Florencia Montagnini
RESEARCH STATEMENT
August 2022

My research focuses on sustainability of forests and agroforestry systems; sustainable land use systems that integrate ecological principles with economic, social, and political factors; sustainable agriculture, organic farming, soil conservation and management; rural development; forest landscape restoration; reforestation of degraded lands with native species; ecosystem services (biodiversity, carbon and watershed protection); adaptation and mitigation to climate change; Payments for Environmental Services as tools for restoration, conservation, and rural development. Biodiversity conservation in human dominated landscapes; biodiversity islands.

I am currently conducting projects in regions encompassing major types of tropical and subtropical forest as well as temperate grasslands in Latin America. The research is in collaboration with universities and other academic, private and government institutions in Argentina, Brazil, Costa Rica, Ecuador, and Panama. The following is a short description of these projects. Full descriptions, related articles and other research activities associated with these projects are in my research webpage: https://drflorenciamontagnini.wordpress.com with updates in other professional websitses (Linkedin, Research Gate, Facebook), and also in the MacMillian Center for Latin America and Iberian Studies website, as shown in my CV.

1- Restoration of Degraded Lands with Native Timber and Multipurpose Species in the Province of Misiones, Argentina

The Upper Parana Atlantic Forest, a biodiversity hotspot of highly threatened biodiversity, extends to northeastern Argentina in the province of Misiones. The Misiones forests are part of the Interior Atlantic Forests, an expanse of the highly threatened Atlantic forest of Brazil, where we are also engaged in ecosystem restoration projects. The use of native species for multiple purposes is a contribution to the production, restoration, and conservation of their diversity.

In collaboration with the School of Forest Science of the University of Misiones (UNaM), with whom our school has an active Memorandum of Understanding (MOU) we maintain long-term experimental settings that we had started in the 1990s. These experimental settings include: 1. Mixed and pure plantations with native tree species on degraded land, and 2. Enrichment of overexploited /secondary forests with native species.

It is remarkable that once the initial funding from Yale University related sources ended, these projects have been successfully phased out as they are fully integrated within the local academic institutions' programs and other collaborators' agendas. We started these long-term projects with funding from the A.W. Mellon Foundation and other sources (as shown in my CV), however we have been successful obtaining funding to follow up on them from local government agencies and private companies. This local funding covers research expenses like transportation and supplies, while salaries of the collaborating researchers and technical personnel are paid by the University of Misiones. INTA contributes supporting soil sampling and analyses.

We planned these projects from the start in a participatory manner, meeting with the local researchers, assembling research teams according to our respective expertise, and delineating goals, objectives and methodologies that fulfilled specific needs in each case. The results of our joint projects have been used and applied by practitioners including farmers, research and technical personnel, as well as local and national government. Our collaborative projects also serve educational purposes as the sites are used by students for their course practices and theses. Therefore these projects are good examples of the integration of scientific and practitioner goals in research and education.

1. *Mixed and pure native-species plantations on degraded lands*

Current studies, after 30 years of establishment of the plantations include:

- Tree growth and biomass
- Tree community composition and structure
- Understory diversity of species from natural regeneration
- Seed bank and dispersal agents
- Functional ecological groups and seed dispersal syndromes of regenerating species
- Soil fertility as influenced by the native tree plantations and natural regeneration

We presented our most recent results at a conference in Misiones, Argentina (see **Presentations in CV)**. We are currently writing articles and book chapters on results of these current investigations (see CV).

2. *Enrichment of overexploited /secondary forests with native species*

Likewise, we are following up on the enrichment plantings that we established in the early 1990s in the Guarani Ecological Reserve in Misiones, an over 5000-ha forest reserve that belongs to the Province of Misiones, part of the almost 250,000-ha Yaboti Green Corridor in the Atlantic Forest. Our experiences in the Guarani Reserve and other locations in Misiones (Montagnini et al. 1997, 2006), served as background for legislation at the national and provincial level that includes forest enrichment as a silvicultural practice. Our results were instrumental in determining species, designs, incentives and monitoring of this restoration practice in Argentina.

The School of Forest Science of the University of Misiones has managed and used the Guarani Reserve for research and education for over 30 years, and we are now compiling the results of these activities in a book: "Treinta años de experiencias en la Reserva de Uso Múltiple Guaraní (RUMG), Misiones, Argentina. Facultad de Ciencias Forestales, Universidad Nacional de Misiones, Eldorado, Misiones, Argentina". I am the leading author of a chapter on forest enrichment (Montagnini et al. in press), and I am a co-author in chapters on other subjects with colleagues from the School of Forest Sciences.

2- **Organic agroforestry systems in combination with commercial crops**

Alternative agro-ecological solutions based on scientific research arise worldwide in order to find a sustainable balance between productivity, biodiversity conservation and food sovereignty. These

are often drawn from age-old practices that have been passed down by indigenous knowledge through centuries. In this context, we are conducting research on organic agroforestry systems using native trees species in Argentina and in Costa Rica.

In Misiones, Argentina we are studying the factors influencing the integration of native tree species in organic agroforestry systems including yerba mate, *Ilex paraguariensis*, a species of long traditional use by original indigenous people in the Atlantic Forest region of South America. Yerba mate leaves are consumed locally as an infusion as it is energizing and also contains high amounts of anti-oxidants, and it is currently marketed certified organic tea in the USA and other countries (Montagnini et al. 2011). In this research we also collaborate with INTA, the National Institute for Agricultural Technology, and with local farmers.

Following up on these studies we are starting new projects in collaboration with INTA and with Guayaki, a private company that produces certified organic yerba mate in Argentina, Brazil and Paraguay and maintains two ecological reserves in Misiones (Guayaki.com). We are planning to examine soils, productivity and environmental services (biodiversity, carbon) in the organic farms, comparing with conventional monocultures of the yerba mate crop.

In Costa Rica we started long-term research experiments associating coffee with native species at CATIE (Centro Agronómico Tropical de Investigación y Enseñanza, Tropical Agriculture Research and Higher Education Center, catie.ac.cr) in 2001, before I ended a 4-year position there as Head of the Forests and Biodiversity Department. The experimental design includes coffee with and without shade trees, shaded plots with the most commonly used shade tree species in the region, and two other native tree species with the intention of further diversity coffee agroforestry systems (Rossi et al. 2011). In addition the experimental system includes treatments with and without the addition of organic as well as conventional chemical inputs.

Over the years several Yale YSE students have carried their research in our site, and currently we are summarizing 30 years of results in a joint article coauthors by several researchers from CATIE, former students and others (de Melo et al. 2021).

3- Conservation and Registration of Seed Sources in Reserve Remnants in the Province of Misiones, Argentina

The restoration of degraded lands necessitates the appropriate plant propagation material that can ensure viability and diversity of the restored areas. In Argentina, national and provincial laws promote the restoration of degraded forest areas. This project is led by Beatriz Eibl from the School of Forest Science of the National University of Misiones. Since 2018, a registry of forest areas and seed trees has been implemented nationwide to serve as a repository of biodiversity and plant propagation material, controlled by the National Seed Institute (INASE) elaborated in scientific/technical cooperation with the School of Forestry of the National University of Misiones. In these registered areas, which can be in private, public, or protected lands, propagation material is certified, with priority given to arboreal species and rare, endemic, threatened and/or vulnerable species.

Recent results of this research will be published as a chapter (Eibl et al. 2021) in my most recent book:
Montagnini, F. (Ed.). 2022. *Biodiversity Islands. Strategies for Conservation in Human-Dominated Environments*. Series: Topics in Biodiversity and Conservation 20, Springer, Cham. (eBook): https://doi.org/10.1007/978-3-030-92234-4. 709 pp

To date, more than 1,000 registered seed trees have been recorded in more than 54 hectares of forest remnants in Misiones. The certification of propagation material obtained from conservation areas, seed banks, nursery plants and tree plantations grown in the field follows a certification protocol for quality control that allows native species to be included in productive systems (for firewood, wood, medicinal, ornamental, honey, food, essences, landscape, restoration, others) and to provide income to the owners (Eibl et al. 2022, see CV).

4- **Domestication and conservation of genetic diversity of native multipurpose species of the Misiones forest**

This is another collaborative project with colleagues of the University of Misiones (Niella et al. 2022, see CV). In tropical and subtropical forests, tree species are vulnerable to habitat fragmentation and population reductions. The resulting negative genetic effects, such as loss of genetic variability and inbreeding depression, can affect the long-term survival of forest species, leading to their further vulnerability or extinction. While *in situ* strategies such as protected areas and biodiversity islands may be an option for biodiversity conservation, in practice there are many challenges to these strategies in humid subtropical ecosystems, where there is high tree species diversity and low abundance per species (0.1-1 trees/ha). Trees in remnants of forests, which can serve as biodiversity islands, must have high genetic diversity so that they can persist through time by adapting to disturbances. There is a great need to expand the genetic basis of collection of species' propagation material, so that the germplasm available for restoration programs includes the largest possible genetic diversity.

To address this need we are developing strategies for domestication and conservation of the genetic variability of native species of the Interior Atlantic Forest, or Selva Paranaense. In the last couple of years, we have focused our research on two species, *Peltophorum dubium* and *Enterolobium contortosiliquum*. We are focusing on the preservation and production of propagules with high genetic diversity of two native species, *Peltophorum dubium* and *Enterolobium contortisiliquum*, which are good candidates for forest restoration or enrichment projects. These two species are of interest not only to the forest industry due to the quality of their wood, but also to fauna as they are both melliferous. Previous research has shown that they are suitable for restoration of degraded areas, consociated agro-livestock or silvicultural systems. We established short- and long-term provenance and progeny trials and a vegetative reproduction methodology to produce propagation material to ensure the genetic diversity of these two species for domestication, including for restoration and enrichment. Our results lay the foundation for the conservation of genetic variability of *P. dubium* and *E. contortosiliquum* and contribute to the design of a possible biodiversity island strategy for these species.

I am advising a doctoral student from the University of Misiones who is conducting his research as part of our project with funding from CONICET, the National Council of Scientific and Technical Research of Argentina. He presented results of his research on growth and survival of progenies of *Enterolobium contortisiliquum* greenhouse and field experiments in a recent scientific meeting (See Buchweis et al. in list of **Presentations**).

5- Strategies for restoration of the Atlantic Forest of Bahia, Brazil

In Brazil, in collaboration with the University of Southern Bahia, with CEPLAC (Center for Cacao Promotion and Research), and with the Center for Environmental Studies of the Michelin Tire Company, both of which have active MOUs with our School, we are examining alternatives for restoration of the highly endangered Atlantic Forest, using different strategies according to the degree of degradation of the landscape (Piotto et al. 2019, 2020, 2021).

The Atlantic forest of Brazil is a biodiversity hotspot that retains less than 12% of its original area. Non-pioneer tree species with limited dispersal are the most impacted by recent habitat loss and fragmentation. As several attempts to establish non-pioneer tree species in pastures and agricultural fields in the Atlantic forest have failed, restoration strategies that consider planting these species in other habitats, such as in enrichment planting in the understory of secondary forests may be more successful.

The Michelin Tire Company has supported our research on their 10,000 hectares forest reserve in Itubera, Bahia, where we have used old rubber plantations as "nurses" by enriching the groves with native species. We planted five native non-pioneer tree species (*Sloanea obtusifolia, Garcinia macrophylla, Copaifera lucens, Symphonia globulifera*, and *Pouteria reticulata*) in April 2009, with four site replications and four treatments (open fields, open fields with pioneers, young secondary forests, and rubber plantations). Survival, height, and dbh (diameter at the breast height) were measured every year for six years. We also measured canopy cover and soil physical and chemical parameters. We are also developing strategies for the restoration of native secondary forests and abandoned pastures with mixed plantations of native species. We have just published results of our study on the performance of non-pioneer threatened tree species planted in open fields, young secondary forests, and rubber groves in Bahia, Brazil (Piotto et al. 2020, see CV).

We are following up on this research with our collaborators from Brazil, Daniel Piotto from Universidade Federal do Sul da Bahia, and Kevin Flesher from Reserva Ecológica Michelin, planning to thin the plantations, among other activities; however we have experienced delays in field work due to the COVID 19 pandemic.

6- Reforestation, agroforestry and silvopastoral systems with native species in Panama

I participated in the initial framing and setting of the Native Timber Species Plantation Experiment (NTSP), which is part of the "Agua Salud" (Water/Health) project that studies the ecosystem services provided by forests and mixed and pure plantations of native tees, within the Panama Canal Watershed as a collaborative research project between our School and the Smithsonian Tropical Research Institute (STRI). Recently I advised students who conducted

their MS Thesis in Panama, for example, Veronica Chang, MS 2019: Evaluations of reforestation success of native tree species of tropical dry forest in cattle ranching landscapes in the Azuero Peninsula, Panama (Chang et al. 2019); Viola Taubmann (MEM 2021): A comparative financial analysis of intensive and ANR-based silvopastoral systems on the Azuero Peninsula in Panama.

As ELTI maintains presentce in Panama though their reforestation /restoration actions in their premanent site in the Azuero peninsula, I continue to be involved in our students' projects in the region.

7- Biodiversity Islands in human-dominated landscapes

As part of the activities of the Program in Tropical Forestry and Agroforestry, for the last couple of years we conducted several studies on developing the concept of the framing and planning tool we call Biodiversity Islands. A Biodiversity Island acts as an ecological refuge, where plants and animals can thrive without major degenerative interference from human activity. The economic benefits of adopting and recognizing Biodiversity Islands within the landscape include ecosystem services, biodiversity conservation, and natural capital resources (biodiversityislands.org). In collaboration with several colleagues and YSE students (Brett Levin, MEM '18, Sara del Fierro, MF'19) we created the above-mentioned website, resulting in my most recent book: **Montagnini, F**. (Ed.). 2022. *Biodiversity Islands. Strategies for Conservation in Human- Dominated Environments*. Series: Topics in Biodiversity and Conservation 20, Springer, Cham. (eBook): https://doi.org/10.1007/978-3-030-92234-4. 709 pp

In collaboration with colleagues from INTA and other co-authors of one of the chapters of the book (Gonzalez et al. 2021) we are following up on a project called: **The Islands of Resilience in South Santa Fe Province, Argentina. Recovering Areas with Real Potential for Hosting Biodiversity and to Integrate with Sustainable Food Production Strategies.** This Project started in May, 2019 and more recently a local educational center, Centro de Educación Agropecuaria Nº5 (Center for Agricultural Education) from San Genaro (Santa Fe, Argentina) started collaborating with the research team.

"Islands of resilience" are defined from the perspective of landscape ecology as "patches", as they are areas with greater biodiversity than the surrounding anthropic matrix, which is dominated by an extensive homogenized and simplified territory associated with the agro-industrial production model or system of soy cultivation. The Argentinean humid pampas were once a large grassland biome. Starting when the European colonizers arrived five centuries ago, and lasting until present, the original grassland ecosystems suffered an extreme transformation and have now almost completely disappeared. Today this region is under pressure from an "agriculture without farmers" dependent on external inputs which are increasingly scarce. This has serious social, environmental, and economic implications. The landscape matrix has been increasingly alternating its seasonal composition between fallows and monocultures of wheat, corn, and soybean. If allowed to continue, this artificialization of ecosystems, dependent on fossil fuels, chemical inputs, and biotechnology, represents a serious threat to present and future social and environmental wellbeing (González et al. 2022).

This new model of agricultural production, which heavily relied on the soybean, replaced diverse cropping systems, and became dominant. With less reliance on people, it led to the migration of the rural settler and the abandonment of their homes and surroundings. These abandoned settlements were largely left untouched, which allowed for the development of plant secondary succession, sheltered by the infrastructure that had been left behind and its generally wooded surroundings. The abandoned areas contained exotic species such as fruit trees and others that would provide shade, shelter from the winds and some wood products, such as firewood for cooking and heating. Not all these abandoned relics have been preserved. However, it is still common to observe these "patches" in the pampas landscape of monoculture, where nature reveals its biotic potential. This shows the capacity of resilience of the Pampean grasslands to recolonize these relics through successive occupation of space with spontaneous species, starting with pioneers and then moving into stages of greater forest maturity.

"Resiliency islands" are key elements of a strategy aimed at establishing mechanisms compatible with the joint practices of production and conservation, because they help recover spaces with real potential to host biodiversity, while they can also contribute to strengthening the economy and endogenous development of local communities. The sustainable management of local agroecosystems leads to the development of territorialized food systems that link the production of healthy food with local consumption.

We have identified surviving land areas that persisted in the increasingly anthropic landscape of this region, constituting patches of biodiversity referred to as "islands of resilience." In this project, we analyze a case study located in the city of Las Rosas (Santa Fe province, Argentina). We are examining plant and animal diversity, observing the presence of other indicators of ecological success, and developing strategies to integrate these ecosystems into a more sustainable way to produce food for local consumption and marketing.

For example, recent project activities include thinning parts of the forest patches to allow for intercropping with food species such as rye. Weeding was done to eliminate competition between lines of *Prosopis* sp, and after soil preparation, rye (*Secale cereale*) was planted in association with Persian clover, *Trifolium resupinatum*. A similar design was implemented on patches of secondary forests dominated by *Broussonetia papyrifera* (paper mulberry, an exotic tree species) which were pruned and thinned as needed. Before planting, the soil was cleaned and scarified. In another sector of the island with several different tree species we pruned as needed to allow enough light for planting vegetable species. We also planted native tree species such as *Vachellia caven* and *Celtis tala* trees (Libertario González, personal communication, July 14 2021).

We are gradually thinning/replacing the exotic species with native ones of similar functions in the landscape. We expect that the interinstitutional actions can grow and develop to establish a regional agroforestry network. The "islands of resilience" and the peri-urban fringes of cities are potential interconnected "nodes" of production, transformation, organization and distribution of healthy food to the surrounding communities (González et al. 2022).