depend on a continuous flow of financial resources for maintenance. It worth asking what NGOs expect as "institutional strengthening" since, considering the current challenge they face to enable their projects, it seems to mean direct funding. International NGOs play an important role in articulating (and advocating) between scales and levels with actors from the federal, state and municipal public sectors, as well as in injecting financial resources into specific FLR actions in the Paraíba Valley.

In the current Paraíba Valley network, the category of public actors is the one with the highest number of actors, indicating that public actors play a central role in FLR. The São José dos Campos City Hall stands out for its history of pioneering restoration initiatives in the region and for using economic instruments such as Payments for Environmental Services. At the state level, the centrality of SIMA stands out, responsible for designing state environmental regularization programs and regulations governing ecological restoration in the state of São Paulo (Aronson et al., 2011; Chaves *et al.*, 2015).

The "rural producers" and "for-profit private actors" categories comprise the main groups of

peripheral actors. In the Paraíba Valley network, most of the peripheral actors are at the local level (8 [25%[), with 7 rural producers among them. Rural landowners' involvement in forest restoration is fundamental to reducing the fragmentation of the *Mata Atlântica* region (Ribeiro *et al.*, 2009), by connecting the remaining forest fragments present in these private areas (Tabarelli *et al.*, 2005). However, the peripheral position of the rural producers in the Paraíba Valley FLR network suggests certain difficulty among these actors to access diverse information and resources for LDR. As suggested by Zinngrebe et al. (2020), when discussing the factors that can lead to scaling up of Agroforestry system implementation initiatives in Honduras, Peru, Indonesia and Rwanda, bridge organizations such as non-governmental organizations representing rural producers and public organizations at the local level can play a crucial role in promoting integration and easing collaborative processes between social actors.

Also noteworthy at the other levels are the peripheral actors represented by mining companies and highway concessionaires, with activities that depend on environmental licensing and require environmental compensation, conduct adjustment agreements (*Termos de Ajustamento de Conduta*, TAC) and environmental recovery commitment agreements (*Termos de Compromisso de Recuperação Ambiental*, TCRA). As presented by Andrade et al. (2018), these agreements represent the largest sources of financial resources for the forest restoration chain in the Paraíba Valley. However, despite their position in the network, it draws the attention that these peripheral actors have connections with the main actors with an intermediary role (bridge organization), such as *Corredor Ecológico*, TNC and SIMA, which implies favorable conditions for expanding their integration with the other actors in the network. However, it is necessary to verify whether the low centrality degree of these actors is an indicator of their detachment from the ongoing FLR processes in the Paraíba Valley, or even a methodological bias of Net-Map associated with the low participation of representatives of these actors in the social landscape mapping workshops.

It is important to note some limitations of the social landscape mapping for surveying data about social networks, which involves the social actors and their connections. In participatory workshops, the Net-Map app has methodological limitations that are reflected in the diagrams of the social networks and in the metrics obtained. The social landscape of the Paraíba Valley FLR presented in this study (Figure 3) is the result of the view and knowledge of the individuals who took part in its creation and reflects a specific moment in time: 2019. The history of initiatives and their proponents shows a number of important social actors in the region, such as the private not-for-profit category (Akarui), the private for-profit category (Suzano) and the representation of rural producers, such as rural producers' associations. There were no representatives of these actors in the Net-Map activity. As a consequence, it is possible that their connections are either not represented or under-represented, that is, with a lower centrality degree, in the Paraíba Valley FLR social landscape map (Figure 3). Another limitation of Net-Map pointed out by Zinngrebe *et al.* (2020) is related to the duration of the social mapping activity, which can affect the quality of the social landscape maps due to the participants' fatigue.

Regarding the identified limitations of the social network analysis method, the low centrality

degree of some social actors with a relevant role in the Paraíba Valley stands out, as they appear frequently both in the history of initiatives and in some of the interviewees' testimonies. This is the case of informal networks such as the Paraíba Valley Agroforestry Network and the Paraíba Valley Forest Restoration Actors' Network, which are the product of the self-organization of some of the actors mapped and others not present in the governance network mapped in this study. Alexandra et al. (2018) attribute to the Actors' Network the potential to strengthen and articulate the forest restoration chain through meetings, dissemination of information and participation in public policies, thus contributing to developing the forest economy in the region.

5. Conclusion

The FLR governance analysis in the Paraíba Valley indicates a history of initiatives that involve multiple social actors, connected with each other and at different levels. The case of FLR in the Paraíba Valley brings the interests of heterogeneous social actors into the governance scenario, in addition to the countless opportunities for the development of FLR implementation models that, in the long term, can contribute to improving a shared view of FLR governance within the regional landscape. Particularly noteworthy is the centrality of actors from the private not-for-profit and public categories, with greater presence of FLR initiatives at the micro-regional level, which corresponds to the area covered by the Paraíba do Sul river basin, as well as the redundancy of central social actors in the roles of bridge organizations, disseminators and change agents.

For the network of social actors in the Paraíba Valley FLR to be able to advance in the number and size of FLR initiatives, it is necessary to deal with some of the challenges that arise, such as attracting and distributing financial resources to actors at the local, municipal and micro-regional levels; guaranteeing long-term continuity of the projects; increasing the involvement of rural landowners; and coordinating actions between the social actors in the Paraíba Valley. In the Paraíba Valley FLR network, rural producers' involvement takes place through networks promoted by external actors and through interaction with NGO representatives, in the execution of projects and mobilization actions. However, in order for the efforts to involve rural producers to have effective results and with a view to scaling up the initiatives, it is necessary to create spaces and guarantee their participation in decisions about the FLR projects. In other words, the social actors benefited by FLR actions should participate in the formulations and decisions regarding where and how to restore landscapes.

The analysis of the FLR social network in the Paraíba Valley made it possible to identify the social actors, such as civil society and public organizations, with the capacity to promote actions regarding articulation, dissemination and integration of actors in the network. Therefore, one of the strategies suggested for strengthening FLR governance in the Paraíba Valley is to reinforce these social roles through the allocation of resources for these actions by the central social actors. Integration of the peripheral actors may increase network cohesion, with effects of the ability to formulate and implement FLR projects and programs. In addition, initiatives

that are more representative of local demands and have a greater capacity for maintenance and gains in scale can be expected if they are part of the FLR network governance process that is already in progress.

Although the network of social actors in the Paraíba Valley FLR is a snapshot of the time when the data was collected (2019-2020), the analysis method used for the network of social actors presented in this study can serve as a diagnosis (though partial, but drawn with the involvement of active actors) of the potentialities and weaknesses of articulation, collaboration and sharing of resources between actors, which can be adjusted to favor initiatives that promote gains in the FLR scale. Describing the history of initiatives and systematizing the experiences learned may assist in improving the design of future FLR projects and programs in the SPPV. The description of the governance process presented in this study can be complemented by future studies that analyze the historical evolution of the centrality and profile of the network and the corresponding changes in the roles of the FLR social actors in the Paraíba Valley.

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