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Research Article

Collective Córregos da Tiririca: Restoration of Riparian Forest in a Tributary Stream of Itaipu Lagoon, Niterói-RJ, Brazil

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The lake system Itaipu-Piratininga in Niterói, north of the Guanabara Bay, is drained by a set of streams. As a result of urban expansion in the oceanic region of the city, those streams became dirty and polluted. In a time-scale of twenty-five years, after studies on water biodiversity, the lake system became eutrophied, with shallow waters. One way to recover the health of the ecosystem is to restore the freshwater rivers draining the system. The present study proposes to inform about the experience of agroforestry restoration of the riparian forest in a tributary of Itaipu lake, as well as to bring an evaluation of local biodiversity – arboreal plants, terrestrial, and aquatic vertebrates. After the inventory was made, there followed the agroforestry planting of the riparian forest by the organized civil society through the collective Córregos da Tiririca [streams at Tiririca mountains]. The technique employed for restoration is related, as it corresponds to an adaptation of the principles of syntropic agriculture to the reality of an urban stream.

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> There is no bad land!
> Ernst Götsch 1997

Introduction

The Itaipu-Piratininga lagoon system hydrographically belongs to the microbasins of Niterói, inserted in the macro-drainage of Guanabara Bay, in the Metropolitan Region of Rio de Janeiro. It makes up the first system of coastal lagoons north of Guanabara Bay still alive in the landscape. These lagoons, isolated by coastal stripes, occupy the coast of Rio de Janeiro as far as Cabo Frio (Fontenelle and Corrêa 2014; Wehrs 1984). This region has been inhabited since prehistoric times by riverine populations. The coastal plain on the edge of the Itaipu and Piratininga lagoons is characterized by the geomorphological feature of fixed dunes that contain traces of the shell mound peoples who inhabited the region (Gaspar *et al*. 2008), dating back to more than 20 thousand years of history of human occupation on the coast (Cunha*et al*. 2021). The oldest current human colonization is made up of fishermen and shellfish gatherers who continue to practice the art of fishing and extractivism in the area that today belongs to the Itaipu Marine Extractive Reserve (ICMBio, 2013).

Still in the second half of the twentieth century, a boom in construction activities led to severe intervention in the lagoon system. Rectified rivers, drained swamps, restinga, and mangrove swamps were set aside. The urbanization still maintains traces of clandestine sewage draining into the rivers, with the lagoon system as the final spillway. Now, in the twenty-first century, lagoons are increasingly facing the scarcity of their fishery resources (Sarmento-Soares et al., 2023). The bathing ability of the lagoons has been compromised in recent decades, with a loss of water quality and a consequent reduction of biodiversity in the lagoon system. Recent studies illustrate that the addition of quality clean freshwaters is directly related to the mitigation and solution of this problem (Freitas, 2023). Water availability reached a critical situation because, without obtaining a volume of water from the discharge of its rivers, the lagoon becomes increasingly shallower, loses its water depth, and the strong waves of high tide in some months of the year push sand to the mouth of the lagoon, blocking its outlet channel to the sea.

The entire system is connected. The coastal watershed associated with this lagoon system drains an area of about 50 km2 between rivers and lagoons. It is home to estuarine fish, paludose birds, crabs, shrimps, alligators, large mammals, and many animals of the local fauna. All that remains is to clean up the rivers that supply the lagoon – and social movements are consolidating in their defense (Instituto Floresta Darcy Ribeiro - Amadarcy Forest Institute, Lagoa para Sempre – Lagoon Forever Movement, Instituto Nossos Riachos - Our Streams Institute). Revitalization initiatives, whether of the mangrove swamp or the recovery of the riparian forest of its streams (Pontes et al., 2021; Coletivo Córregos da Tiririca 2019), and initiatives of the municipal government (Parque Orla de Piratininga, 2023) have begun in recent years.

Agroecological restoration is successfully reported in the field, in crops, and near conservation units, as an alternative to reconcile agricultural production with the conservation of natural resources. However, restoration of riparian forest using agroforestry is rare (Mota, 2019). The present study aims to report the experience of agroforestry restoration of the riparian forest in a stream tributary of Itaipu lake as well as to bring an evaluation of local biodiversity. In this sense, an adaptation of the principles of syntropic agriculture was employed for restoration. Additionally, an assessment of the local biodiversity - flora, terrestrial, and aquatic fauna - is given. For a perspective of the results achieved in youth education, see Sarmento-Soares *et al*. (in press).

Methodology

Georeferenced maps of the micro-basins of Niterói, including the macro-drainage of the Itaipu lagoon, were prepared using the GPS program Trackmaker Professional 4.8 (Ferreira Júnior 2012), based on the hydrographic map of the state of Rio de Janeiro at a scale of 1:25,000, made available by INEA - State Institute of the Environment of Rio de Janeiro - in 2016, with adjustments using the Google Earth application and field checks (Figure 1). The results of cartographic length and area were calculated based on the maps constructed and using the same program. The names of the watercourses were adopted according to the same chart and with adjustment of names used locally, or in the absence of these names, the name of the geographical localities that may characterize the unnamed streams was used.

The study area is located on Boa Vista Avenue, Campo Belo neighborhood, at Itaipu, municipality of Niterói, RJ. The recompositing of the left marginal strip of a 900-meter stretch on the left bank of the Colibris stream was worked on, between the geographic coordinates Latitude: -22.9538S and Longitude: -43.0289W. The methodology used was an adaptation of the agroforestry cropping system, named syntropic agriculture by Ernst Gotsch (Gotsch 1996). The methodology for syntropic planting was adapted from Rebello (2018) and Andrade and Passini (2022) to the reality of an urban environment. The technique was adapted to the conditions and requirements of an environment with a limited protected area width, ranging from 0.5 to 1.5 meters only. The planting consisted of the following stages: 1. grass mowing; 2. mixing of bare soil; 3. digging out the clumps of grass roots; 4. incorporation of minced woody matter into the soil and removal of roots of invasive plants, turning them upwards to serve as organic fertilization; 5. nest preparation. Dense nests were built, with a distance of between 1.5 and 3 meters, in order to accelerate the recovery of the riverbank and reduce the erosion process on the riverbank. To organize the seeds, a "muvuca," a mixture of different seeds including fast-growing herbaceous plants, was organized. Seeds of bean (Cavallia ensiformis) and/or pea (Cajanus cajan) were planted in each nest for nitrogen fixation in the soil. Fast-growing tubercles such as the maniva (Manihot esculenta), sweet potatoes (Ipomoea batatas), and pork yams (Colocasia esculenta) were included. Staking of shrubs such as blackberry (Morus nigra), daisy (Thinonia diversifolia), and boldo (Peumus boldus) was fixed on the nest border. And in the center of the nest, up to 3 seedlings of species from different strata (lianas, shrubs, trees) were planted. The management of invasive alien plants was carried out as the growth of the species in the nests occurred, in order to take advantage of the shade. Pruning management was carried out in the autumn and winter months of each year, in order to minimize edge effects.

To diagnose the tree and shrub flora, the individuals were photographed through the iNaturalist application at the address < https://www.inaturalist.org/projects/corrego-dos-colibris > accessible for public consultation. The observed terrestrial fauna was also identified through the iNaturalist application, and by consulting specialists.

To diagnose the aquatic fauna, fish were captured in the stream with the help of a manual netting (50 x 60 cm, 1 mm between meshes) and a manual sieve, with the license of SISBIO 57145-3, exploring the aquatic environments. Specimens were captured and photographed while alive in a field aquarium and returned to the environment. Historical records were obtained from the ichthyological collections of the MNRJ, MZUSP, and ZUEC collections and based on the available literature. Institutional abbreviations followed Sabaj-Pérez (2023).

Study area. The Serra da Tiririca is a coastal massif surrounded by wide sedimentation plains. The Serra separates the municipalities of Niterói and Maricá in the state of Rio de Janeiro. The Serra da Tiririca State Park – PESET – shelters the Itaipu lagoon system through its buffer zone, and some springs and wetlands are found within the Park. In the plains, the lagoon system in Niterói is formed by two lagoons, Itaipu and Piratininga, connected to each other by the Camboatá channel. The artificial channel of Camboatá was built with the aim of providing hydraulic balance between the lagoons, minimizing flooding and the proliferation of diseases such as malaria (Sergipense 1997). Nowadays, the opening of the lagoon system to the sea is made in a perennial way, in the Itaipu channel, and the perennial connection between the sea and the lagoon has covered its surroundings with mangroves, where the white mangrove Laguncularia racemosa predominates.

The foothills of the Serra da Tiririca act as a watershed between the rivers Inoã, Itaocaia, and Aldeia on the northern slope towards Maricá. On the southern slope, in the direction of Niterói, the João Mendes River, and the Boa Vista (or Vala River), Colibris, and Itacoatiara streams, contributors to the Itaipu Lagoon (Sarmento-Soares et al. 2023). The Piratininga Lagoon receives, in turn, the Arrozal and Jacaré rivers, as well as the Viração and Cafubá streams, with headwaters in the Serra Grande (Rodrigues et al. 2004). Together, these watercourses and the two lagoons and canals form the macro-basin of the Oceanic Region, fully inserted in the municipality of Niterói. Figure 1 illustrates the lagoon system and its rivers.

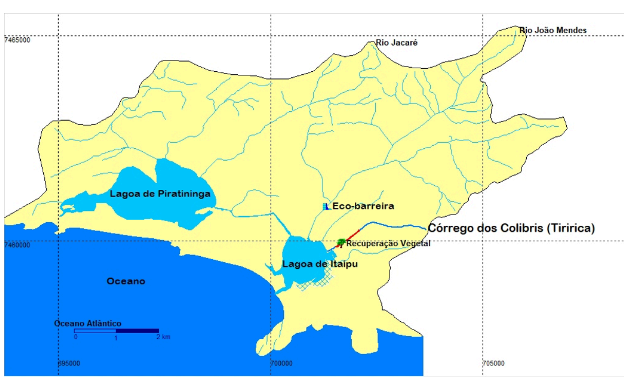

Figure 1. (A) Micro-basins of the Itaipu-Piratininga lagoon system, with indication of the main contributors (Jacaré River and João Mendes River). Ecobarrier of the João Mendes River and location of the plant recovery stretch in the Colibris stream, with springs in the Serra da Tiririca State Park. Adapted from the Guanabara Bay Matrix Topographic Map SF-23-Z-B-IV-4 of 1:50,000. (B) Satellite image with the riparian vegetation recovery site (Google Earth view).

The Colibris stream, the object of this study, has its headwaters within the Serra da Tiririca State Park, upstream of the Colibris stream trail, accessible by Scylla Souza Ribeiro Street, in the Peixoto neighborhood in Itaipu, Niterói. The fluvial valley of the Colibris stream is a region covered by secondary vegetation, in the process of regeneration for more than 50 years, and includes the swamp of Pacas, a flooded area associated with the forest. Downstream of the protected area, the stream continues channeled, crossing the Peixoto neighborhood, and emerges in its final stretch after crossing the Francisco da Cruz Nunes road downstream of the 4th GMAR fire station. In its final course towards the Itaipu lagoon, the Colibris stream had its path rectified, bordered by Boa Vista Avenue. The entire Boa Vista neighborhood corresponds to an occupation area that originally was the floodplain of the Itaipu lagoon. In a stretch of 420 meters along Boa Vista Avenue, the first stage of the process of restoring the riparian forest with syntropic agriculture began. (Drone video 1 - drone footage of the situation of the Tiririca stream at the beginning of the project). A second sequential stretch to the east of another 260 meters was started in 2023, making a total of 680 linear meters of stretches under recovery towards the mouth of the Itaipu lagoon.

Drone video 1 - Aerial view of the Colibris stream filmed with a drone in 2020. Images: Alexandre Neves. https://youtu.be/xg_V0EwS0yE

Results

The environment. At the beginning of the agroforestry intervention in the marginal area of the stream, it had a high ravine, in a slow and gradual process of silting. Each summer, the waters of the stream dragged a little more from the bank, eroding and clearing the street, making it narrower and narrower, and in turn, the stream became shallower. On the edges, there are some sparse trees (jambo, mango tree, umbrella). The water contained organic pollutants, resulting from clandestine sewage points. The murky waters flowed in a low current, and there were tufts of grass in and out of the river. In the stretches with a lot of sunlight, floating aquatic plants such as the leather hat and water hyacinth were present. The area without riparian protection allowed the advance of the weeds that covered the bed of the stream annually, forcing its removal before the summer rains, with the use of excavator trucks, heavy machinery that caused serious damage to the banks, aggravating the effects of erosion and siltation.

The Collective. The volunteers registered the project with the municipality of Niterói Department of the Environment, informing them of the intended action. Since its creation in April 2019, the Córrego da Tiririca collective has carried out several actions articulated with the municipal government. With the Niterói Cleaning Company (Clin) in the activities of cleaning and use of chopped plant material as a result of pruning in the city; with the Regional Office of the City Hall for the Oceanic Region of Niterói; with the Sustainable Program of the City of Niterói; and at the state level with the Serra da Tiririca State Park. The Collective had technical support from CARPE Socio-Environmental Projects, the Nossos Riachos Institute, as well as the Darcy Ribeiro Forest Institute – AmaDarcy.

The planting process in syntropic agriculture began in May 2019, in the form of monthly joint efforts. The participation of CARPE volunteers was fundamental for the joint learning and adaptation of syntropic agriculture techniques to the urban reality of restoration of a riparian forest where there was only grass and landfill. Figure 2 illustrates the team in one of the task forces.

Figure 2. Eighth joint effort held on April 12, 2023, the first collective event organized after the pandemic. Photo: Roberto Pinheiro.

Syntropy. Agroecology can be understood as the application of ecological concepts to design sustainable agroecosystems, in practices that lead from the simple to the complex (Andrade, Passini, 2022). Syntropic agriculture is a model of agroecological planting where fertilizer, poison, inputs, and even irrigation are dispensed with. The supply of organic matter is done through pruning, which generates its own substrates for the composition of the soil. In an agroforest, there is a temporal succession of plant species, which are plants that coexist with each other but have their different objectives when it comes to occupying space. The first step was to mow the abundant grass, dumping the cut vegetation on the spot. From the moment the land became accessible, the assembly of the nests began. The name "nest" (or cradle) refers to life, a place to grow living plants. The nests were set up by digging the soil to a depth of approximately 20 cm or more, enough to house the seedlings (Figure 3).

Figure 3. Nest building by volunteers. In the middle, a Sapucaia tree (*Lecithis pisonis*). Together with the main tree, different seeds were left on the substrate in a unique nest. Around the nest, pieces of wood and herbs to facilitate drainage of water. Image: Luisa Sarmento.

Planting began in May 2019. Shredded matter was poured around each nest, obtained by donation from the city hall. Originating from the activity of street maintenance, the minced matter refers to the fragmentation of branches and leaves by a picker. In a joint effort, the city donated a truckload of minced matter (Figure 4-A). In each nest, seedlings of species from the Atlantic Forest were planted, intercropped with edible species. When the nest was planted, a seed mound was left (Figure 4-B). The "Muvuca" is a well-thought-out combination of plants. Plants capable of invigorating the soil through a drastic change in local conditions. In a single nest, everything was planted together and mixed, with fast-growing plants (such as tomatoes and beans), along with other shrubs (such as citrus, coffee, bananas), and those with slow growth (such as guapuruvu, ipê). This successional technique makes the growth time differentiated. Vegetables and grains grow fast, nourish the soil, and shade the young seedlings of the slow-growing trees. Thus, each plant marks its ability to grow and live the first few years. The construction of a nest is much more than a simple consortium. The intuition of what should be done in the system is important to think about the whole, assembled with plants that coexist with each other (Fig. 4-C).

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Figure 4. Stages of the planting process using syntropic agriculture. A. Picadeira used for shredding branches and dry vegetation. B. Pricked matter to incorporate into the soil. C. Project site sign posted at the end of O. D. Street. Teachings on nest building. E. Separation of seedlings for planting. F. Fruit eaten, seed planted (cocoa and cajá). G. Muvuca seeds used for planting. H. Maintenance of the space after the incorporation of the minced matter into the soil. Images: Roberto Pinheiro.

And so began the transformation of the territory. Through the use and experimentation of the syntropic agriculture technique in an urban environment, it was possible to plant tree species from the Atlantic Forest intercropped with food species in a degraded area. Irrigation became necessary to a lesser extent, once a month until the system stabilized. Choosing to start in autumn was favorable, a time with a mild incidence of the sun's rays. The organic matter from the pruning was the only external input incorporated into the soil. Organic matter directly alters the physicochemical characteristics of the soil, promoting several benefits in a systemic process. The dry and rigid soil at the beginning of the project, formed by tabatinga and embankment, was gradually transformed. With the presence of minced matter and new plants in the system, the soil was structured, which became more consolidated and more alive, with varied microorganisms. Ants, fungi, and decomposers came to work the matter in the soil by associating with the roots of the pruned plants. The syntropy carried out in the Colibris stream did not require inputs or fertilizers. It needed management and pruning. In the pruning process, organic matter was incorporated into the soil. The process makes it possible to collaborate in the formation of trees so that they adequately occupy the different strata and also to remove the species that have already fulfilled their function, thus carrying out agroforestry management. Agroforestry in the stream also had a character of change that is affective, the feeling of belonging to both a group and a place, from a socio-environmental perspective with climatic, community, forestry, and environmental gains (compare with drone video 1, recorded in 2020).

Drone video 2 – Aerial view of Colibris stream filmed with a drone in 2023. Images: Vantuil Neves. https://youtu.be/HLknIskYBAI

The organic matter deposited in the soil, in the form of leaves, flowers, and fruits, ensures the necessary moisture, absorbs nutrients, and sediments. In the 2023 summer rains, this vegetation held back the floods, and there was no damage to the water body. The healthy forest helped to keep the water clean, living up to the name riparian forest – the eyelashes of the river. Several animals used the space of the riparian forest corridor in search of shelter and food (Table 3).

Figure 5. Evolution of the project's entrance garden space and installation of the information sign on Francisco da Cruz Nunes road, where the river leaves the tunnels stretch and starts to run in the open.

Aquatic life - Urban rivers function as green corridors, connecting the Tiririca mountain range to the Itaipu lagoon, allowing the circulation of animals and the dispersal of forest seeds in the urban space.

Exploring the rivers that drain into the Itaipu lagoon, freshwater species were captured; we found two species of bellies, Phalloptychus januarius and Poecilia reticulata, the tilapia Oreochromis niloticus, and also an estuarine species, the amoré, Dormitator maculatus. Another species collected by us was the mangrove rivulid Kryptolebias hermaphroditus in the lagoon floodplain (Sarmento-Soares et al. 2023).

Certain fish are able to exploit the anthropized environment of the streams and wetlands of the Itaipu lagoon, which gives them shelter and protection. The urban aquatic environment is susceptible to the invasion of non-native species, as well as those tolerant to extreme variations (Vieira and Shibatta 2007). But in current conditions, fish such as tilapia serve as food for the riverside dwellers who live around the lagoon. The supply of river water that feeds the floodplain of the Itaipu lagoon contributes sediments and nutrients to the mangrove, locally inhabited by commercially important species such as sea bass (Centropomus undecimalis) and mullet (Mugil liza), still present but in small quantities.

Table 1 contains the list of species in the contributing streams of the lagoon system.

For a list of the botanical species that currently occupy the recovered area, see Table 2.

Ordem	Família	Espécie sugerida	Ambiente	Origem dos dados e ano	Nome popular
Atheriniformes	Atherinopsidae	Atherinella brasiliensis	Lagoa	Sergipense 1997	Peixe rei
Carangiformes	Centropomidae	*Centropomus undecimalis*	Lagoa	Sergipense 1997	Robalo
Characiformes	Erythrinidae	*Hoplias malabaricus*	Riacho	Sergipense 1997	Traíra
Cichliformes	Cichlidae	*Geophagus brasiliensis*	Lagoa/Riacho	MNRJ & Sergipense 1997	Acará
Cichliformes	Cichlidae	*Oreochromis niloticus*	Riacho	obs. pessoal 2023	Tilápia
Cyprinodontiformes	Anablepidae	*Jenynsia lineata*	Lagoa/Riacho	MNRJ 1942 & Sergipense 1997	Barrigudinho
Cyprinodontiformes	Poeciliidae	*Phalloceros harpagos*	Riacho	MNRJ 1997 & Sergipense 1997	Barrigudinho
Cyprinodontiformes	Poeciliidae	*Phalloptychus januarius*	Riacho/Alagado	MNRJ 2016 & Sergipense 1997 & obs. pessoal 2023	Barrigudinho
Cyprinodontiformes	Poeciliidae	*Poecilia reticulata*	Riacho	Sergipense 1997 & obs. pessoal 2023	Barrigudinho
Cyprinodontiformes	Poeciliidae	*Poecilia vivipara*	Lagoa/Riacho	MNRJ s/data & MNRJ 2016 & Sergipense 1997	Barrigudinho
Cyprinodontiformes	Rivulidae	*Kryptolebias hermaphroditus*	Alagado	Sarmento-Soares et al. 2023	Rivulídeo de mangue
Gobiiformes	Eleotrididae	*Dormitator maculatus*	Riacho	obs. pessoal 2023	Amoré
Gobiiformes	Eleotrididae	*Eleotris pisonis*	Lagoa	Sergipense 1997	Amoré
Gobiiformes	Gobiidae	*Bathygobius soporator*	Lagoa	ZUEC 2004/2005	Maria da toca
Gobiiformes	Gobiidae	*Ctenogobius boleosoma*	Lagoa	ZUEC 2005	Moreia
Gobiiformes	Gobiidae	*Gobionellus oceanicus*	Lagoa	MNRJ 1988	Miroró
Mugiliformes	Mugilidae	*Mugil curema*	Lagoa	Sergipense 1997	Parati
Mugiliformes	Mugilidae	*Mugil liza*	Lagoa	Sergipense 1997	Tainha
Perciformes	Gerreidae	*Diapterus rhombeus*	Lagoa	MNRJ 2003	Carapeba
Perciformes	Gerreidae	*Eugerres brasilianus*	Canal	MZUSP 1990/1991	Carapeba
Siluriformes	Callichthyidae	*Callichthys callichthys*	Riacho	Sergipense 1997	Tamboatá
Siluriformes	Heptapteridae	*Rhamdia quelen*	Riacho	Sergipense 1997	Jundiá
Siluriformes	Loricariidae	*Hypostomus affinis*	Riacho	Sergipense 1997	Cascudo
Synbranchiformes	Synbranchidae	*Synbranchus marmoratus*	Riacho	Sergipense 1997	Mussum

Table 1. Fish found in the lagoons and streams adjacent to the lagoons in Niterói

Regarding terrestrial life - 150 species have been identified on iNaturalist based on 410 observations (Table 3). Experts estimate 180 species locally.

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Nome científico	Nome popular		Nome científico	Nome popular
Acrostichum danaeifolium	Samambaia-Gigante-Do-Brejo		Kalanchoe pinnata	Saião
Adenanthera pavonina	Tento-Carolina		Lantana camara	Camará-Juba
Albizia julibrissin	Acácia-de-Constantinopla		Laportea aestuans	Urtiga-Vermelha
Aloe vera	Babosa		Leucaena leucocephala	Leucena
Alternanthera brasiliana	Penicilina		Libidibia ferrea	Pau-Ferro
Ananas sp.	Abacaxi		Lippia alba	Erva-Cidreira-Brasileira
Annona muricata	Gravioleira		Luffa aegyptiaca	Bucha Vegetal
Artocarpus heterophyllus	Jaca		Macroptilium lathyroides	Feijão-do-campo
Basella alba	Bertalha		Malpighia emarginata	Acerola
Bauhinia variegata	Casco-de-Vaca-Lilás		Mangifera indica	Mangueira
Bauhinia variegata candida	Pata-de-Vaca		Manihot esculenta	Mandioca
Bixa orellana	Urucum		Mentha × piperita	Hortelã-Pimenta
Brugmansia suaveolens	Trombeta		Mimosa pudica	Dormideira
Cabobanthus polysphaerus	Assa-Peixe		Moquilea tomentosa	Oiti
Caesalpinia pulcherrima	Flor-de-Pavão		Morinda citrifolia	Noni
Cajanus cajan	Guandu		Morus nigra	Amora-preta
Canavalia ensiformis	Feijão-de-Porco		Murraya paniculata	Murta-de-Cheiro
Carica papaya	Mamão-Papaia		Musa × paradisiaca	Banana
Caryota mitis	Palmeira-rabo-de-peixe		Pachira aquatica	Castanha-Do-Maranhão
Cascabela thevetia	Chapéu-de-Napoleão		Parapiptadenia rigida	Angico
Cecropia pachystachya	Embaúba-Branca		Parthenium bipinnatifidum	Erva-amargosa
Ceiba speciosa	Paineira		Parthenium hysterophorus	Losna-branca
Cestrum laevigatum	Canema		Persea americana	Abacate
Citharexylum myrianthum	Tucaneira		Phaseolus vulgaris	Feijão
Citrus × aurantium	Laranja-Amarga		Pistia stratiotes	Alface-d'Água
Citrus × limon	Limão		Plathymenia reticulata	Pau-Amarelo
Citrus deliciosa	Mexerica		Pleroma heteromallum	Orelha-de-Onça
Clitoria fairchildiana	Sombreiro		Plinia cauliflora	Jaboticabeira
Clusia fluminensis	Clusia		Plumeria rubra	Jasmim-Manga
Cocos nucifera	Coqueiro-Comum		Pontederia crassipes	Aguapé
Coffea arabica	Café		Pseudobombax grandiflorum	Embiruçu
Coleus barbatus	Boldo-Brasileiro		Psidium guajava	Goiabeira
Coleus scutellarioides	Coleus		Pterygota brasiliensis	Pau-Rei
Commelina sp.	Tapoerabas e Afins		Ricinus communis	Mamona
Cordia superba	Grão-de-Galo		Rubus rosifolius	Amora-Vermelha
Cosmos sulphureus	Cosmos-Amarelo		Rumex sp.	Línguas-de-Vaca
Costus atlanticus	Cana-de-Macaco		Saccharum officinarum	Cana-de-Açúcar
Ctenanthe setosa	Maranta-Cinza		Sansevieria trifasciata	Espada-de-São-Jorge
Cucurbita pepo	Abóbora		Schizolobium parahyba	Guapuruvu
Delonix regia	Flamboyant		Senegalia polyphylla	Espinheiro-Preto
Didymopanax morototoni	Sambacuim		Senna pendula	Fedegoso
Dioscorea polystachya	Inhame Chinês		Sesbania virgata	Feijãozinho
Echinodorus grandiflorus	Chapéu-de-Couro		Solanum americanum	Maria-Pretinha
Enterolobium contortisiliquum	Ximbuva		Solanum betaceum	Tamarilho
Episcia cupreata	Planta-Tapete		Solanum diphyllum	Erva-moura
Eriobotrya japonica	Nespereira		Solanum diphyllum	Erva-moura
Eugenia brasiliensis	Grumixama		Solanum torvum	Jurubeba
Eugenia uniflora	Pitangueira		Sparattosperma leucanthum	Cinco-Folhas
Euphorbia heterophylla	Leiteira		Spathiphyllum wallisii	Lírio-da-Paz
Euterpe edulis	Juçara		Spermacoce verticillata	Vassourinha-de-Botão

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Nome científico	Nome popular		Nome científico	Nome popular
Ficus sp.	Figueiras		Spondias dulcis	Cajá-manga
Gallesia integrifolia	Pau-d'alho		Sterculia foetida	Chichá-Fedorento
Garcinia macrophylla	Bacupari		Syagrus romanzoffiana	Jerivá
Gossypium hirsutum	Algodão		Syzygium malaccense	Jambeiro-Vermelho
Guarea guidonia	Marinheiro		Tabebuia rosea	Ipê-Rosa-Centro-Americano
Heptapleurum heptaphyllum	Almecegueira		Talinum fruticosum	Beldroega graúda
Indigofera spicata	Amendoin bravo		Tecoma stans	Ipê-de-Jardim
Indigofera spicata	Ipê-Do-Morro		Terminalia catappa	Amendoeira-da-Índia
Iochroma arborescens	Fruta-de-Sabiá		Trema micrantha	Grandiúva
Ipomoea batatas	Batata-Doce		Trimezia gracilis	Íris-da-Praia
Ipomoea sp.	Glórias-da-manhã e Afins		Triplaris americana	Pau-Formiga
Jacaranda mimosifolia	Jacarandá-Mimoso		Turnera subulata	Xanana
Jatropha gossypiifolia	Pinhão-Roxo		Varronia curassavica	Erva Baleeira
Jatropha multifida	Mertiolate		Vernonanthura patens	Assa-peixe
			Xanthosoma sagittifolium	Taioba

Table 2. Check List of plant species found on the left bank of the Colibris stream, identified through consultation with specialists and the iNaturalist application

Scientific name	Popular name		Scientific name	Popular name
Amynthas sp.	Minhoca		*Furnarius figulus*	Casaca-de-Couro-da-Lama
Anartia jatrophae	Borboleta-Pavão-Branco		*Mecistomela marginata*	Besouro
Ardea alba	Garça-Branca-Grande		*Orthemis sp.*	Libélula
Boana albomarginata	Perereca-Araponga		*Pachylis laticornis*	Percevejo
Canthon sp.	Pilulares		*Pachylis nervosus*	Percevejo
Chelymorpha cribraria	Joaninha		*Phoebis philea*	Borboleta-Gema
Conocephalus sp.	Esperança		*Sicalis flaveola*	Canário-da-Terra
Dione juno	Borboleta-Do-Maracujá		*Sphictyrtus chrysis*	Percevejo-Quebra-Pedra
Diplopoda	Piolhos-de-Cobra		*Trachyderes succinctus*	Besouro
Dysdercus sp.	Percevejos-Manchadores		*Tribo Pierini*	Borboleta
Egretta thula	Garça-Branca-Pequena		*Tribo Polyommatini*	Borboleta
Fluvicola nengeta	Lavadeira-Mascarada		*Yphthimoides celmis*	Borboleta

Table 3. List of animal species – arthropods and birds – found on the left bank of the Colibris stream, identified with iNaturalist

And then came the pandemic. With the pandemic, in 2020, the collective's face-to-face activities were reduced. The online agroecological conversation circles – the garden talk – helped a lot to keep motivation high, in meetings that also had affective gain (Blog Córregos da Tiririca 2023). With the vaccination, little by little, the collective returned to practice, maintaining social distancing, working in pairs per section. After four years of agroforestry planting (2019-2023), the landscape has changed (Supplementary material 2 - drone video 2023). The small forest installed on the riverbank had already changed the landscape. Strong roots anchored the soil and prevented the erosion that occurred before.

Discussion and Conclusions

It is possible to infer that the initiative to make Serra da Tiririca a protected area was born in the Colibris stream, with the first Public Civil Action filed against an illegal allotment, based on complaints from the local community (Pimentel et al. 2013). The Colibris stream was the place where the first reaction of environmentalists took place, against the attempt of land subdivision in 1989. This reaction boosted the campaign to create PESET – Serra da Tiririca State Park. The area has always been the focus of environmental resistance, the object of controversy and surveillance by environmentalists. It expresses the symbolism of an area where science and a sense of public belonging prevail (Simon 2005). In a region surrounded by small streams in the middle of the expanding city, the Colibris stream has the privilege of having its headwaters within a protected area.

Stream environments are most often neglected in urban centers, and water bodies are rectified, channeled, polluted, or even forgotten under concrete due to the intense occupation of the territory and the growth of the urban fabric. How can we prevent stream environments from being destroyed? Environmental education actions are important and, when combined with environmental restoration actions, they are a possible path. This is how the local society began to act, organizing itself into a Collective for the benefit of restoring a stream in the neighborhood. Residents and friends participate in the Córregos da Tiririca Collective, forming a group around the idea of recovering the riverbank in a voluntary and organized way (Pontes et al. 2021).

Urbanization causes profound changes in stream ecosystems. As more urban structures are built, the more impermeable the soil becomes, making it difficult for rainwater to infiltrate and causing large floods (Marques and Cunico 2021). Without a concordance between water supply and sanitation, as the big cities grew, their rivers became dirty ditches. Once-clear rivers have been lost in the memory of an intensely urbanized landscape (Kury et al. 2021). The collapse of water bodies in the fabric of large cities has turned the gaze away from the population that lives there, who ended up disregarding the river as a living space. Whether for sanitary or engineering reasons, throughout the twentieth century, rivers were buried and forgotten. Plans to control flooding in major cities have opted to build swimming pools underneath the squares, diverting rivers into subterranean tunnels, as happened with the coastal rivers of the metropolitan region of Rio de Janeiro (Sarmento-Soares 2023).

But before reaching this point, it is possible to devise another path for urban rivers. Surface runoff can be controlled by planting riparian forests in peri-urban streams. Thinking about the conservation of urban biodiversity helps to conceive the growth of cities in the form of nature-based solutions. Vegetated linear parks help reduce heat island effects and generate greener cities (Dearborn and Kark 2010). Connecting the conservation of urban streams can receive support from the local community through environmental education actions and the promotion of well-being (Marques and Cunico 2021).

From a social point of view, to grow a different range of foods, providing food security to those who live in the surroundings. At the moment, there are aromatic herbs, teas, spices, fruits, and leaves that have been planted for those who come and want to pick them up. Beans and also tubers are part of the seasonal menu of the riverside. In this vein, syntropic agriculture practices are based on the philosophy of Good Living, in which social justice is the matrix of action and practice towards better coexistence among the people of the place.

There is now compelling evidence that with climate change, extreme events will become more frequent. Long droughts and severe torrential rains have been recorded around the world. To mitigate the severe climate effects, plantations need to be more resilient from a water point of view (Damant and Villela 2017).

From the perspective of mitigating climate effects, agroecology emerges with a potential influence on water, ecosystems, cultivated biodiversity, seeds, and soil (Anderson et al. 2021). It is contrary to the current established model that aims at high productivity of uniform products, with monocultures that spread over large territories. This productivity only remains high, however, if we consider short periods of time. Syntropic agriculture, on the other hand, uses the mechanism that nature itself uses in its forests (Andrade and Passini, 2022). Agroforestry increases climate resilience, with more resistance to extreme events and water regulation. It is linked to the farmer's intuition and recovers degraded or unproductive areas. It maintains constant productivity for long years, as it does not degrade the soil.

Agroecological practices have been adopted in different cultures around the world (Altieri, 2018). The use of "criolla" seeds contributes to promoting food sovereignty.

Sustainable food systems are inclusive, resilient, safe, and diverse, promoting health and affordable food for people. Agroecological experiences extend from the Andes mountain range, with the Quechua and Aymara (Bidasecca, Vommaro, 2021), to the Himalayas with the Lepchas (Anderson et al. 2021). But there is something in common - agroecology is assumed as a technology with a strong socio-environmental connotation (Anderson et al., op.cit.). Many social scientists associate agroecology with food security. Faced with this scenario, agroecology reaffirms itself as a method capable of building localized agrifood systems, bringing production closer to consumption. Through it, it is possible to establish subsistence family farming and improve the surrounding ecosystem. In this sense, it is seen as a social, cultural, and political movement. Agroforestry in cities can be an important ally for food security in urban areas. Agroecology strengthens bonds of social equity through movements focused on issues such as climate change or food security, movements that have roots in social justice and affirmative action.

Formal and informal networks of collaboration at the base of the collective, of coordinated movements, are necessary for the transformation of the landscape (Anderson et al. 2021). Many urban societies grow individually, creating a barrier to cooperation. Individualization deterritorializes and limits care to the walls of one's own house or condominium, in a spirit of fear and insecurity.

Collaboration networks function as islands of success – building systems of learning and exchange that enable innovation in a network of cross-functional collaborators, as well as the co-production of knowledge, working in partnership in the political arena to reach new spheres. Thus, the Córrego da Tiririca Collective embraces new partnerships with other initiatives in the Itaipu lagoon system, such as the Eco barrier of the João Mendes River and the Mangue Real.

The social organization promotes innovation and goes against the urban trend of transforming the stream into a fetid ditch, whose destiny is to be buried under the concrete of the cities. This was the case with many rivers in the macro-drainage of Guanabara Bay. For example, the Carioca River, in the capital, Rio de Janeiro, whose only open stretches are in Largo do Boticário and upstream, near its headwaters, in the neighborhood of Cosme Velho. The Carioca, which was once one of the main sources of supply in the capital of the empire, is still channeled, anonymous, buried under the streets of the neighborhoods of Laranjeiras and Flamengo. Few residents of Rio know of its existence, let alone its history (Silva and Seixas-Filho 2016).

Protecting and reforesting the areas at the edge of the forest, in the riparian forest, is much more than recomposing the PPA area of the river. It is to restore the food webs and aquatic food chains that have been lost with the process of urbanization. The riparian forest promotes green corridors in linear parks. Green infrastructure is an important refuge for the coexistence of the urban and the natural (Bratman et al. 2019). Forested areas in urban spaces provide shade and mild temperatures (Lopez et al. 2020). And streams, including urban streams, are important aquatic systems, as they make up to 70% of the drainage networks of a watershed (Vannotte et al. 1980; Vieira et al. 2022). Urban green spaces confer benefits that go far beyond the environmental, conferring physical and mental health to those who frequent them. The maintenance of riparian vegetation, combined with soil conservation techniques and the rational use of urban space, improves the quality and volume of river water. It also makes a positive contribution to aquatic ecosystems.

Final considerations

Carrying out the recovery of vegetation on the banks of watercourses is a requirement of the Forest Code. Additionally, the recovery of riparian forest has an educative purpose. The general lack of knowledge about the function and benefits of this vegetation by the population results in its removal as a solution to all the problems encountered by it. Conservation actions need to be desired by the local people. Conservation can only exist if we bring together the different social actors in a common goal. Like any proposal for intervention in the space, the planting on the banks of the Hummingbird Stream was covered with socio-environmental complexities. The union around a collective, the engagement of the neighborhoods, the indirect action of the government with the direct participation of some of its actors, and the recognition that that forested area is in the public interest is what allows the evolution of soil quality, the increase of green cover, food production, and the success of planting in general.

Statements and Declarations

Authors' Contributions

All authors contributed equally to the contextualization, formal analysis, research, and original writing of the manuscript. RFMP and FSTT contributed to the methodology. Final revision and LMSS editing. All authors have read and agreed with the present version of the manuscript.

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