Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

Socioeconomic impacts of urban restoration in the Atlantic Forest, Brazil

Luisa S. Lemgruber [a,c,*], Veronica Maioli [a], Agnieszka E. Latawiec [a,b,e,f], Alexandro Solórzano [b], Luiz F.D. Moraes [c,d], Eric D.S.M. Lino [a], Ingrid A.B. Pena [a,b], Bernardo B.N. Strassburg [a,b,g]

[a] *International Institute for Sustainability, Estrada Dona Castorina 124, 22460-320, Rio de Janeiro, Brazil*
[b] *Department of Geography and the Environment, Rio Conservation and Sustainability Science Centre, Pontifícia Universidade Católica, 22453900, Rio de Janeiro, Brazil*
[c] *Escola Nacional de Botânica Tropical (ENBT), Rua Pacheco Leão, 2040-Solar da Imperatriz, Horto, 22460-036, Rio de Janeiro, Brazil*
[d] *Brazilian Agricultural Research Corporation, Embrapa Agrobiology, Rodovia BR 465, Km 7, 23891-000, Seropédica, Rio de Janeiro, Brazil*
[e] *Department of Production Engineering, Logistics and Applied Computer Science, Faculty of Production and Power Engineering, University of Agriculture in Kraków, Balicka 116B, 30-149, Kraków, Poland*
[f] *School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, UK*
[g] *Programa de Pós Graduação em Ecologia, Universidade Federal do Rio de Janeiro, 68020, Rio de Janeiro, Brazil*

ARTICLE INFO

ABSTRACT

Ecological restoration provides a range of ecosystem services. However, the social aspects of restoration are rarely reported. Here we assess the socioeconomic effects of the restoration project called "Mutirão Reflorestamento" (MR), located in an urban fragment of Atlantic Forest in Rio de Janeiro. We conducted a survey in eight communities, involving 139 residents, where 62 worked for the MR Project, and 77 were not directly involved. To collect the data, we conducted focus groups (N = 23, totalling 62 participants) and personal interviews (N = 44). We found that the main positive contributions of the MR Project were job creation and increased income. The presence of Forest was also associated with the improvement of air and life quality, for example through the provision of recreational areas. The lack of formal work benefits and recently reduced budget for the project were indicated as negative aspects of the MR Project. The main recommendations to improve the Project were: enhance communication between city hall, residents and MR participants, and the appraisal and recognition of the project participants. The results represent the voices of communities directly involved and impacted by restoration, and they may contribute to improving restoration projects in tropical countries.

1. Introduction

Tropical forest ecosystems host at least two-thirds of the Earth's terrestrial biodiversity and provide significant local, regional and global benefits to people through the provision of ecosystem services (Gardner et al., 2009). The Brazilian Atlantic Forest is one of the world's most diverse and threatened tropical forest biome, and an important global biodiversity hotspot, with elevated rates of endemism and species diversity (Tabarelli et al., 2010; Joly et al., 2014). It provides essential ecosystem services such as water flow regulation, slope protection, and climate regulation for approximately 70 % of the Brazilian population (Forzza et al., 2010), since the largest Brazilian metropolitan areas, as Rio de Janeiro and São Paulo, are within the Atlantic forest domain (Scarano and Ceotto, 2015). It represents the resource base for a considerable part of the country's gross domestic product (Scarano, 2014).

Despite its importance, the Atlantic Forest has suffered from forest loss and fragmentation (Ribeiro et al., 2009; Guedes and Seehusen, 2011), losing 73–84 % of its native vegetation cover (Strassburg et al., 2018). It is estimated that 60 % of the ecosystem services (ES) that guarantee the populations well-being in this biome have already been suppressed or are under pressure such as, maintenance of water cycles and air quality, protection of biodiversity, and scenic beauty (Guedes and Seehusen, 2011). This fragmented forest was generated by a society that is also directly affected by it's loss, showing the interdependence and the importance of creating a healthier use and consciousness of the services it provides. The outlook for regional sustainable development is alarming, especially given the current climate instability, and increased extreme events, which in turn, increases the vulnerability of local social-ecological systems (da Silva et al., 2016).

Brazil has integrated landscape management, planning and engagement in forest restoration initiatives with promising results and perspectives (Joly et al., 2010; Calmon et al., 2011; Joly et al., 2014; Rezende et al., 2018; Crouzeilles et al., 2019; Strassburg et al., 2018). These are supported by policy measures regarding forest management, restoration and conservation in Brazil such as the Atlantic Forest Law (n° 11.482/2006) and the Native Vegetation Protection Law (n° 12.651/2012). The main barriers to achieve these goals include high costs of restoration techniques, lack of investments, limited technical assistance, and poor governance in certain regions (Chazdon, 2017; Strassburg et al., 2018). Several techniques can be used on forest landscape restoration (FLR) (Chazdon, 2017), including natural regeneration, that allows forests to regrow without human intervention. However, direct planting of seedlings or seeds (active restoration) (Palma and Laurence, 2015) has a more significant potential to support the local economy by stimulating job creation and strengthening the restoration chain (Crouzeilles et al., 2017).

Regardless of the technique, FLR offers opportunities to design more livable, healthy, and resilient cities (Elmqvist et al., 2015), such as re-energization of working relations with the land that produce material benefits for people (e.g. fiber and food), expansion and improvement of access to potable water, environmental education, spiritual development and income generation. By associating forest restoration with ES benefits, FLR can also help to reduce risks of disasters, which is especially relevant in urban cities like Rio de Janeiro, which presents disorderly occupation on hillsides and landslide risk areas.

Urban forests worldwide have been also evaluated by the provision of ecosystem services and the reduction of risks (Livesley et al., 2016), but perceptions and feelings that urban dwellers have regarding nature in the city are diverse, sometimes contested between groups of stakeholders and can even be ambivalent. Evaluation efforts have noticed that people that believe they benefit from urban forest restoration may even reject restoration actions due to the approach (technique, strategy) adopted (Bright et al., 2002). Thus, the concepts and practices developed to implement urban ecological restoration must be sensitive to multiple understandings (Trigger and Head, 2010).

Although social aspects and local perception are essential in FLR projects, understanding local stakeholders' perceptions on restoration benefits for their well-being is one of the most critical knowledge gaps of restoration. Projects must be aware of the relative importance of restoration given by stakeholders towards the restoration of urban forests; positive feedback is suggested to be linked to stakeholders' values, and negative to emotions (Bright et al., 2002; Burger, 2002). Including public perception into the restoration of urban forests may be strategic, since restoration may somehow threaten the sense of place (Buis, 2009).

Further than just evaluating processes and environmental aspects, evaluative criteria for restoration projects also include socioeconomic outcomes (Conley and Moote, 2003). Evaluation based on socioeconomic indicators and how restoration projects interfere in the protection of urban human populations and their well-being are paramount to aid adequate decision-making and formulation of public policies to maximize the benefits of the restoration over time (Agol et al., 2014).

The "Mutirão Reflorestamento" Project (MR) is one of the most important examples of a large-scale urban restoration project in Brazil and featured by the UN as an Ecosystem Based Disaster Risk Reduction example (Camarotti and Spink, 2003; Herzog and Finotti, 2013; Nehren et al., 2014; Lange et al., 2018). The MR was awarded by the Brazilian Ministry of Environment, selected as part of the UN project: Mega-Cities and composes the database of best practices and local leadership of the United Nations Human Settlements Programme (UNCHS) (Nehren et al., 2014). Despite all of these accolades and recognition of the MR as an important forest restoration and disaster risk reduction initiative, there are still some knowledge gaps regarding socioeconomic indicators and perception of local residents regarding the restoration project. Filling this gap will help to identify motivations and causes of forest loss and degradation, improve trade-off negotiation that can satisfy different

"stakeholders" needs, and develop strategies to strengthen local organization and participation, forming strategic alliances (Buis, 2009). Taking this into account, our main research question is: How do the local residents perceive and interact with the restoration projects in their communities? We also answer the following specific questions: (a) What are the residents' perception of forest cover? (b) What are the residents' perception of the MR Project? (c) What recommendations are made by the residents to improve the MR and community wellbeing? In this work, we focus on the perception of the eight communities where the MR Project is implemented. We analyze their perception regarding i) the ecosystem services and the 'communities' relationship with the surrounding forest, and ii) the positive and negative impacts of MR Project in their lives. We also collect recommendations of the residents to increase the quality of the Project.

2. Materials and methods

2.1. About the MR project and study area

"Mutirão Reflorestamento" Project was implemented in 1987 in the Rio de Janeiro (Rio) city and remains active to the present by the Environmental Municipal Secretary (SMAC, in the Portuguese acronym) (Rio de Janeiro, 2019). It had two main goals: recovery of the Atlantic Forest native vegetation and provide job opportunities for community residents. During its 33 years of implementation, the MR Project has trained about 15,000 community residents and restored over 3400 ha with 136 reforestation projects around the city of Rio, mostly in slopes and hilly terrain close to poor communities, usually favelas (slums) (Rio de Janeiro, 2019). The MR Project included areas based on three criteria: 1) steep slopes with degraded vegetation and soil, close to poor communities and subject to landslides; 2) valleys with irregular occupation and with flooding risks, due to the silting of rivers and channels; 3) areas adjacent to Protected Areas or Areas of Permanent Protection (APP) (Rodrigues, 2007).

For this study, eight communities from 72 active projects were selected based on: i) proximity to restored areas, ii) over 20 years of project implementation, iii) project still active, and iv) feasibility/safety to collect field data. The eight communities were "Dona Marta", "Chácara do Céu", "Vidigal", "Entre Rios", "Rio da Prata", "Cantagalo", "Capoeira Grande" and "Guaratiba" (Fig. 1). Supplementary Table A.1 presents the social data of the analyzed communities.

In those eight communities, 115 ha of forests were restored since the MR Project implementation, completely changing the vegetation cover in those areas (see Fig. B.1 - B.5 in the supplementary material). The analyzed communities are distributed in two geographic zones of the state of Rio de Janeiro - South zone and West zone. The South Zone where Dona Marta, Vidigal and Chácara do Céu communities are located, is the richest part of the city, with a Human Development Index (HDI) of 0,722, the highest income area and with the best urban infrastructure, equipment, and services in RJ (see supplementary Table A.1). It also presents famous ecotourists' attractions, such as the Christ statue and Tijuca National Park, one of the most visited Brazilian National Parks with 3953 ha restored forest (PNT, 2020). However, it is important to stress the social inequality embedded in the areas, as the analyzed communities present a completely different social and economic context from the rest of the South zone: lack of basic sanitation, urban planning, and quality education, with high rates of violence due to drug trafficking.

In contrast, the West Zone where Entre Rios, Rio da Prata, Cantagalo, Capoeira Grande, and Guaratiba are located, was a rural hinterland area until the mid-20th century and currently presents an accelerated population growth and urban sprawl by the lower and middle-class population of RJ. The West Zone is characterized by the lack of infrastructure, absence of urban assets, land conflicts, socio-environmental problems, and intense land speculation (Torres, 2004; Araujo and Cortado, 2020), with the HDI ranges from 0493 to 0597 (see supplementary Table A.1)
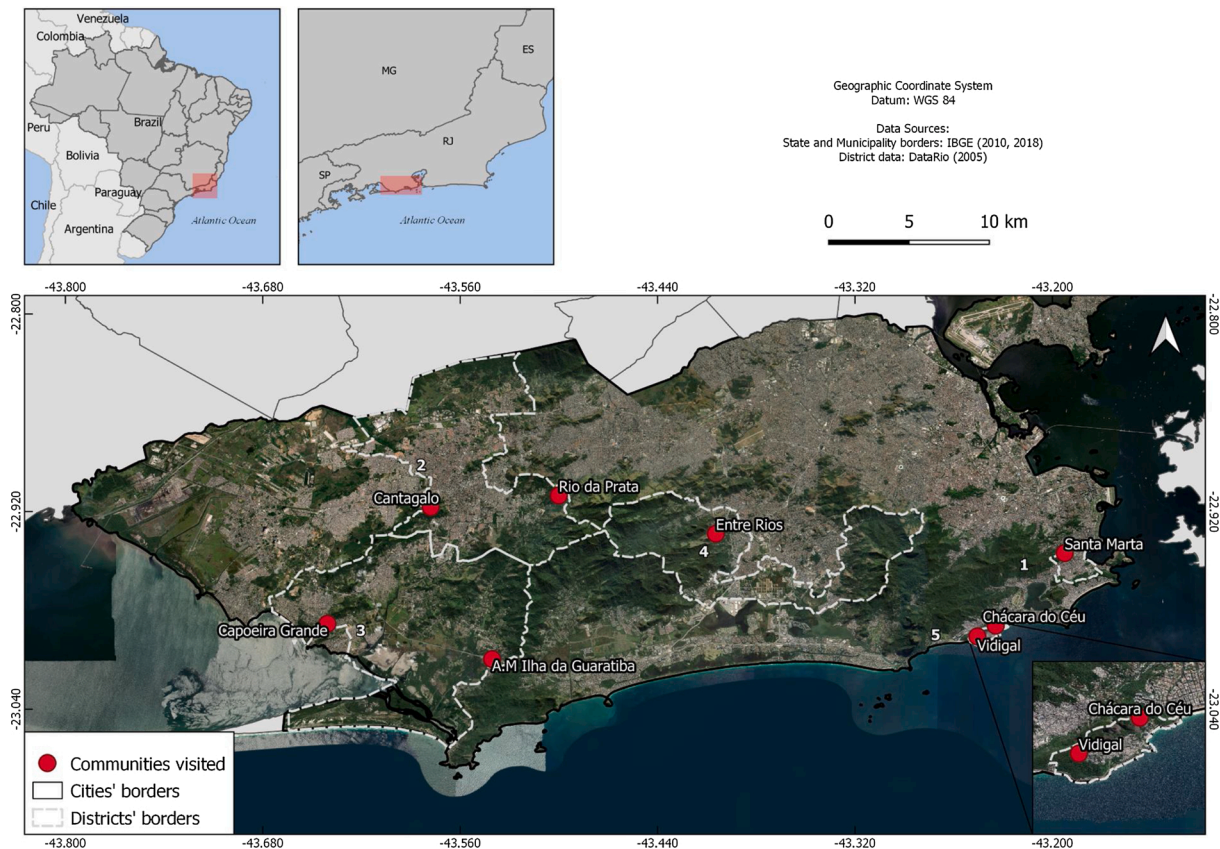
Fig. 1. Location of the eight communities (dots) analyzed in the present research at Rio de Janeiro's municipalities.

([Data Rio, 2010](#)). These communities are surrounded by the Pedra Branca State Park, mainly visited by its surrounding population.

2.2. Data collection and analysis

The field survey included participatory research with residents of eight communities using focus groups. We chose this methodology as they can help in the normative understanding of collective judgments of social groups. Moreover, it is considered an exemplary method for collecting data when time and financial resources are limited, and when it is necessary to gather information from different stakeholders in potentially violent areas ([Latawiec et al., 2014](#), [2017](#)).

We performed one focus group in each analyzed community, with a total of 64 residents who worked in the MR Project (referred to as project participant - PP from now on) and 35 residents not directly involved in the MR Project (referred to as non-project participant - NPP). The NPP were randomly contacted by the residents association of each community. Although we aim to have the same number of participants in each focus group, attendance varies due to the number of PP in each community. We also did an additional 44 individual face-to-face, semi-structured interviews with NPPs, due to their lower number in the focus group. Since NPPs had no direct relation to the MR Project, we made broader questions focused on their perception of the forest areas, rather than on their perception of the MR Project (see supplementary material for the questionnaires). Considering that perception can change due to the characteristics of the surrounding environment ([Oliveira, 2001](#); [Profes, 2006](#); [Vilhena and Oliveira, 2010](#)), the NPP interviewed were randomly selected around the communities, balancing the number of interviewers who lived far and close to the restoration sites.

We used open questions to assess the participants' perception of the forest and of the MR Project. Specifically for the question "What does the forest mean to you?", we used pictures of ecosystem benefits (more

biodiversity, less biodiversity, more pollination, less pollination, etc), and asked the participants to indicate the five most representatives ([Fig. 2](#)).

The answers collected using focus groups and individual interviews were organized using Excel® worksheet, and later analyzed by discourse analysis ([Cruickshank, 2012](#)). Afterwards, we calculated the percentages of each category and ranked the most common categories in the focus groups.

3. Results

3.1. Forest perception

The majority (61 %) of NPP perceived an increase of forest cover due to reforestation (not all of them linked this increase to MR Project), and 27 % reported an expansion of the communities and consequently, an increase of deforestation even with the MR Project implementation. For the participants (PP and NPP), having forest means more biodiversity, scenic beauty, fresh air, and water ([Fig. 2](#)). Furthermore, the PP group associated forests with increased income and a decrease of environmental disasters, while the NPP group associated it with recreation (access to waterfalls, trails, flying kites).

When explicitly asked about the benefits of having forest near their homes, the NPP associated it with providing better air quality (36 %), a better lifestyle (23 %), increasing biodiversity (9 %), recreation areas (9 %) and scenic beauty (7 %). The majority (70 %) do not see any negative aspect of having forests in the surrounding areas and only 21 % indicate the presence of unwanted animals, such as snakes and mosquitos.

Most interviewers currently live close to the forest fragments where 40 % of PP and 58 % of NPP would not desire to leave. The satisfaction with their home place was mainly due to the benefits provided by the forest. Although living close to the forest areas, 57 % of NPP indicated
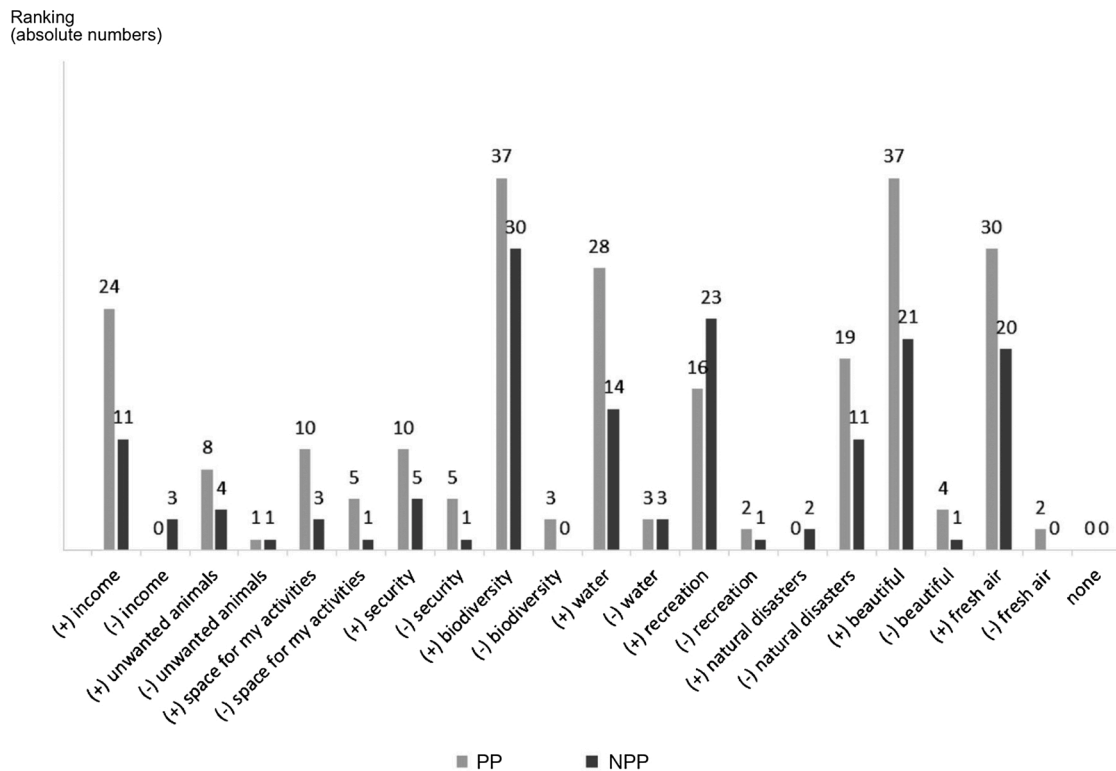
Fig. 2. Ranking (5 stickers for each one) of the participants' perceptions (PP and NPP) about "What the forest means to you?" (number of PP = 64 and NPP = 35).

having little relation with the forest, while 32 % use it for recreation, especially in Dona Marta, Chácara and Vidigal communities located at the south zone of Rio (Fig. 1), from where it is possible to access tourist attractions such as trails and famous landmarks.

3.2. Perception about 'Mutirão Reflorestamento' project

The main benefits of Mutirão Reflorestamento reported by the PP were: I) better air quality (19 %), II) income and work opportunity (18 %), III) pleasant work environment (16 %), work-residence proximity and flexible working hours, and IV) increase in forest cover (9%). For the NPP, the main benefits of the Project were: I) integration with nature (18 %), which stimulates cleaner and preserved areas, II) raising income and job opportunities (14 %) and III) increased forest cover (12 %) (Fig. 3a).

Negative aspects of the Project were listed for the PP as I) absence of labour benefits (41 %), including lack of a formal contract, no paid vacations, health insurance and meals, II) reduced budget for the Project over the years and decrease in payment value (26 %), and III) work risks (10 %), such as lack of personal protection equipment and assistance in case of accidents (Fig. 3b).

According to the NPP group, 24 % claimed that the Project did not have any negative aspects. Although 14 % pointed out the reduced budget for PP, 11 % mentioned the absence of labour benefits for PP and 11 % cited the presence of insects and snakes around their houses as negative impacts (Fig. 3b).

3.3. Communities' recommendations

Among the propositions to improve the MR Project, the highlighted points made by PP were: I) to increase labour benefits (14 %), such as a formal contract and better working conditions; II) more training courses and technical training (10 %) and III) the presence of environmental agents inside the activity area of MR Project (9 %), to increase safety and respect for the workers during the service.

The main proposals of the NPP were who claimed to know the

Project, I) increase labour benefits and greater comfort for the PP during the work (18 %), which are associated with a formal contract and access to private health care II) improve the environmental education for the community (16 %), to discourage littering, deforestation, forest invasion, illegal forest fires, and to promote ecological walks and hiking, environmental awareness and the importance of trees.

Overall, the points to improve the Project made by both groups were: I) raising environmental education in the communities (34 %), II) broaden project dissemination in the communities (27 %), III) increase labor benefits for the PP (23 %) and IV) improve communication with decision-makers at the municipality level (17 %). Oversight/supervision of the MR projects, reforestation, and the incorporation of useful trees (especially fruit trees) in the projects, were also mentioned by PP and NPP groups (together accounting for 17 %).

4. Discussion

4.1. Perception about the forests

The ecosystem services most noted as forest benefits by the participants were related to the improvement of climate and air quality, pleasant environment and a better lifestyle. These services are more "visible" for the society and usually more valued for providing direct benefits to people (Scholte et al., 2015; Miranda, 2017). Individuals tend to look to nature's aspects that guarantee sustenance, health, and satisfaction in their lives (Profes, 2006; Miranda, 2017). As an example, we provide a citation from a NPP interviewed: "*In the past, my son had bronchitis and after I moved here, he got better because of the forest*" (interviewee at the community of Entre Rios, west zone).

For the participants, the existence and maintenance of forests represented an opportunity to increase the communities income through tourism, increase ecological recreation, as well as provide other cultural ecosystem services, such as the strengthening of cultural identity, sense of belonging and community pride (Ribeiro et al., 2016). The opportunity to increase income was pointed out mostly by residents from the
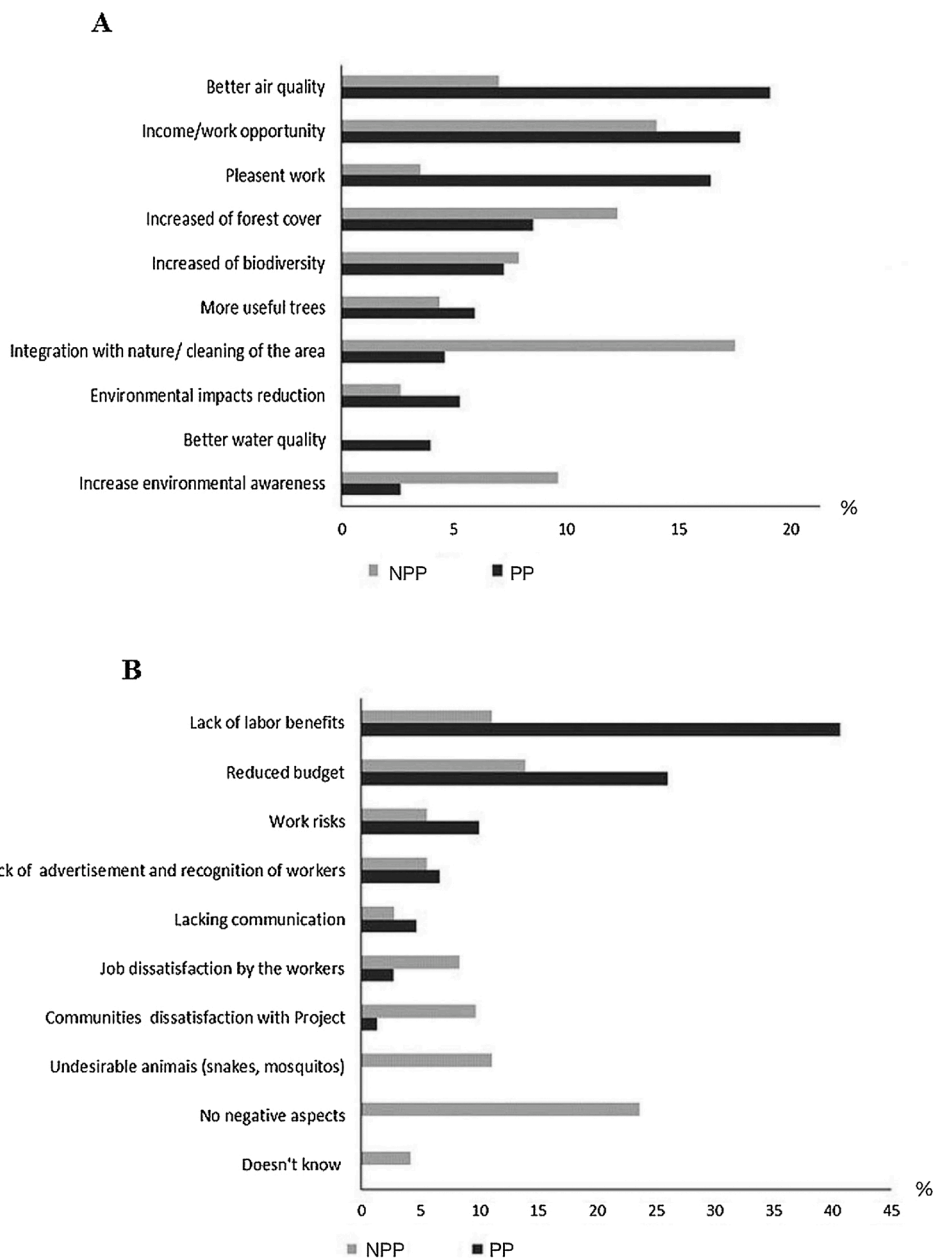
A

B

Fig. 3. a) MR benefits perceived by the PP and NPP of Focus Groups from the eight communities included in the research (%) (number of PP = 64 and NPP = 35). b) MR negative aspects perceived by the PP and NPP of Focus Groups from the eight communities included in the research (%) (number of PP = 64 and NPP = 35).

communities located in the South Zone, which has a higher tourist flow due to its central location in RJ.

Although the great majority of interviewees perceived the forest as a provider of important ecosystem services (Fig. 2), few (4 %) saw it as a drawback due to the presence and/or increase of unwanted animals and associated forest with garbage accumulation. The few participants with negative views of the forest were all from the Guaratiba community, an area with intense tourist flow due to the trails that reach remote beaches. In their view, forest cover can lead to a higher occurrence of snakes on the trail that may discourage tourism and, in consequence, harm their income. This highlights the importance of environmental education within restoration projects that can raise awareness about the social and environmental benefits of preserving natural spaces.

Considering that 27 % of the NPP reported the expansion of the community and deforestation in the last years, even with the MR Project presence, it's important to invest more in environmental surveillance and control, education activities, and better dissemination of the

Project. In the da Prata community, for example, one of the NPP interviewed said: "*I raised my daughter in the woods. I was against building the church in the place of the woods, but nowadays, the forest no longer exists because it became a Family Clinic.*[1] *I used to like to go for a walk to have contact with nature.*" This can be related to the ongoing urban sprawl in the West Zone simultaneously to the lack of investment in surveillance and management of the Pedra Branca State Park. On the other hand, 39 % said that the forest cover had increased in the last years linked to the MR Project, and 23 % did not relate specifically to the Project: "*In the past it was all grass. The forest area had decreased because of the community expansion, but after the landslide, the favela no longer increased towards the forest and the reforestation took place. Sometimes, a car passes by bringing the seedlings to replant the forest.*" (NPP interviewed from the Vidigal community). Only 9% said that they had not perceived the differences,

---

[1] Medical Service of the Municipality of Rio de Janeiro.

and 2 % in the Vidigal community had mentioned the increase in ecotourism inside those areas.

Communities are located in the hilly mountains of Rio. The geographic aspects (e.g., elevation and slope) of the mountain and the location of forest fragments, together with historical factors such as previous land use, could also influence the connection/relation of residents with the forest. For example, when the easiest accesses to the forests are located at the top of the mountain, the residents living in the bottom part of the community do not relate much to it. In our study, we observed that in Dona Marta where the residents that live closest to the forest in the highest part of the mountain declared using the forest for trails and other recreational purposes, and those who live in the lower part, do not usually have a relationship with this area, demonstrating that environmental perception of the participants can be also related to their proximity to forest fragments.

The perception also can change because of other factors such as individual historical use with the forest area and the presence of an environmental agent in the community, which represents the MR Project and could also stimulate environmental activities within the communities (Profes, 2006; Ribeiro and Ribeiro, 2016).

The interviewees of the Chácara do Céu community (South Zone) said they have a closer relationship with the forest area. According to our study, the connection between nature and residents in this area is mainly influenced by their easy access to the native forest area, considering the proximity with the community and the presence of Penhasco Dois Irmãos Natural Park that offers a recreational area. The presence of an environmental agent inside the community that carries out environmental education activities with the residents is another crucial aspect to consider when evaluating the communities' close ties with the surrounding forest. The size of the community can also influence this relationship, considering that Dona Marta has 3908 residents, while Chácara do Céu currently is home of only 694 (see supplementary Table A.1) (SABREN, 2010).

Furthermore, awareness can serve as a powerful tool to protect the restored areas from fires, irregular expansion of the community, among other factors. This tool is an essential step of a more extensive integrating process that starts with residents perceiving the importance of the environment for their quality of life and then leading to positive actions and success of projects and public policies (Melazo, 2005).

4.2. Perception of the Mutirão Reflorestamento project

The participants perceive the MR as a positive Project for the communities that achieves environmental, social, and economic goals such as the generation of income, biodiversity increase, improvement in air and climate quality, recreation, containment of communities' expansion, and fire reduction (Miranda, 2017).

The recognition of the relationship between forest and income comes from the fact that despite being temporary and informal, the job in the MR Project was the primary source of income for many participants (Salgado, 1998; Santos et al., 2003). This is especially important in an area where most of the population earn less than two minimum wages per month ($370/month). Despite the absence of a formal employment relationship, the MR Project contributes to the "management of the non-employable", allowing the inclusion of people with a low level of education and over 50 years, giving opportunity for those less able to be part of the formal market (Macedo, 2002).

The negative perceptions highlighted by the participants (Fig. 3b) is similar to Miranda's (2017) findings, as 67 % of the PP cited the dangers of venomous animals, and 22 % reported the communities' disrespect for the reforestation areas (e.g., disposing of garbage). In addition, they pointed out inadequate use of the areas by the residents (as fire activities) and the lack of protective equipment and first aid kits. These issues bring direct consequences and risks to the PP and to the Project, causing a general feeling of insecurity, and the risk that the MR Project is temporarily suspended.

One interesting and alarming result was the association of increased forest cover with violence. According to the participants, the expansion of forest cover together with the favelas' geographical aspects (hilly, optimal vantage points to see who is coming, narrow streets, and good escape routes to other mountains nearby), provide coverage, hiding places, and escape routes for drug dealers and thieves, hence increasing violence in the area. Some of the MR projects on the northern slopes of the Tijuca Forest are within the territories of violent drug dealers that controlled the favelas. The MR Project in these areas can only occur with the permission of the head of drug trafficking. Nevertheless, the restoration activities can continue normally, except in extreme cases, for example, when there are conflicts among rival gangs or when there are police operations.

4.3. Recommendations to the project and beyond

Several conservation initiatives based on opinions from local populations improved the commitment and success of their Project (Muler, 2014). The MR Project was no different, where the involvement of local communities in the ecological restoration has proved to be effective in ensuring the success and duration of the activities. However, 86 % of the survey participants suggested a more participatory and bottom-up approach, including residents in the design, implementation, and monitoring phases of the Project: "*The Project should get a group of ten local people to get to know more the work of the PP. I would like to know more about the species of fauna and flora. I would like to know more about the Project. I would like to know more about the medicinal plants that exist in the forest. The Project has to work hard on environmental education. They should pick up the children once a month and take them to the woods, to make trails and breathe another type of air.*" (NPP interviewed from the Cantagalo community). According to Miranda (2017), less than half of the PP interviewed in her research had knowledge and participation in the species' choices used in the restoration, for example.

This need for inclusion can also be correlated to improve communication with project coordinators and the city hall, and listen to the communities' feedback about security issues, technical assistance, and environmental education actions, as one PP from the Entre Rios community said: "*The city hall may propose more ecological walking with the adults and children. They would like to know more about the forest fauna and flora that exists here*". The availability of training courses could help remedy some of these shortcomings and increase their confidence with the work (Miranda, 2017).

More significant presence and responsibility of the Project's environmental agents was highlighted as key to promote courses, workshops, and environmental training for all residents, including the Project participants. This was also recommended in other research in urban favelas in RJ (Muler et al., 2017). It could maximize the effects of dissemination strategies and resident participation in environmental management decisions, stimulating the feeling of citizenship and a closer relationship with the governmental stakeholders (Rodrigues et al., 2012; Lemgruber, 2014). Increasing local community participation in restoration and environmental projects facilitates the maintenance of labour workers and reduces conflicts between implementing agents and residents by a direct dialogue (Muler, 2014).

Participants also recommend increasing the number of fruit tree species in restoration areas, which can contribute to local food security. Muler et al. (2017) also found that 60 % of residents living close to a restored area prefer the inclusion of fruit trees and exotic species with economic value. Restoring areas with Agroforestry Systems (AFS) has proven to be useful for both ecological and socioeconomic aspects since it restores ecosystems, promotes biodiversity, enhances food security, and generates income (Martins and Ranieri, 2014). Restoring urban areas with AFSs would be particularly suitable to include fruit trees making this type of restoration project design much more attractive for the local community and also being an excellent way to overcome socioeconomic obstacles sustainably (Vieira et al., 2009; Brancalion et al.,

2014; Muler, 2014; Muler et al., 2017; Fagerholm et al., 2016).

The logic behind this is simple: the community residents should be the stewards of the regenerating forests surrounding them and partners of the restoration project managers rather than being alienated from the entire process. Hybrid forest-orchard systems and agroforestry systems could be important tools to foster social-ecological resilience, promoting community engagement, nature reconnection, and sustainable food production for a nutritious diet (Vira et al., 2015).

Restoration projects surrounding urban and peri-urban vulnerable communities – such as the MR Project – could include a buffer zone between the residential area and the 'core' restoration area (comprised solely of native species), that would include a dynamic mixture of native and exotic fruit trees and other useful species in a semi-managed hybrid forest-orchard system. This border area would engage residents needs stressed in this study and other similar studies (Muler et al., 2017), promoting not only a sense of recognition of their local knowledge and demands but also foster stewardship among residents, that could potentially extend to the restoration areas and remnant forest areas. Furthermore, restoration design in densely populated areas should use a multifunctional landscape approach that aims at achieving multiple goals, taking into account stakeholders' needs, and using adaptive management techniques (Sayer et al., 2013). These goals would simultaneously provide food security, livelihood opportunities, maintenance of species and ecological functions, and fulfill cultural, spiritual, and recreational needs (O'Farrell and Anderson, 2010).

5. Conclusion

This study showed that the inclusion and participation of residents in community restoration projects can bring benefits such as income generation, local well-being, and perception of environmental benefits provided by the restoration. This integration with the community encourages the continuation and development of the restoration projects, once the restoration workers themselves become responsible for the results achieved, stimulating the recovery of their sense of pride and local identity.

The success of the MR Project can be assessed by the acceptance and involvement of the local community and their perceptions about the benefits of restorative environmental services for human well-being. The perception of ecosystem services can increase environmental awareness about nature conservation and ecological restoration, support public policies, and socio-ecological mobilization strategies that support better land stewardship practices. Analyzing the representation of the forest through communities' perceptions can help to understand the relationship between humans and forests and their perceptions about ecosystem services.

The best way to strengthen this awareness is by including community residents in the restoration design, valuing their local knowledge, needs, and demands. It can promote trust and fruitful engagement between project managers and residents, rendering a common goal that includes social-ecological benefits, increasing the Project's success rate. Site choices should be made based not only on ecological and geographical aspects but also based on community needs and demands, local ecological knowledge as well as their land-use history.

Furthermore, traditional restoration design should shy away from solely fulfilling ecological indicators, embracing exotic species, especially useful ones such as fruit trees, and better incorporate bottom-up community participation. In a social-ecological systems framework, local actors and non-native species play important roles in maintaining or even enhancing social-ecological resilience in urban forests and restoration areas promoting essential ecosystem services (Ewel and Putz, 2004; Lamb et al., 2005; Hallet et al., 2013; Solórzano et al., 2017). In uncertain times due to governance instability, climate insecurity, environmental and land tenure change, simple yet highly effective solutions can go a long way in strengthening social-ecological resilience. Integrated governance is necessary for multi-functional landscapes and

successful restoration initiatives in the Anthropocene (Sunderland et al., 2015). Investments in conservation, restoration, and sustainable ecosystem use should be increasingly viewed as synergistic in generating ecological, social, and economic benefits and therefore providing solutions to the biodiversity conservation x food insecurity conundrum (Sunderland et al., 2015).

Authorship contribution

LSL and AL: design the study concept.
LSL, VM, IABP, AL: analyzed the results and wrote the paper.
AS, LFDM, BS: validated and discussed the results.
EL: made the map.

CRediT authorship contribution statement

Luisa Santiago Lemgruber: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing - original draft. **Agnieszka Latawiec:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing - original draft, Writing - review & editing. **Veronica Maioli:** Data curation, Formal analysis, Investigation, Software, Validation, Writing - review & editing. **Luiz Fernando Moraes:** Data curation, Formal analysis, Investigation, Software, Validation, Writing - review & editing. **Alexandro Solórzano:** Project colaboration, Field work and data collection, Writing - review & editing. **Ingrid A. B. Pena**: Funding acquisition, Resources, Writing - review & editing. **Bernado Strassburg:** Data curation, Formal analysis, Investigation, Software, Validation, Writing - review & editing. **Eric Lino:** made the map.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ufug.2021.127271.

References

Agol, D., Latawiec, A.E., Strassburg, B.B.N., 2014. Evaluating impacts of development and conservation projects using sustainability indicators: opportunities and challenges. Environ. Impact Assess. Rev. 48, 1–9. https://doi.org/10.1016/j.eiar.2014.04.001.

Araujo, M., Cortado, T.J., 2020. A Zona Oeste do Rio de Janeiro, fronteira dos estudos urbanos? Dilemas, Rev. Estud. Conflito Controle Soc. 13, 7–30.

Brancalion, P.H.S., Cardozo, I.V., Camatta, A., et al., 2014. Cultural ecosystem services and popular perceptions of the benefits of an ecological restoration project in the brazilian Atlantic Forest. Restor. Ecol. 22, 65–71. https://doi.org/10.1111/rec.12025.

Bright, A.D., Barro, S.C., Burtz, R.T., 2002. Public attitudes toward ecological restoration in the Chicago metropolitan region. Soc. Nat. Res. Int. J. 15 (9), 763–785. https://doi.org/10.1080/08941920290069344.

Buis, A.E., 2009. Public support for river restoration. A mixed-method study into local residents' support for and framing of river management and ecological restoration in the Dutch floodplains. J. Environ. Manage. 90, 2680–2689.

Burger, J., 2002. Restoration, stewardship, environmental health, and policy: understanding stakeholders' perceptions. Environ. Manage. 30 (5), 631–640. https://doi.org/10.1007/s00267-002-2664-0.

Calmon, M., Brancalion, P.H.S., Paese, A., Aronson, J., et al., 2011. Emerging threats and opportunities for large-scale ecological restoration in the Atlantic Forest of Brazil. Restor. Ecol. 19, 154–158. https://doi.org/10.1111/j.1526-100X.2011.00772.x.

Camarotti, I., Spink, P., 2003. Estratégias locais para redução da pobreza: construindo a cidadania Ilka Camarotti e Peter Spink, org, second ed. EAESP, São Paulo.

Chazdon, R.L., 2017. Landscape restoration, natural regeneration, and the forests of the future. Ann. Mo. Bot. Gard. 102, 251–257. https://doi.org/10.3417/2016035.

Conley, A., Moote, M.A., 2003. Evaluating collaborative natural resource management. Soc. Nat. Resour. 16, 371–386.

Crouzeilles, R., Ferreira, M.S., Chazdon, R.L., et al., 2017. Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. Sci. Adv. 3, e1701345 https://doi.org/10.1126/sciadv.1701345.

Crouzeilles, R., Santiami, E., Rosa, M., et al., 2019. There is hope for achieving ambitious Atlantic Forest restoration commitments. Perspect. Ecol. Conserv. 17, 80–83. https://doi.org/10.1016/j.pecon.2019.04.003.

Cruickshank, J., 2012. The role of qualitative interviews in discourse theory. Critic. Appr. Discourse Anal. Across Disciplines 6, 1752–3079.

da Silva, J.M.C., Pinto, L.P., Hirota, M., et al., 2016. Conservação da Mata Atlântica Brasileira - um balanço dos últimos dez anos (Orgs.), 2016. In: Cabral, D.C., Bustamante, A.G. (Eds.), Metamorfoses florestais: Culturas, ecologias e as transformações históricas da Mata Atlântica. Editora Prismas, Curitiba.

Data Rio, 2010. Índice de Desenvolvimento Social (IDS) por Áreas de Planejamento (AP), Regiões de Planejamento (RP), Regiões Administrativas (RA), Bairros e Favelas do Município do Rio de Janeiro. Instituto Pereira Passos. Available at http://www.data.rio/datasets/fa85ddc76a524380ad7fc60e3006ee97 (Accessed 11 june 2020).

Elmqvist, T., Setala, H., Handel, S.N., et al., 2015. Benefits of restoring ecosystem services in urban areas. Curr. Opin. Environ. Sustain. 14, 101–108. https://doi.org/10.1016/j.cosust.2015.05.001.

Ewel, J.J., Putz, F.E., 2004. A place for alien species in ecosystem restoration. Front. Ecol. Environ. 2, 354–360.

Fagerholm, N., Torralba, M., Burgess, P.J., Plieninger, T., 2016. A systematic map of ecosystem services assessments around European agroforestry. Ecol. Indic. 62, 47–65. https://doi.org/10.1016/j.ecolind.2015.11.016.

Forzza, R.C., Leitman, P.M., Costa, A.F., et al., 2010. Catálogo de Plantas e Fungos do Brasil. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro: Andréa Jakobsson Estúdio.

Gardner, T.A., Barlow, J., Chazdon, R., et al., 2009. Prospects for tropical forest biodiversity in a human-modified world. Ecol. Lett. 12, 561–582. https://doi.org/10.1111/j.1461-0248.2009.01294.x.

Guedes, F.B., Seehusen, S.E., 2011. Pagamento por Serviços Ambientais na Mata Atlântica: lições aprendidas e desafios. MMA, Brasília.

Hallet, L., Standish, R.L., Hulvey, K.B., et al., 2013. Towards a conceptual framework for novel ecosystems (Orgs.), 2013. In: Hobbs, R., Higgs, E., Hall, C. (Eds.), Novel Ecosystems: Intervening in the New Ecological World Order. Wiley-Blackwell, Oxford.

Herzog, C.P., Finotti, R., et al., 2013. Local assessment of Rio de Janeiro City: Two case studies of urbanization trends and ecological impacts. In: Elmqvist, T. (Ed.), Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities. Springer, Dordrecht.

Joly, C.A., Rodrigues, R.R., Metzger, J.P., et al., 2010. Biodiversity conservation research, training, and policy in Sao Paulo. Science 328, 1358–1359. https://doi.org/10.1126/science.1188639.

Joly, C.A., Metzger, J.P., Tabarelli, M., 2014. Experiences from the Brazilian Atlantic Forest: ecological findings and conservation initiatives. New Phytol. 204, 459–473. https://doi.org/10.1111/nph.12989.

Lamb, D., Erskine, P.D., Parrotta, J., 2005. Restoration of degraded tropical forest landscapes. Science 310, 1628–1632.

Lange, W., Sandholz, S., Nehren, U., 2018. Strengthening urban resilience through nature: the potential of ecosystem-based measures for reduction of landslide risk in Rio de Janeiro. Lincoln Institute of Land Policy Working Paper WP18WL1. https://doi.org/10.13140/RG.2.2.27900.23689.

Latawiec, A.E., Strassburg, B.B.N., Rodriguez, A.M., et al., 2014. Suriname: reconciling agricultural development and conservation of unique natural wealth. Land Use Policy 38, 627–636. https://doi.org/10.1016/j.landusepol.2014.01.007.

Latawiec, A.E., Strassburg, B.B.N., Silva, D., et al., 2017. Improving land management in Brazil: the producers' perspective. Agric. Ecosyst. Environ. 240, 276–286. https://doi.org/10.1016/j.agee.2017.01.043.

Lemgruber, L.S., 2014. In: Tijuca, R.J. (Ed.), O papel do Mutirão de reflorestamento sobre a percepção ambiental dos moradores do Morro da Formiga. Pontifical Catholic University of Rio de janeiro, Rio de Janeiro, Brazil (Unpublished work from end of graduate course treatises).

Livesley, S.J., McPherson, E.G., Calfapietra, C., 2016. The urban forest and ecosystem services: impacts on urban water, heat, and pollution cycles at the tree, street, and city scale. J. Environ. Qual. 45, 119–124. https://doi.org/10.2134/jeq2015.11.0567.

Macedo, M.A., 2002. Trabalho informal e política de inserção: uma relação em debate. Rev. Polã-ticas Pãoblicas 6, 97–112.

Martins, T.P., Ranieri, V.E.L., 2014. Sistemas agroflorestais como alternativa para as reservas legais. Ambiente Soc. 17, 79–96. https://doi.org/10.1590/S1414-753X2014000300006.

Melazo, G.C., 2005. A percepção ambiental e educação ambiental: uma reflexão sobre as relações interpessoais e ambientais no espaço urbano. Olhares Trilhas 6, 45–51. https://doi.org/10.14393/OT.

Miranda, B.C., 2017. Projetos de restauração ecológica: percepção ambiental e interação de comunidades urbanas. Unpublished master's dissertation. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro/Escola Nacional de Botânica Tropical, Rio de Janeiro.

Muler, A.E., 2014. Avaliação de uma Floresta Atlântica urbana em restauração: da ecologia às questões sociais. Unpublished master's dissertation. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro / Escola Nacional de Botânica Tropical, Rio de Janeiro, Brazil.

Muler, A.E., Prieto, P.V., Richards, R.C., Brancalion, P.H.S., Braga, J.M.A., 2017. Ecological outcomes and popular perceptions of urban restored forests in Rio de Janeiro, Brazil. Environ. Conserv. 1–8 v. 00.

Nehren, U., Sudmeier-Rieux, K., Sandholz, S., Estrella, M., Lomarda, M., Guillén, T., 2014. The Ecosystem-based Disaster Risk Reduction: Case Study and Exercise Source Book. UNEP and CNRD. ISBN: 978-3-00-045844-045846.

O'Farrell, P.J., Anderson, P.M.L., 2010. Sustainable multifunctional landscapes: a review to implementation. Curr. Opin. Environ. Sustain. 2, 59–65.

Oliveira, T.M.V., 2001. Amostragem não probabilística: Adequação de situações para uso e Limitações de amostras por Conveniência, Julgamento e Quotas. Available at http://www.fecap.br/adm_online/art23/tania2.htm (Accessed 20 January 2016).

Palma, A.C., Laurence, S.G.W., 2015. A review of the use of direct seeding and seedling plantings in restoration: what do we know and where should we go? Appl. Veg. Sci. 18, 561–568. https://doi.org/10.1111/avsc.12173.

PNT - Parque Nacional da Tijuca. Available at https://parquenacionaldatijuca.rio/ (Accessed 4 Jun. 2020.).

Profes, M.B., 2006. Contribuição da percepção ambiental a intervenções mais sustentáveis em assentamentos precários em áreas de vulnerabilidade ambiental – Caso Ilha Grande dos marinheiros. Unpublished master's dissertation. Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.

Rezende, C.L., Scarano, F.R., Assad, E.D., et al., 2018. From hotspot to hopespot: an opportunity for the Brazilian Atlantic Forest. Perspect. Ecol. Conserv. 16, 208–2014. https://doi.org/10.1016/j.pecon.2018.10.002.

Ribeiro, F.P., Ribeiro, K.T., 2016. Participative mapping of cultural ecosystem services in Pedra Branca State Park, Brazil. Perspect. Ecol. Conserv. 14, 120–127. https://doi.org/10.1016/j.ncon.2016.09.004.

Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J., Hirota, M.M., 2009. The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. Biol. Conserv. 142, 1141–1153. https://doi.org/10.1016/j.biocon.2009.02.021.

Rio de Janeiro, 2019. 33 anos plantando florestas no Rio de Janeiro. Prefeitura da cidade do Rio de Janeiro, Secretaria Municipal do Meio Ambiente da Cidade (SMAC), Rio de Janeiro.

Rodrigues, D., 2007. Mutirão Reflorestamento: 20 anos recuperando áreas naturais degradadas. Available at http://www0.rio.rj.gov.br/pcrj/destaques/especial/mutirao_reflorestamento2.htm (Accessed 19 December 2014).

Rodrigues, M.L., Malheiros, T.F., Fernandes, V., et al., 2012. A percepção ambiental como instrumento de apoio na Gestão e na formulação de políticas públicas ambientais. Saúde Sociedade 21, 96–110. https://doi.org/10.1590/S0104-12902012000700009.

SABREN, 2010. Sistema de Assentamentos de Baixa Renda. Instituto Pereira Passos. Available at http://pcrj.maps.arcgis.com/apps/MapJournal/index.html?appid=4df92f92f1ef4d21aa77892acb358540 (Accessed 18 June 2020).

Salgado, S., 1998. Mutirão de Reflorestamento. In: Fujiwara, L.M., Alessio, N.L.N., Farah, M.F.S. (Eds.), 1998. 20 Experiências de Gestão Pública e Cidadania. Programa Gestão Pública e Cidadania, São Paulo.

Santos, C.J.F., et al., 2003. Restauração Ecológica associada ao Social no Contexto Urbano: o projeto Mutirão Reflorestamento, 2003. In: Kageyama, Paulo, Y. (Eds.), Restauração Ecológica de Ecossistemas Naturais. FEPAF, Botucatu.

Sayer, J., et al., 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proc. Natl. Acad. Sci. U. S. A. 110, 8349–8356.

Scarano, F.ábio R., 2014. Mata Atlântica: uma história do futuro. Edições de Janeiro, Rio de Janeiro.

Scarano, F.R., Ceotto, P., 2015. Brazilian Atlantic forest: impact, vulnerability, and adaptation to climate change. Biodivers. Conserv. 24 (2015), 2319–2331. https://doi.org/10.1007/s10531-015-0972-y.

Scholte, S.S., van Teeffelen, A.J., Verburg, P.H., 2015. Integrating socio-cultural perspectives into ecosystem service valuation: a review of concepts and methods. Ecol. Econ. 114, 67–78. https://doi.org/10.1016/j.ecolecon.2015.03.007.

Solórzano, A., Cabral, D.C., Oliveira, R.R., 2017. Revealing hidden Forest dialogs: species introduction, charcoal production and the environmental history of Rio de Janeiro's Urban forests (Org.). In: de Melo, Cristina Joanaz, Vaz, Estelita, Pinto, L.ígia M.Costa (Eds.), Environmental History in the Making Volume II: Acting, 1 ed., Vol. 2. Spinger, 2017, pp. 219–237.

Strassburg, B.B.N., Beyer, H.L., Crouzeilles, R., et al., 2018. Strategic approaches to restoring ecosystems can triple conservation gains and halve costs. Ecol. Evol. 3, 62–70. https://doi.org/10.1038/s41559-018-0743-8.

Sunderland, T., Baudron, F., Ickowitz, A., et al., 2015. Response options across the landscape. In: Vira, B., Wildburger, C., Mansourian, S. (Eds.), Forests, Trees and Landscapes for Food Security and Nutrition. A Global Assessment Report, 172p. IUFRO World Series Volume 33. Vienna.

Tabarelli, M., Aguiar, A.V., Ribeiro, M.C., et al., 2010. Prospects for biodiversity conservation in the Atlantic Forest: lessons from aging human-modified landscapes. Biol. Conserv. 143, 2328–2340. https://doi.org/10.1016/j.biocon.2010.02.005.

Torres, H.G., 2004. Fronteira Paulistana. Anais… XIV Encontro Nacional de Estudos Populacionais. Associação Brasileira de Estudos Populacionais, Caxambu.

Vieira, D.L.M., Holl, K.D., Peneireiro, F.M., 2009. Agro-successional restoration as a strategy to facilitate tropical forest recovery. Restor. Ecol. 17, 451–459. https://doi.org/10.1111/j.1526-100X.2009.00570.

Vilhena, R.H., Oliveira, M.P., 2010. Percepção Ambiental e Qualidade de Vida Sob o Olhar do Cidadão: Estudo de Caso na Vila de São Sebastião de Arapixi - Chaves – Ilha Do Marajó – PA. V Encontro Nacional da Anppas 4 a 7 de outubro de 2010. Florianópolis, SC, Brasil.

Vira, B., Agarwal, B., Jamnadass, R., et al., 2015. Forests, trees and landscapes for food security and nutrition. In: Vira, B., Wildburger, C., Mansourian, S. (Eds.), 2015. Forests, Trees and Landscapes for Food Security and Nutrition. A Global Assessment Report, 172 p. IUFRO World Series Volume 33.