

Chapter 22

Integrating Researchers for Understanding Biodiversity in Atlantic Forest



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Abstract Long-term and interdisciplinary studies are needed to understand biodiversity and unravel ecological processes, test ecological hypotheses, propose public policies, and help decision-makers, especially with regard to human impacts and their consequences on the environment. These studies began with the Long-Term Ecological Research Program (LTER), generating knowledge about Brazilian ecosystems and their biodiversity. However, an integrative methodology was lacking in LTER sites, which was obtained using the RAPELD method developed in an Amazonian LTER site. In 2004, the Biodiversity Research Network Program (PPBio) was created in the Amazon and semiarid biomes, based on the strategy of creating regional hubs that served less favored regions in terms of human resources training and with great potential for biodiversity. In 2012, PPBio was expanded to the other Brazilian biomes. In a relatively short time, PPBio achieved consistent results, largely due to the use of RAPELD as an integrative methodology, which led to greater integration of information on different biotic and abiotic factors, as well as the availability of data in public repositories. LTER and PPBio are complementary networks of great relevance for the knowledge and conservation of Brazilian biodiversity, and their integration needs to be strengthened in the Atlantic Forest.

Keywords Biodiversity · PELD · Integrative Methodology · RAPELD · Network research · PPBio

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22.1 From Single to Integrated Studies

Modern science is increasingly collaborative in all research fields (Sidone et al. 2016), and research in ecology has long been collaborative due to the complexities that it deals with, but interdisciplinarity is becoming increasingly important as the complexity of the ecological problems facing humanity increases (Goring et al. 2014; Hobbie et al. 2003). Formulating and testing ecological theory demands long-term interdisciplinary study and long-term experiments, particularly considering recent global changes (Barbosa 2013; Hobbie et al. 2003).

Long-term collaborative research projects have increased since the establishment of the US Long-Term Ecological Research (US LTER) in 1980. By the 1990s, a consensus was established that many ecological questions require a particular study site to be investigated for a long time (Gosz 1998). In 1993, scientists from 16 countries meeting in the USA identified a “growing need for global communication and collaboration among long-term ecological researchers and to capture ecological phenomena in the context of global change.” As a result, international LTER (ILTER) was founded during a meeting of researchers from the US Long-Term Ecological Research (US LTER) (Forsberg 1993). Strayer et al. (1986) pointed out that designing and operating such studies requires careful consideration of the potential problems if they are to be effective in the long term. Some of the challenges of interdisciplinary collaborative projects include the need for clear governance schemes and an explicit data-sharing policy that includes standard protocols for metadata, data quality, intellectual property, and other issues (Penman et al. 2011).

22.2 PELD, the Long-Term Research Program of Brazil

Until about 40 years ago, most researchers in Brazil were concerned with relatively short-term ecological questions, and long-term research was virtually nonexistent. Most ecological studies at that time were primarily involved with questions related to organismal-level biology (e.g., ecophysiology, population dynamics, development, and parasitism) or descriptive community studies (e.g., succession, species interactions, and productivity). These generally did not involve questions that require long-term studies to obtain answers, but they were the building blocks over which long-term studies would later develop. In addition, long-term research requires continuous funding, which was not available at the time.

In 1996, the Brazilian Forum of Coordinators of the Graduate Programs in Ecology proposed to establish an integrated program in Ecology, the Brazilian PIE (Barbosa et al. 1998, 2000). As a result, the Brazilian National Science Foundation (Conselho Nacional do Desenvolvimento Científico e Tecnológico – CNPq) adopted PIE as one of its programs, which was structured with a subprogram focusing on capacity building and research, and another subprogram specifically on long-term

research, the “Pesquisas Ecológicas de Longa Duração” (PELD). Later, PIE was incorporated in PELD (Barbosa 2013; Mamede et al. 2013). This was the starting point for long-term studies in Brazil, and the PELD became a member of ILTER. This Brazilian initiative occurred soon after ILTER was established in 1993, and the Brazilian program was one of the pioneers in long-term ecological research. An initial set of nine potential sites were identified to establish long-term studies in Brazil (Barbosa 2013).

PELD/CNPq aims to generate knowledge on Brazilian ecosystems and their biodiversity and to promote the transference of such knowledge to civil society. Its priorities are to propose policies for the development of ecology in Brazil (thus including interactions and processes as well as organismal-level or descriptive studies), to develop research and information networks, to support international cooperation, to propose methodological standardization, to increase human-resource training and institutional development, and to act harmoniously with other government programs, such as the sustainable development policy committee and the National Agenda 21 (Barbosa 2013).

PELD has had an increasing number of sites since the first call for the establishment of sites was made by CNPq in 1997. Nine sites were established in 1999 with relatively restricted funding, with no guarantee of future support. However, in 2000, CNPq included a specific budget for this program in the Brazilian Pluriannual Plan (PPA). In 2001, CNPq made a second call, and three additional sites were aggregated to the program, then with 12 sites. However, for a megadiverse country, such as Brazil, encompassing at least six biomes, the number of LTER sites was still small and not representative of Brazilian ecosystems. In 2009, supplementary funds allowed a third call, which brought 14 additional sites into the program. By then, there were a total of 26 sites. This represented a marked expansion of PELD which improved its distribution among Brazilian landscapes. Since then, PELD has aggregated funds from 11 state funding agencies (states of Amazonas, Bahia, Goiás, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Paraná, Rio Grande do Sul, São Paulo, Rio de Janeiro, and Pará). With these additional funds, CNPq made a fourth call in 2012, and another four sites were aggregated, giving the program’s present 31 LTER sites (Mamede et al. 2013). Of these, a large portion (15 sites or about 48%) was established in the Atlantic Forest Biome or in ecotone ecosystems adjacent to the Atlantic Forest (one site). There is a bias in the number of sites for the Atlantic Forest biome compared to the Amazon and Cerrado that have larger territorial extensions. This bias reflects the concentration of Brazil’s scientific institutions and, consequently, most of the country’s science production in all research fields, in the Atlantic Forest Domain (Motta et al. 2002; Sidone et al. 2016). These research sites housed studies on a wide range of issues, including ecosystems, habitats, environments, and landscapes, such as Atlantic Forest physiognomies at different altitudes, Araucaria forests, restingas, mangroves, floodplains, estuaries, coastal lagoons, and transitions between Atlantic Forest and other ecosystems (Table 22.1 and Fig. 22.1).

The initial challenges of the first PELD sites were to not only produce scientific products in quantity but also analyze how the information generated shed light on

Table 22.1 PELD projects in the Atlantic Forest region

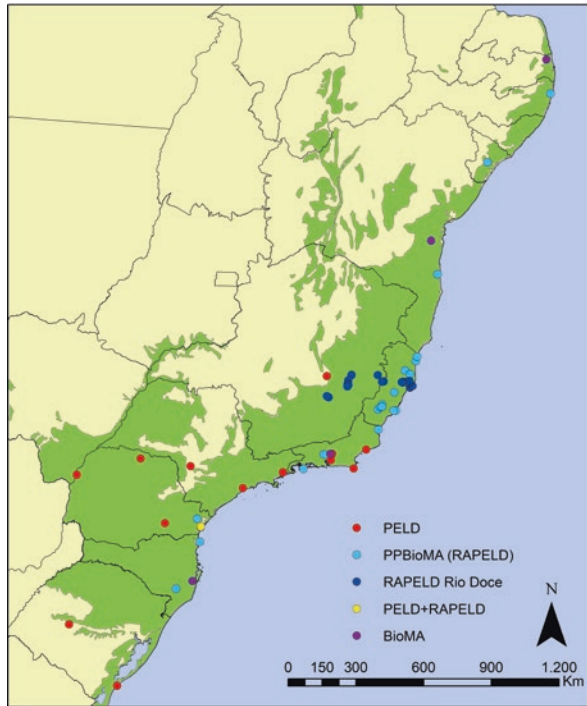
Acronym	Full name	Main institution	State	Beginning year	Ecosystem
MLRD	Atlantic Forest and lacustrine system of the middle Rio Doce	Universidade Federal de Minas Gerais	Minas Gerais	1999	Atlantic Forest, freshwater lakes
ELFA	Araucaria forests of Southern Brazil	Universidade Federal do Paraná	Paraná	1999	Araucaria forest, Atlantic Forest-araucaria transition
PIAP	The Upper Paraná River floodplain	Universidade Estadual de Maringá	Paraná	1999	Rivers, lakes, floodplains
RLaC	Restingas and coastal lagoons of the northern Rio de Janeiro	Universidade Federal do Rio de Janeiro	Rio de Janeiro	1999	Restinga, coastal lagoons
ELPA	Patos lagoon estuary and adjacent coast	Universidade Federal do Rio Grande	Rio Grande do Sul	1999	Coastal lagoon, estuary, beaches
PEBG	Guanabara Bay, Rio de Janeiro	Universidade Federal do Rio de Janeiro	Rio de Janeiro	2009	Marine ecosystem, mangroove, beaches
CSUL	South fields of Pampa and Atlantic Forest biomes	Universidade Federal do Rio Grande do Sul	Rio Grande do Sul	2009	South fields, Atlantic Forest
BROA	The ecology of UHE Carlos Botelho (Lobo-Broa Reservoir) and its watershed, São Paulo, Brazil	Instituto Internacional de Ecologia	São Paulo	2009	Lakes, riparian forest
FGAF	Functional gradient of Atlantic Forest	Universidade Estadual de Campinas	São Paulo	2009	Atlantic Forest
CRSC	Rock outcrops of Serra do Cipó-MG	Universidade Federal de Minas Gerais	Minas Gerais	2012	Rock outcrops, Cerrado-Atlantic Forest transition
LAG	Lagamar	Universidade Federal do Paraná	Paraná	2012	Atlantic Forest
MCF	Central fluminense mosaic of parks and reserves	Universidade Federal do Rio de Janeiro	Rio de Janeiro	2012	Atlantic Forest
ITA	Structure and dynamics of communities in coastal rivers and streams from the Atlantic Forest – Itanhaém river basin	Universidade Estadual Paulista	São Paulo	2012	Rivers, riparian forest

(continued)

Table 22.1 (continued)

Acronym	Full name	Main institution	State	Beginning year	Ecosystem
MAAM	Forest restoration in Atlantic Forest and Amazonia	USP-ESALQ	São Paulo	2012	Atlantic Forest
MANP	Brazilian orth Parana state seasonal Atlantic Forest	Universidade Estadual de Londrina	Paraná	2014	Atlantic forest

Fig. 22.1 Location of PEELD sites (red circles), RAPELD (blue circles; light blue: PPBio sites of the PPBioMA network; dark blue: monitoring sites along Rio Doce), PEELD site that applies RAPELD (yellow circle) and PPBio sites of BioM.A. network (purple circles) throughout the Atlantic Forest and transition ecosystems (green area), as delimited by the Atlantic Forest Law. (Federal Law 11,428/2006, IBGE 2012)



long-term issues. Long-term ecological research involves the understanding of processes, which requires the identification of mechanisms that affect the processes and the interactions between them. Also, human populations exert increasing pressures on natural resources, leading to the erosion of biodiversity and generating global effects, such as climate change and species extinction. All this requires time to be understood (Mamede et al. 2013; Tabarelli et al. 2013). During the initial stages, data produced in some sites were not linked to long-term issues, but over the years, with the implementation of new sites and evaluation of PEELD by CNPq, this culture is changing, resulting in each site increasingly reflecting on the information base it has generated and how this can be used to address long-term questions. Nevertheless, there is a persistent need for standardization of methodologies among sites. Ideally,

this will facilitate data collection following the same methodological procedures and spatial scales, guarantee the statistical independence of the observations, and allow comparisons among sites, even those in other countries or continents. This does not imply that only standardized studies can be undertaken at each site. Rather, a subset of studies in each site should use standardized methodologies to permit within and among biome comparisons. We have come a long way in standardizing methods, but we need to understand that science is a culture, and to change culture we need to teach young people the ethical, scientific, and financial values of integration. We would go a long way as well if standardized methodologies were required or recommended in public calls and environmental-impact studies. One method for such standardization is the RAPELD method, which was developed within one of the original PELD sites, and this could form the basis for part of the standardization within the program (Magnusson et al. 2005, 2008).

After nearly two decades, most sites have generated information that increases possibilities for biodiversity conservation, comprehension of ecological processes, their function and dynamics, long-term ecological responses to plurianual variation, knowledge of human impacts on different ecosystems, and knowledge of hydrological systems. These give guidance for sustainable regional development, public policies, dialogue with multiple stakeholders, and training of human resources within the scope of each project (Mamede et al. 2013; Tabarelli et al. 2013). PELD has been strategic not only to improve the knowledge of biodiversity and conservation and to provide subsidy for stakeholders, but also to stimulate a scientific culture embracing long-term ecological research as fundamental to conciliate human well-being and the sustainable use of natural resources. Together with the other PELD sites in Brazil, the Atlantic Forest-biome sites are contributing to an important set of long-term actions and integrated research in the Atlantic Forest biome and with other biodiversity programs, such as the Biodiversity Research Program (Programa de Pesquisas em Biodiversidade – PPBio) of the Ministry of Science, Technology and Innovations (MCTI). The PPBio adopted the RAPELD method in most of its field sites, so integration between PELD and PPBio promises to increase greatly the number of LTER sites in the Atlantic Forest and the possibility of comparisons among them.

22.3 Searching for an Integrated Methodology: RAPELD

There was a proliferation of biodiversity monitoring schemes in the 1980s and 1990s, which collectively gained the name of environmentally distributed ecological networks (EDENs) (Craine et al. 2007), and a group of Amazonian researchers started to search for field methods that would allow integration of data from multiple sites. Most previous attempts at standardization had focused on capture or measurement protocols and ignored the problem of spatial standardization. Some plot-based monitoring schemes were designed primarily for plant

studies, and their scales are generally not suitable for other organisms (e.g., CTFS, RAINFOR Projects), or when designed to monitor multiple organisms, they are not standardized at different scales (e.g., TEAM), or the scales are small and not relevant to managers (e.g., GLORIA) (Magnusson et al. 2013). Most researchers only considered spatial aspects within their local study site, did not realize the difficulty of integrating studies that have no common spatial scale, and reported their results as though they could be generalized to landscapes, regions, or continents.

The problem is that the effect of most variables is strongly and nonlinearly related to spatial scale (Koblitz et al. 2017). For instance, variation in soil attributes might have very little effect on the composition of plant assemblages within study sites covering several meters, large effects in sites covering kilometers, no detectable effect on comparisons among regions, and variable effects in comparisons among continents. Also, the results for most academic studies were for spatial scales largely irrelevant for managers of protected areas and decision-makers in municipalities, states, or countries. It is not possible to standardize at all scales, but the objective was to have a sampling design that would allow comparisons among sites at a few spatial scales of interest to land managers and that would allow calibration and validation of remote-sensing methods that could allow scaling up at little additional cost (Magnusson et al. 2013).

Most biodiversity-monitoring projects focused on only a few taxa (e.g., woody plants), on a limited range of habitats (e.g., mountain tops) or limited to a particular technology (e.g., camera-trapping). Their designs normally also made it difficult to include data on abiotic drivers, such as soils, hydrology, and topography, which are essential to allow the evaluation of human-induced changes and natural variation across landscapes. Many designs were investigated over a period of more than a decade (Koehler 2000, Jucevica and Melecis 2005, Magnusson et al. 2005, 2013, among other examples below) before the group settled on a compromise arrangement that allowed the inclusion of almost all taxa and environmental drivers, while deviating as little as possible from traditional methods to facilitate the integration of previous studies when possible (Magnusson et al. 2005).

The system, called RAPELD (rapid assessment surveys (RAP) + PELD – from the Brazilian acronym for LTER), was first installed in Reserva Ducke, which is part of the Long-Term Ecological Research (LTER) site Amazon Forest – Manaus, which was then Site #1 of the Brazilian LTER. The design is basically a modular network of trails and permanent plots that can be accommodated to sample all elements of biodiversity at scales of 1 km or greater (Costa and Magnusson 2010).

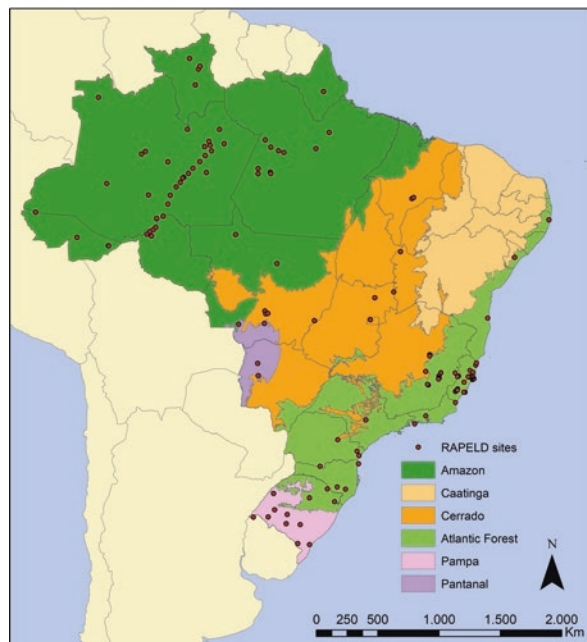
The first study using RAPELD methodology from Reserva Ducke was published in 2005 (Kinupp and Magnusson 2005), but there are now over 50 papers published using RAPELD methodology that included data from the reserve. These cover many taxa and life forms, including mites, frogs, butterflies, bats, fish, herbs and trees, and processes such as groundwater availability and carbon storage. Data are made available locally and in international networks, such as Data One,

RAINFOR, and ATDN. The number of publications from Reserva Ducke had been relatively limited before the installation of the RAPELD grid, but by 2008, it was considered one of the most productive research sites in the neotropics (Pitman et al. 2011).

RAPELD methodology is required by the Brazilian Environmental Authority (IBAMA) in environmental impact assessments for some types of infrastructure development, such as hydroelectric dams and highways. These have resulted in information on the status of trees (Moser et al. 2014), harpy eagles (Aguiar-Silva et al. 2015; Sanaiotti et al. 2015), bats (Bobrowiec and Tavares 2017), frogs (Carneiro et al. 2016; Koblitz et al. 2017; Ortiz et al. 2018), lizards (Morães et al. 2016), snakes (Fraga et al. 2014, 2017, 2018), and processes affecting multiple taxa (Santorelli et al. 2018).

RAPELD modules installed in Australia have revealed information on taxa ranging from koalas to forest trees (Hero et al. 2010, 2013; Lollback et al. 2017). Experimental modules have also been installed in Nepal and Liberia, but the only country besides Brazil with an actively expanding network of RAPELD modules at the moment is Argentina (https://ppbio.inpa.gov.br/en/PPBio_International/PPBio_Argentina). Within Brazil, the Program for Biodiversity Research (PPBio) has installed RAPELD modules in long-term ecological research sites in all biomes except the semiarid, and there are now more than 130 distributed across the country (Peixoto et al. 2016, Fig. 22.2). The biome with the largest number of RAPELD modules outside of Amazonia is the Atlantic Forest.

Fig. 22.2 Location of RAPELD sites throughout the different biomes in Brazil. (IBGE 2019)



22.4 Integrating Research: The Brazilian Program for Biodiversity Research (PPBio)

Brazil hosted the United Nations Conference on Environment and Development in 1992, in Rio de Janeiro, the so-called RIO-92. One of the most important documents generated during RIO-92 was the Convention on Biological Diversity (CBD). Although Brazil was a signatory, Brazil implemented the National Biodiversity Policy in line with the CBD only 10 years later, with the general objective of “promoting in an integrated way, conservation of biodiversity and sustainable use of its components, with the fair and equitable sharing of the benefits derived from the use of genetic resources, components of genetic heritage and traditional knowledge associated with such resources” (Decree No. 4.339, 22 August 2002, *Diário Oficial da União*). However, biodiversity research was generally conducted as isolated surveys which were not converted into chains of knowledge production, nor was the knowledge generated shared with the different sectors of society or other researchers.

In 2004, to align biodiversity research with the National Biodiversity Policy, after several meetings with researchers and biodiversity stakeholders, the then Ministry of Science and Technology created the Brazilian Program for Biodiversity Research, the PPBio (Ordinance 268 of June 18, 2004, MCT, *Diário Oficial da União*) (Pezzini et al. 2012). The objectives of PPBio were to support, maintain, and expand the inventory networks and biological collections of Brazil; support research in thematic areas; disseminate the results for different purposes, such as environmental management and education; and develop strategic actions to implement biodiversity-research policies, addressing the issues raised by the CDB (Overbeck et al. 2018). PPBio was based on a strategy of creation of regional hubs that attended less-favored regions in terms of training of human resources and that had great biodiversity potential (Baccaro et al. 2008). Thus, the first research networks were created in the Amazon and in the Brazilian semiarid region.

In a relatively short time, the PPBio obtained consistent results, in large part due to use of RAPELD as an integrative methodology, which led to further integration of information on different biotic and abiotic factors (Baccaro et al. 2008), such as vertebrates and invertebrates (Pereira et al. 2019; Graça et al. 2015), topography (Norris et al. 2014), distance to the water table (Schiatti et al. 2014), soil bacteria and fungi (Braga-Neto et al. 2008), and soil chemical elements (Moura et al. 2015).

PPBio was expanded in 2012 by seeking the formation of new research networks and expanding its research area to include the other Brazilian biomes. Today, it is the largest biodiversity network in Brazil encompassing more than 600 researchers in 90 institutions (Fernandes et al. 2017). Two networks were established in the Atlantic Forest biome, BioM.A. and PPBioMA. This biome suffers from degradation throughout its distribution, with only about 28% of remaining forest remnants and still conserving one of the largest samples of biodiversity on the planet (Rezende et al. 2018), which led the Atlantic Forest to be indicated as one of the 34 world

biodiversity hotspots (Myers et al. 2000). Integration within the networks took place in different ways. The first network (BioM.A.) had been operating for about 20 years in the Serra dos Órgãos region (within the PELD Mosaico da Mata Atlântica Central Fluminense), with monitoring in permanent plots (e.g., Vieira et al. 2018; Brigatti et al. 2016), and was structured in themes (inventories, collections, research) covering three other sites (Guaribas Biological Reserve, PB; Pratigi Environmental Protect Area, BA; and Serra do Tabuleiro State Park, SC) (Fig. 22.1). The second network was established as an expansion of PPBio to the Atlantic Forest with distinct projects in the regional hubs (Northeast, Southeast, and South regions) and with articulation through an executive hub, with the use of the RAPELD methodology in each sampling site of this network, in order to facilitate the integration of data in different regions.

The first RAPELD modules in the Atlantic Forest were installed in the Una Biological Reserve in the State of Bahia and in the Ilha Grande State Park in the State of Rio de Janeiro, prior to the official start of the program in the Atlantic Forest biome. Subsequently, with the formation of the PPBioMA network, there was an expansion of RAPELD modules to other areas of the biome. Today, there are more than 21 sites with RAPELD modules covering coastal sand dunes, semideciduous seasonal forest, dense rainforest, mixed rainforest, and high-altitude fields (Table 22.2 and Fig. 22.1). Twenty-two RAPELD modules are also being used to monitor the environmental impact along the Doce River in the states of Minas Gerais and Espírito Santo, caused by the world's largest mine-waste-dam rupture environmental disaster (IBAMA 2017).

The accumulated knowledge from those years has already generated several papers within the network (e.g., Ferreguetti et al. 2018; Oliveira et al. 2019; Tromboni et al. 2018; Figueiredo et al. 2017), among the networks (e.g., Fernandes et al. 2017; Overbeck et al. 2018), data papers with other partners (e.g., Ramos et al. 2019), and dissemination materials, such as field guides and catalogs (e.g., Santos et al. 2017). While the scientific papers mainly reach the scientific community, the field guides are fundamental to unveil Brazilian biodiversity, unknown to most Brazilian citizens and local stakeholders.

Nevertheless, integration of a research network goes beyond sample sites with standardized methodology; internalization is necessary to ensure the expansion of knowledge of biodiversity and its use in multidisciplinary knowledge-production chains. This has taken place via the training of researchers, students, technicians, environmental analysts, and the public in general in several regions throughout the Atlantic Forest (Marques et al. 2016). PPBioMA has trained more than 530 people in technical and scientific courses, such as survey and monitoring of biodiversity, taxonomy of Atlantic Forest tree species, scientific photography, environmental legislation, scientific writing and data analysis, functional diversity, ecological networks, and data management.

Freely available data is necessary to ensure integration among researchers and demands, as well as to help decision-makers and managers in relation to public policies, effectively making the research results tools for conservation. The information

Table 22.2 Location of RAPELD modules in the Atlantic Forest. The main institution corresponds to the one that coordinated the project in one of the three hubs (NE, northeast; SE, southeast; and S, south) of the PPBioMA network

Acronym	Full name	Main institution	Hub/state	Ecosystem
PEDI	Parque Estadual Dois Irmãos	Universidade Federal Rural de Pernambuco	NE/Pernambuco	Atlantic Forest
PNSI	Parque Nacional Serra de Itabaiana	Universidade Federal de Sergipe	NE/Sergipe	Atlantic Forest and Caatinga
RBV	Reserva Biológica Una	Universidade Estadual de Santa Cruz	NE/Bahia	Atlantic Forest
RBS	Reserva Biológica Sooretama	Universidade Federal do Espírito Santo	SE/Espírito Santo	Coastal plain forest
RNV	Reserva Natural Vale	Universidade do Estado do Rio de Janeiro	SE/Espírito Santo	Coastal plain forest
PEMF	Parque Estadual Mata das Flores	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Atlantic Forest
PEPCV	Parque Estadual Paulo César Vinha	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Restinga, coastal lagoons
APAS	Área de Proteção Ambiental de Setiba	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Restinga, coastal plain
PEPA	Parque Estadual Pedra Azul	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Atlantic Forest
PEFG	Parque Estadual Forno Grande	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Atlantic Forest
RPPNAB	Reserva Particular do Patrimônio Natural Águia Branca	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Atlantic Forest
APACB	Área de Proteção Ambiental Conceição da Barra	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Restinga, coastal plain
RBAR	Reserva Biológica Augusto Ruschi	Instituto Nacional da Mata Atlântica	SE/Espírito Santo	Atlantic Forest
PEI	Parque Estadual Itaúnas	Instituto Estadual do Meio Ambiente	SE/Espírito Santo	Restinga, coastal plain
EEEG	Estação Ecológica Estadual Guaxindiba	Universidade Estadual do Norte Fluminense	SE/Rio de Janeiro	Coastal plain forest
RBT	Reserva Biológica do Tingüá	Jardim Botânico do Rio de Janeiro	SE/Rio de Janeiro	Atlantic Forest
PEIG	Parque Estadual da Ilha Grande	Universidade do Estado do Rio de Janeiro	SE/Rio de Janeiro	Atlantic Forest, restinga
RNRC	Reserva Natural do Rio Cachoeira	Universidade Federal do Paraná	S/Paraná	Atlantic Forest
RG	Rio Guaraguaçu	Universidade Federal do Paraná	S/Paraná	Coastal plain

(continued)

Table 22.2 (continued)

Acronym	Full name	Main institution	Hub/state	Ecosystem
PEA	Parque Estadual Acaraí	Universidade Regional de Joinville	S/Santa Catarina	Restinga
PNSJ	Parque Nacional São Joaquim	Universidade Federal de Santa Catarina	S/Santa Catarina	Araucaria forest, cloud forest, altitude fields

available on biotic and abiotic aspects, as well as the logistics of the research sites, make the research sites attractive, increasing the integration among researchers (Magnusson et al. 2013). Furthermore, the relevance of data and metadata availability in network projects is the integration of research, specially in times of budget cuts. PPBio has a data policy (MCT 2009) to ensure open access to robust and persistent data, and these have been made available on the DataOne platform (<https://www.dataone.org/>) and the Information System on Brazilian Biodiversity – SiBBR (<http://www.sibbr.gov.br/>).

22.5 Integrating Research and Biodiversity Conservation

Prioritization of new areas for protection is often undertaken based on a combination of field biological data, current and/or predicted patterns of forest loss, socio-economic factors, infrastructural and institutional capacity issues, and politics, because not all sites are or can be conserved (e.g., private areas, areas used for expansion of agriculture or pasture) (MMA 2007). That means that scientists need to provide the best evidence they can to maintain at least some areas being developed under criteria that establish conservation priorities.

Within this perspective, long-term studies in Brazil, especially those related to PELD, RAPELD, and PPBio, offer an integrated and multiscale approach based on a combination of field data, current and/or predicted patterns of forest loss, and socioeconomic factors, as well as involving actors at local to national levels, infrastructural and institutional capacity issues, and politics. Almost all Brazilian LTER sites and PPBio have projects dealing with environmental education within different ecosystems (Barbosa et al. 2004). However, PELD and RAPELD sites are still mostly concentrated in the south and southeast of the Atlantic Forest and should be expanded to the Northeast (Fig. 22.1). Furthermore, there is no overlap between Atlantic Forest PELD sites and PPBio sites with the standardized RAPELD infrastructure, except for a small overlap in the Lagamar PELD where there is one site with a RAPELD module (Fig. 22.1). The standardized methodology is a need that the PELD has not yet been able to incorporate in its sites, and RAPELD has shown its suitability for integrating research in and among sites, as well as with other initiatives (e.g., RAINFOR, ATDN). Standardized methods must also be expanded to studies developed in marine environments, and RAPELD could be the model for this.

Political commitments and policy instruments to halt biodiversity loss require robust data and a diverse indicator set to monitor and report on biodiversity trends and gaps in data availability, and narrowly based indicator sets are significant information barriers to fulfilling these needs (Geijzendorffer et al. 2016). Brazil will likely fail to reach the National Targets for Biodiversity 2011–2020, and it will be difficult to fulfill the restoration target of the Brazilian Nationally Determined Contribution (NDC) and to advance with the sustainable development goals, especially due underfunding (Fernandes et al. 2017). Therefore, scarce resources have to be applied strategically.

Financial constraints represent an important challenge that needs to be addressed. The investment needed for long-term studies must be constant in terms of flux, and a relatively low amount has been destined for all types of research each year (less than 1% from the Brazilian GDP). The low-investment policies will be harmful not only to science and technology (Angelo 2016) but also to sustainable development and nature conservation (Overbeck et al. 2018). PELD and PPBio represent strategic actions that need to be financed if Brazil is to meet its international obligations and provide the data necessary to provide economic and environmental security for its citizens.

Applying scientific knowledge to biodiversity-conservation practice and decision-making is a challenge around the globe (Pullin et al. 2004; Kueffer et al. 2012), and the situation is no different regarding research in the Atlantic Forest. Often, the scale at which research is done is different from the scale of interest to decision-makers (Bacellar et al. 2020). That is why the use of a standardized method that considers multiple scales by PELD and PPBio may contribute to filling the research-implementation gap.

PELD and PPBio are complementary network programs of great relevance for the knowledge and conservation of Brazilian biodiversity, and their integration needs to be strengthened in the Atlantic Forest.

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