BIOLOGICAL DYNAMICS OF FOREST FRAGMENTATION PROJECT - BDFFP

ANNUAL REPORT - 2021

Dr. Thomas E. Lovejoy, BDFFP Patron (08/22/1941 - 12/25/2021).

Manaus, March 2022

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- NOTE OF CONDOLENCE

On 25th Dec 21 – Christmas day

Dearest,

Today, I just wanted to wish you a great Christmas and a prosperous New Year. Sincere wishes from me and from everyone at BDFFP.
Unfortunately, I regret to inform you that at this time of Christmas celebrations, our dear Tom Lovejoy passed away bravely fighting for his life. We have all lost a great person who dedicated himself to the conservation of this planet, especially the Amazon rainforests. He always believed that it should be possible to live with proper development without destroying our only home. The illumination brought by science, facts, statistics, research, and the scientific results of generations of researchers and scholars gave Tom an anchor for his enthusiasm. By his daily dedication, he became one of the most outstanding researchers in his field of knowledge. He influenced generations of scholars, decision-makers, and the general public. He expanded scientific knowledge and helped create or change public policies focused on protecting nature, providing the opportunity for the best rational use of resources. He was always thinking about future generations and the future of the planet.
As he was affectionately called by those close to him, Tom raised a beautiful family, developed a passion for Brazil, and engaged a generation of conservationists. He trained many people in the art of understanding the natural world and the art of understanding human nature or how humans should behave to achieve a better world. Tom made the world better and left a great legacy.
He certainly left a complex mission for all his admirers – we must continue his work to create a better world, for all species, for all-natural systems. We will miss him.
Among his legacy is the great initiative of the BDFFP – a bold and complex scientific program that has just turned 41 years old. The dedication of a large group of professionals associated with BDFFP helped to advise almost 300 master's and doctoral students and more than 1500 assistants in research. Hundreds of students attended field courses, and dozens of field assistants learned their trade and shared their knowledge with others. BDFFP has cataloged thousands of species and recorded numerous scientific results that clarify the consequences of forest fragmentation or tropical forest dynamics. All of which influence research and researchers worldwide. Our BDFFP group adds new scientific articles to the existing 830 high-impact articles each month. We train students and researchers to deal with significant issues in the world.
Everyone who participated in this tremendous scientific adventure in the heart of the Amazon owes much to Tom. On behalf of all, I would like to express that we dedicate positive thoughts to Tom at this moment. We will miss him eternally, and we will be eternally grateful. We recognize his restrained and polite voice and his calm, peaceful, extraordinary, and visionary look at the world.

Long live ("*Viva*") Tom Lovejoy!

José Luís Camargo, on behalf of the BDFFP team.

BDFFP – WHO ARE WE?

Created in 1979, the Biological Dynamics of Forest Fragments Project, known as BDFFP, is a long-term project that aims to understand the consequences caused by the process of forest fragmentation in the remaining *terra firme* forests of the Central Amazon. To this end, we monitor biodiversity and study forest fragments, always compared to adjacent continuous forests. We have observed over time how forest fragmentation has affected natural systems. Thus, for more than four decades, we have collected and processed information that places our study areas as the best known in the entire Amazon.

The study area is an Area of Relevant Ecological Interest (ARIE), one of the Brazilian National System of Conservation Units (SNUC) categories.
The ARIE was created in 1985 and received the name PDBFF. Today, it is co-managed by ICMBio and INPA/BDFFP and has 27 reserves spread over 1,000 km^2. Of this total, 11 reserves of 1, 10, and 100 ha became forest fragments surrounded by pastures and then by secondary forests. Another 13 reserves are areas equivalent in size to the forest fragments (same size classes) but within the continuous forest. Another three 1000 ha reserves were created and are considered control areas.

The BDPFF Research Group is part of the Coordination of Environmental Dynamics of the Amazon – CODAM, one of INPA's four research coordination.

The ALFA (Association for the Survey of the Amazon Forest), a non-profit civil association, was created in 1986 to support the administrative, legal, and logistical activities of the BDFFP.

More recently, ALFA formalized an agreement with ABC (Amazon Biodiversity Center), a U.S. association that raises funds and provides financial and technical support to ALFA. Through donations via ABC, ALFA manages personnel, administration, logistics, infrastructure, and general maintenance of the BDFFP. Funds for research and training are requested by associated scientists and come from Brazilian funding agencies (CNPq, CAPES, and FAPEAM) and, to a lesser extent, from foreign institutions (such as NSF; Sacharuna Foundation; Frohing Foundation).

OUR MISSION

The BDFFP's mission is to:

1) Determine the ecological consequences of deforestation and tropical forest fragmentation on fauna, flora, and ecosystem interactions and processes in the Amazon.

2) Train future professionals to work in different fields of knowledge related or not to forest fragmentation and

3) Transfer the information generated to different sectors of society to favor the conservation and rational use of forest resources.

Impact of COVID - 2019 on BDFFP 2021 activities

Since mid-March 2020, the BDFFP has paralyzed its field activities due to the COVID-19 pandemic, and everyone has been working from home. At the beginning of 2021, with the second wave of Covid in Manaus, the situation became even more severe and dramatic. Both INPA and ICMBio, for reasons of safety and public health, did not authorize entry into the reserves, and the suspension of our face-to-face activities continued. Unfortunately, thousands of people lost their lives to Covid-19 in Manaus; some were acquaintances or collaborators of the BDFFP. We lost the botanist Paulo Apóstolo Lima Assunção, who worked on numerous projects, especially in identifying species of the Lecythidaceae family. Marcelo Menim, an expert in herpetology and teacher at the Federal University of Amazonas, a collaborator of many editions of the field course Fragmentation of the Amazon Landscape, has also died of Covid-19. The year 2020 had already been tricky for everyone, but the second wave of Covid-19 arrived stronger and made 2021, especially the first semester, a terrible and traumatic year for many.

Only in September 2021, with due care, were we able to resume fieldwork. But many students and researchers preferred not to take any chances and continued with their activities suspended. Most of the planned activities for 2020 stayed compromised. Perhaps the most impacting was the break in the historical series of some monitoring we carried out, including the completion of the tree census, the continuation of the census of lianas and palm trees, and the annual census of secondary forests. The re-isolation of the reserves initially planned to occur in the summer of 2020 had to be postponed again in 2021. Re-isolation refers to the removal of secondary vegetation every five years within 100 m around the forest fragments to keep them isolated from the surrounding vegetation. Also quite serious was the interruption of field collections of research projects by students and researchers or even the beginning of students' fieldwork, resulting in a significant delay in everyone's schedule and the flow of new students.

BDFFP TEAM

Employees	Position	
José Luís Campana Camargo	Executive Secretary	
Ary Jorge Correa Ferreira	Manager	
Maria Rosely Cavalcante Hipólito	Personnel Administration	
Cleucilene da Silva Nery	Financial Administration	
Ivany Pereira Pinto	Administrative Assistant	
Ana Cristina Segalin de Andrade	Research Assistant	
Manoela Borges	Research Assistant	
Luiz Raimundo de Queiroz	Driver	
Breno Cavalcante Hipólito	Driver/Mechanic	
João Batista da Silva	Field Assistant	
Osmaildo Ferreira da Silva	Field Assistant	
Sérgio Costa da Silva	Field Assistant	
José Adaílton Correia da Silva	Field Assistant	
Alexandre Oliveira dos Santos	Field Assistant	
Ronaldo Costa dos Santos	Field Assistant	up to Oct. 21

RESEARCHERS OF THE BDFFP GROUP

Name	Institution
Alberto Vicentini	INPA
Alexandre Adalardo de Oliveira	U of São Paulo
Ana Cristina Segalin de Andrade	BDFFP/INPA
Arildo de Souza Dias	U of Goethe Pos-doc
Carlos Alberto Nobre Quesada	INPA
Christoph Friedrich Johannes Meyer	U of Salford
Cintia Cornelius Frische	U Federal of Amazonas
Emilio Miguel Bruna III	U of Florida
Fabricio Beggiato Baccaro	U Federal of Amazonas

Garry Bruce Williamson	State University of Lousiana
Gonçalo Nuno Côrte-Real Ferraz de Oliveira	U Federal of Rio Grande do Sul
Gustavo Quevedo Romero	Unicamp
Heraldo Luis de Vasconcelos	U Federal of Uberlândia
Isolde Dorothea Kossmann Ferraz	INPA
Jansen Alfredo Sampaio Zuanon	INPA
Jorge Luiz Nessimian	U Federal of Rio de Janeiro
José Luís Campana Camargo	BDFFP/INPA
Laynara Figueiredo Lugli	INPA - pos-doc AFEX
Marcelo Gordo	U Federal of Amazonas
Marina Anciães	INPA
Mario Eric Cohn Haft	INPA
Mário Henrique Terra Araujo	INPA - PPG Botany
Maristerra Rodrigues Lemes	INPA
Paulo Enrique Cardoso Peixoto	U Federal de Minas Gerais
Paulo Estefano Dineli Bobrowiec	INPA - pos-doc Ecology
Philip C Stouffer	State University of Lousiana
Rafael Leandro de Assis	Norwegian Natural History Museum
Renato Cintra	INPA
Rita de Cássia Guimarães Mesquita	INPA
Robyn Jeanette Burnham	U of Michigan
Susan Laurance	James Cook University
Tânia Margarete Sanaiotti	INPA
Thomas Lovejoy	George Mason University
Tony Vizcarra Bentos	INPA - pos-doc PCI
William Frederick Laurance	James Cook University
Wilson Roberto Spironello	INPA

STUDENTS ASSOCIATED WITH BDFFP AND THEIR PROJECTS

In 2020-2021, with the suspension or delay in the selection of new students in several Graduate programs, there was a drop in the entry of new students. In general, we receive around 40-45 graduate students per year. In 2021, only two students entered (see table below). However, by the end of 2021, we had in the group 20 students: 16 Ph.D. students, three masters' students, and one undergraduate student (see table below). Another three doctoral students completed their studies in 2021. Giulliana Appel (T&D 283); Vitek Jurinec (T&D 284) and Marcel Caritás Vaz (T&D 285). More information on the new Ph. D.s and other professionals who graduated from the BDFFP since its creation is registered in the Technical Series of Thesis and Dissertations and is part of the Supplementary Material of this report.

Students graduated in 2021:

	Name	Thesis title	Institution
Ph.D.	Giulliana Appel Adviser: Dr. Paulo Bobrowiec	Temporal activity of aerial insectivorous bats in response to lunar luminosity, climatic conditions, and prey-predator interaction in fragmented environments in Central Amazon	INPA
Ph.D.	Vitek Jirinec Adviser: Dr. Philip Stouffer	Population and community dynamics of birds in central Amazon: Examining the past and predicting the future	LSU
Ph.D.	Marcel Caritás Vaz Adviser: Dr. Nathan Kraft	Trait-mediated coexistence in a hyperdiverse tropical forest or why are there so many kinds of trees in the Central Amazon?	UCLA

Current students (2015-2020) and new students (2021):

Only two new students, one for a master's degree and one for a Ph.D. degree, started their activities in 2021.

Below you can see the record of each student, level (Ph.D., Master's, and Undergraduate), home institutions, research projects, and advisors.

Year	Degree	Name	Institution	Thesis/dissertation title	Adviser
2015-Current	Ph.D.	Patrícia de Oliveira Santos	State University of Londrina	Análise filogenética de Burseraceae e Cecidomyiidae: uma evidência de coevolução?	José Eduardo Lahoz da Silva Ribeiro
2016-Current	Ph.D.	Gyovanni Ribeiro	INPA	Litter Production, Microbial Communities and Enzymatic Processes for Decomposing Organic Matter from a Fertilized Primary Forest in the Central Brazilian Amazon	Carlos Alberto Quesada
2017-Current	Ph.D.	Hellen Cunha	INPA	Respiração e Eficiência no Uso do Carbono em uma Floresta Madura na Amazônia Central submetida à adição de fósforo e nitrogênio.	Carlos Alberto Quesada
2017-Current	Ph.D.	Priscila Costa	INPA	*Eschweilera coriacea* (Lecythidaceae): um complexo de espécies ou uma espécie complexa?	AlbertoVicentini /Christopher Dick
2017-Current	Ph.D.	Tamara Farrell Milton	University of Michigan	Hyperdominance, habitat and demography of Lecythidaceae in Brazilian Amazon	Christopher Dick/Robyn Burnham
2017-Current	Ph.D.	Sheila Trierveiler de Souza	INPA	Limitações nutricionais em processos biológicos mediados pela fauna edáfica em florestas da Amazônia Central	Carlos Alberto Quesada

2017-Current	Bachelor	Nicolli Bruna Cabello	Federal University of São Carlos	Análise do formato de folhas e troncos de Lecythidaceae como subsídio para descriminação de espécies na Amazônia Central	Fiorella Mazine/Alberto Vicentini/Christopher Dick
2018-Current	Ph.D.	Claudio Rabelo dos Santos Neto	INPA	Resposta ecológica, funcional e comportamental de assembléias de formigas (Hymenoptera: Formicidae) submetidas à adição de nutrientes no solo em uma floresta na Amazônia Central	Fabrício Baccaro
2019 - Current	Ph.D.	Patricia Rodrigues	LSU	Food scarcity as a mechanism for the decline of terrestrial understory insectivores in forest fragments	Dr. Phillip Stouffer
2019-Current	Ph.D.	Caroline da Cruz Vasconcelos	INPA	Taxonomia, Filogenia e Biogeografia de *Ecclinusa* Mart. (Sapotaceae, Chrysophylloideae)	Mário H. Terra-Araujo /José Luís Camargo & Isolde Ferraz
2019-Current	Ph.D.	Paulo Ricardo Rodrigues Piovesan	INPA	Efeito da fragmentação florestal em lianas do gênero Machaerium Pers. (Fabaceae) na Amazônia Central	Isolde Ferraz/Robyn Burnham/José Luís Camargo
2019 - Current	Ph.D.	Ana Cristina Utta	INPA	Effects of fragmented landscape on diversity patterns and vertical stratification of ants (Hymenoptera: Formicidae) in Brazilian Amazon forests	Dr. Fabricio Baccaro
2019 - Current	Ph.D.	Caio Augusto Batista	INPA	Effect of forest fragmentation on an assembly of species of the Araceae Juss. family in the Central Amazon	Dr. José Luis Camargo
2019 - Current	Ph.D.	Bárbara Brum	INPA	Effects of soil nutritional limitation on dynamics, growth and, tree biomass in a mature forest in central Amazonia	Dr. Carlos Alberto Quesada

2019 - Current	Ph.D.	Tovah Siegel	George Mason University	Assessing the impacts of forest disturbance on ecological interactions in the Brazilian Amazon	Dr. Thomas Lovejoy / Dr. David Luther
2020 - Current	Ph.D.	Peterson Campos	INPA	The effects of climate change on forest dynamics: a study case in Central Amazon	Dr. Alberto Vicentini
2020 - Current	M.Phil.	Milla Freitas	INPA	The effect of forest fragmentation on a palm trees assembly in Central Amazon	Dr. José Luís Camargo
2020 - Current	M.Phil.	Paulo Rodrigues de Melo Neto	INPA	Dynamics of a palm trees assembly of and their relationship with extreme climatic events in upland forest in Central Amazon	Dr. José Luís Camargo
2021- Current	M.Phil.	Gabriela Mendes	INPA	Systematics of *Ilyobius Enderlein*, 1910 (Megaloptera: Sialidae)	Dr. Neusa Hamada
2021- Current	Ph.D.	Raffaello Di Ponzio	UFMG	Soil fertility regulates mutualism between plants with extrafloral nectaries and ants	Dr. Paulo Enrique Peixoto

SCIENTIFIC CONTRIBUTIONS - 2021

Here we present the most significant scientific contributions produced and published by the PDBFF in 2021. Information is organized by central subjects: (1) Climate change – global scale; (2) Climate change and the effect of forest fragmentation – local scale; (3) Importance of secondary forests; (4) Natural history and biological diversity; (5) Inventories, monitoring, historical series, and new species; (6) Technical approaches to inventory and detect species; (7) New species & new occurrences and (8) Scientific production in networks.

We put the number of the Technical Series (ST – XXX) corresponding to the information presented in the text below. Soon after, we offer the Technical Series of publications, but this report only includes articles published in 2021. The complete **Technical Series** of publications is part of the supplementary materials.

(1) Climate change - global scale

Based on a series of data with birds traditionally collected at the BDFFP since 1980. Vitek Jirinec, as part of his doctorate (2021, LSU), found that even in intact and continuous forests, far from sources of anthropic interference, recorded morphological changes in birds. On average, there was a reduction in body mass of 77 species, while 1/3 of the species increased in wing length, leading to a decrease in the mass-wing ratio for 69% of the specie. Seasonal rainfall patterns rather than temperature may explain the changes in morphology. There appears to be a consistent response across species to increase resource savings. **(Jirinec et al. 2021 – ST 822)**. The article received broad media coverage.

In many research agendas, seasonality is overlooked. **Rutt et al. 2021 (ST 799)** show the importance of considering seasonality to define nature conservation policies. When analyzing data collected during his Ph.D. (2020, LSU), Cameron Rutt recorded the dynamics and composition of mixed flocks of birds in continuous forests, fragmented forests, and secondary forests. He concluded that seasonality plays an essential role in such flocks' dynamics. During the summer (driest season), more species become part of the flocks, probably governed by the nesting period and the scarcity of resources (considering arthropods). Seasonality interfered in the dynamics of the mixed group of birds in all environments. Still, the differences were more evident in forest fragments and secondary forests, concluding that seasonality influences the conservation value of settings modified by anthropic actions, especially in unstable weather conditions.

With weather sensors installed on birds and in the environment, it was possible to record foraging patterns of insectivorous birds on the forest floor **(Jirinec et al. 2021 – ST 825)**, another study derived from the doctoral work of Vitek

Jirinec (2021, LSU). In general, the thermal niche is species-specific, but birds prefer environments below or at the maximum limit of their body heat. In any case, they preferred darker environments over those that received more light, such as clearings. Studied species avoided microclimatic conditions that are increasingly common due to climate change, perhaps thus giving clues about the enigmatic decline of such species, even in environments of continuous and preserved forests **(see Stouffer et al. 2020 - ST 802).**

Isabela Silva's master's degree (2015, INPA) creatively addressed another research front **(Silva et al. 2021 - ST 812)** by simulating an increase in temperature according to global climate change scenarios considered by the IPCC. The intention was to understand how changes in the thermal regime would affect seed bank germination in secondary tropical forests. The results show that an increase of up to 5 °C in secondary forest environments did not affect the thermal sensitivity of the species, but 10 °C would cause significant disturbances. Such a situation could lead to a change in floristic composition, transforming regenerating forests into fields with a predominance of shrubs and herbs, leading in the future to a savannization of the Amazon biome. The study reminds us that there may be greater thermal sensitivity for tree species from mature forests.

Scott et al. 2021 (ST 824) evaluated the survival, growth, and reproduction patterns of *Heliconia acuminata* under forest fragmentation and climatic fluctuations over a 10-year time series of demographic monitoring of the species. The populations studied reacted to climatic oscillations up to 36 months after the event. Higher drought intensities (SPEI index) recorded in previous years reduced plant survival. Prolonged dry periods, which reached the wettest period (8-11 months), increased plant growth and flowering and occurred more intensively after two consecutive drier seasons. In addition to evidence of demographic changes and changes in the plant's reproductive cycle associated with climate fluctuations, the study highlights the importance of relying on historical data sets. With just a few years of monitoring, it would not be possible to analyze or interpret such results.

(2) Climate change and the effect of forest fragmentation – local scale

Following the mission of understanding the consequences caused by the forest fragmentation process, some studies, even after four decades of the creation of forest fragments, continue to reaffirm how the edge effect still represents an essential vector of transformation for forest remnants.

This time, through Lidar (Light Detection and Ranging), **(Maeda et al. 2022; ST 833)** evaluated how the forest edge effect can affect the structural dynamics of the forest. Results showed that the closer to the edge, the lower the structural

diversity of the forest. In contrast, the understory near the edges showed a higher leaf density than the canopy, inverting the pattern found in forests without significant disturbances. Using parameters such as the Plant Area Index (PAI) without considering the structuring of the arboreal strata can lead to misinterpretations of such effects.

Still related to the structural modifications of the forest, the edge effect also modifies the leaf phenology of the trees **(Nunes et al. 2022; ST 832)**, especially when the temperature can reach the height of summer (dry season) at 35 °C. Microclimatic data showed that these high temperatures might be more relentless in forest fragments. According to IPCC reports, they may be more common and more frequent in Central Amazon in the coming decades. Every two weeks, between the rainy and dry seasons, Nunes and collaborators collected data on forest structure in transects that started at the forest edges and extended to the most preserved interior of the forest. Along the transect, a more significant loss of material from the large canopy trees was detected, mainly at the end of the dry season.

Meanwhile, the dynamics of the understory plants followed an opposite trajectory. They showed greater intensity of emergence of new leaves in the same period, but mainly in the forest's interior. The phenomenon occurs at forest edges, but the understory dynamics do not depend on the canopy dynamics.

Albiero-Júnior et al. 2021 (ST – 818), based on dendrological techniques to measure growth patterns on trees, revealed that *Theobroma sylvestre* trees located along edges registered a higher growth rate compared with trees of the same species and age located within the forest. *T. sylvestre* is a common short tree species present in the forest understory. In contrast, taller trees (canopy individuals) growing near edges, such as *Scleronema micranthum,* stopped growing for at least ten years after the creation of the forest fragments, and they failed to accumulate biomass by almost 20% during this period **(Albiero-Júnior et al. 2019 - ST 750)**. Both studies were derived from the doctoral thesis of Alci Albiero-Júnior (2019, Esalq – USP). While the canopy trees at the edges stopped their growth, the understory trees took the opportunity to grow. At forest edges, there may be a more significant entry of light associated with the structural changes of the canopy.

Results from these studies, even using data collected by different protocols, produce evidence that the forest structure and dynamics vary enormously between tree strata, especially in fragmented forests. Thus, we can affirm that there are specific dynamics in the different tree strata.

(3) Importance of secondary forests

Converting land use through slash-and-burn techniques in continuous forests leads to a reduction in habitats and an increase in the formation of new forest

fragments and surrounding matrices. Initially, the focus of the BDFFP was only on what had changed in the forest remnants compared to the natural system still preserved and intact in adjacent areas of continuous forests. But, soon after, as we noted the landscape transforming, it was impossible not to miss the dynamics of the abandoned matrices. In the BDFFP, a few years after converting mature forests into pastures, for economic infeasibility, these areas were abandoned as pastures and consequently formed a matrix with secondary forests. Naturally, since the late 1980s and more strongly in the 1990s, studies on forest regeneration began to emerge. One of the long-term studies, *Projeto Pioneiras,* coordinated by Dr. Rita Mesquita (INPA) started and monitored the regeneration of different secondary forests annually.

Initially, we observed only devastation and habitat disturbance in the secondary forests. Naturally, the question was whether these areas would still have some importance or potential for conservation. Recently, we have found more evidence that secondary forests are crucial in improving the conservation of the area.

Regarding birds, we learned this year that within BDFFP, fewer bird species breed in secondary forests (-43%) and 10 ha forest patches (-17%) as compared to undisturbed forests. Both losses are more significant than the decrease associated with the total number of bird species, which is 17% in secondary forests and 10% in forest fragments **(Rutt et al. 2021 – ST 807)**. The authors also confirmed the reproduction of only three species of insectivorous birds that forage on or near the ground in forest fragments and secondary forests. In contrast, nine insectivorous bird species forage on the ground in undisturbed forests. Disturbed forests also had fewer breeding individuals (-35–50%) and, in secondary forests, fewer successful breeding attempts (-24% compared to continuous forests).
Encouragingly, however, some birds are breeding and producing young in disturbed forests, including representatives of almost every guild. That is especially notable for mixed-species flocks and army ant followers: two guilds historically considered vulnerable to anthropogenic disturbance.

Secondary forest regeneration showed a reduction in the probability of extinction of bat lineages over time **(Farneda et al. 2021 – ST 823).** Approximately 30 years of secondary forest regeneration were sufficient for phylogenetic richness to recover to similar levels to that in continuous forests. Temporal changes in α phylogenetic richness were more marked in these environments than in fragmented or continuous forests. Promoting forest succession on degraded lands through a combination of natural and active restoration, ensuring long-term protection of secondary forests, regardless of their age, is critical for conserving the diversity of tropical bats and their associated ecosystem services. Such restoration measures would stimulate the recolonization of distinct bat species in secondary forests, increasing diverse assemblages and ecological functions. Farneda et al. (2021) suggest that forest restoration in degraded tropical areas should be encouraged, and secondary forests protected by law, especially in rural ecosystems with high original forest cover and around protected areas.

In addition to birds and bats, secondary forests facilitate the movement of organisms, mainly arthropods. The surrounding areas of forest fragments covered by regenerating forests support the diversity and composition of regional arthropods **(Aquino et al. 2021 – ST 828)**. The records brought by the arthropod inventories in the different environments studied do not seem to have significant differences in diversity and composition, even though they include species that are typical of specific environments. Recall that the regenerating environments at BDFFP sites circumscribe a region covered mostly by well-preserved forests.

(4) Natural history and biological diversity

It is impossible to know what has changed in a system if we do not know its component species, habitats, and interactions. Our aim is to attract scientific contributions that expand our knowledge of the natural history of organisms, biological diversity, and the natural system.

Even with evidence of the importance of secondary forests, regenerating environments are still not the most attractive homes for some species of aerial insectivorous bats (which hunt insects in flight). A significant interest of the study by Giuliana Appel **(Appel et al. 2021 – ST 813)**, a part of (her?) doctorate (2021 INPA), was to understand the behavior of insectivorous aerial bats under different moonlight intensities. Nocturnal luminosity can shape the behavior of predators and prey. However, the activities of the studied species appeared to be more associated with the structural complexity of forest habitat types than with the intensity of moonlight. Of the nine species studied, six and two species respectively reduced their activities in forest fragments and secondary forests compared to continuous forests.

Among primates, vocalization in encounters with other species helps to understand the behavior of the species involved and the social relationships among them. Tainara Sobroza collected and analyzed detailed information on the vocalizations emitted by two sympatric species. First, *Saguinus bicolor*, a species endemic to the Manaus region and with status as highly threatened because of growth of the city and deforestation in the rural area, and second, *Saguinus midas*, a species with a larger geographic range, including the ARIE PDBFF. Dr. Sobroza experimented with species play-backs during her Ph.D. (2021 INPA). Her studies showed that acoustic displays might be mediating the interaction of species in these areas. Together, these observations suggest behavioral interference, including the competitive displacement of the Collared-tamarin (*S. bicolor*) by the Golden-handed marmoset (*S. midas*), which may have significant consequences for the conservation of the endemic *Saguinus bicolor* **(Sobroza et al. 2021 – ST 811)**. Neither species partition the use of tree strata; what seems to characterize the use of the strata is the seasonality of resources and lower competition **(Sobroza et al. 2021 – ST 817)**.

The continuous forests of the BDFFP are home to one of the most emblematic bird species in the Amazon, the *Corapipo gutturalis*, (white-throated manakin),

which is distinguished by a complex nuptial dance. The males compete among themselves on a stage (generally fallen tree trunks that the birds continuously clean) with an audience of highly selective females, creating a complex display as part of an intricate process of sexual selection. In this study, **(Aramuni et al. 2021 - ST 815)** concluded that the social context of the bird courtship was a strong predictor of variation in the male display within the population. The light intensity in the environment/stages only affected the time spent on the exhibition. In addition, similar displays between males of various ages seem to reflect more competition than cooperation between them.

While many think that bats use only caves for shelter, **Appel et al. (2021 – ST 809)** recorded the occurrence of tents (leaves architecturally manipulated by bats) specifically used as shelter by bats of the species *Uroderma bilobatum, Mesphylla macconnelli*, and *Saccopteryx leptura*. This study revealed for the first time such shelters in the Central Amazon, and they are present in secondary forests, forest fragments, and continuous forests of the ARIE PDBFF. Bats use leaves of *Potalia amara* (Gentianaceae) and the palm *Astrocaryum sciophilum* (Arecaceae) to construct the tents, and even observed bats resting on tangled vines.

Previous data from ants collected in the BDFFP motivated a new study **(Montoya et al. 2021 – ST 820)** that expanded knowledge about fungi that contaminate colonies of other fungi cultivated by ants. The study aimed to pave the way for further studies but created a better understanding of the systematics of these fungi and consequently expand the knowledge about the group's evolutionary history. The authors suggested a new systematic organization and a new species of fungus.

An overview of the diversity of ectoparasites in reptiles and amphibians in the Manaus region, including the ARIE BDFFP, and the relationship of these parasites with infection caused by rickettsiae was the contribution made by another new study **(Dantas-Torres et al. 2021 – ST 827**). The researchers analyzed 385 reptiles (350 lizards, 20 snakes, 12 turtles, three alligators) and 120 amphibians (119 frogs and one blind snake). Ticks of the genus *Amblyomma* (*A. humerale, A. nodosum, A. rotundatum, Amblyomma* spp.) parasitized a total of 35 (10%) lizards, three (25%) turtles, and one (0.8%) frog. *A. nodosum* was recorded for the state of Amazonas for the first time. A rickettsia-infected nymph of *A. humerale* was found in a tegu (*Tupinambis teguixin*), suggesting that this relationship may be more common than one would expect. Amanda Picelli, one of the co-authors of this study, during her doctorate (2020 UFAM), collected part of the data on the ARIE BDFFP.

Ectoparasites were also the subject of an article on research from the BDFFP **(Anjos et al. 2021 – ST 797)**. The authors reported for the first time the occurrence of a yet unidentified species of *Argulus* (Crustacean, Branchiura: Argulidae) that parasitizes tadpoles of *Boana geographica* in Central Amazonia. The recorded infestation was less than 50% and showed no relationship between tadpole size and the ectoparasites.

(5) Inventories, monitoring, historical series, and new species

Data collected in inventories in permanent plots or active search procedures, monitoring of biodiversity, and consequently the creation of historical series make it possible to advance knowledge about the forest system that we study. They also lead to discoveries of new species to science.

Questions that consider the complexity and a more comprehensive look at a temporal or spatial scale allow us to broadly understand natural patterns and cycles. In the BDFFP, there is still the possibility of contrasting information collected in natural environments and environments that have undergone anthropic changes resulting from forest fragmentation.

New technical approaches to inventory and detect species

Researchers working with vertebrates have been adding other techniques for species detection, which can help monitor biodiversity and even expand the scale of inventory and monitoring coverage. Adrià López-Baucells, from his experiences during his doctorate (2018, U of Lisbon), efficiently delved into studies that consider bioacoustics in detecting bats in degraded areas, mainly in the secondary forests of the BDFFP **(López-Baucells 2021 – ST 816)**.

Meanwhile **(Jirinec et al. 2021 – ST 805)** made technological progress in collecting data without causing problems to the organisms studied. He tested adjustable rings for small birds (up to 200 g) as markers; besides being safe for the birds, the technique was also considered efficient.

New species & new occurrences

Adriel Sierra and collaborators made a new inventory of bryophytes in the ARIE PDBFF after 15 years. They concluded that the bryophyte community has been recovering in fragmented environments after 40 years of forest fragment creation, but with a higher turnover in small fragments **(see Sierra et al. al. 2019 - ST 765)**. Charles Zartman (INPA) collected data from the original study as part of his Ph.D. (2004 Duke U.). More recently, Zartman, supervised Adriel Sierra's master's degree (2018 INPA) in which Sierra **(Sierra et al. 2021 – ST 808)** described two new species of bryophytes (*Ceratolejeunea ocirii* and *Ceratolejeunea semicornua*) and documented new records of bryophytes for the state of Amazonas (*Cheilolejeunea savannae, Cololejeunea clavatopapillata, Prionolejeunea galliotii* and Plagiochila *eggersii*) and to Brazil (*Cololejeunea appressa*).

In addition to the tiny organisms described by our collaborators, **Vasconcelos et al. (2021 – ST 806)** published the description of a new tree species, *Chromolocuma brevipedicellata* (Sapotaceae, Chrysophylloideae), which followed the description of another species of Sapotaceae (*Pouteria*

kossmanniae) in the previous year **(see Vasconcelos et al. 2020 – ST 790)**. Both works are part of Carolina Vasconcelos' doctorate (in progress at INPA).

Paulo Gaem, as part of his undergraduate studies, scrutinized the genus *Myrcia* (Myrthaceae) with data originating from inventories carried out in the permanent plots of the BDFFP **(Gaem et al. 2021 – ST 810)**. The authors listed 36 species classified as *Myrcia*, comprising 1/3 of the number of species recorded for the Brazilian Amazon, with 19 of them endemic to this domain. One of them, *M. neospeciosa*, is presented as a new occurrence in the state of Amazonas.

(Gaem et al. 2021 – ST 821) also tested a protocol to delimit sympatric species based on a multi-evidence approach. In addition to morphotyping, the protocol considers the collection of spectroscopic data (NIR) and morphometric data of leaf contours. Thus, of the 38 species studied from the *Myrcia* complex (Myrthaceae), the authors delimitated the species with 81-99% accuracy. Thirteen species delimited in the study belonged to four complexes, with each treated as a single species in the current systematics of the genus. Surveys based only on vegetative traits are essential. Still, in cases like these, it is necessary to go further and complement the studies with fertile material to help in delimitation and potential taxonomic descriptions of new species.

The still incomplete inventory of lianas with over 300 species documented by 2021, described a new species of leguminous liana **(Camargo et al. 2021 – ST 814)**, for the ARIE BDFFP, *Deguelia tenuiflora* (Leguminosae, Papilionoideae). This species is among the ten most abundant liana species at BDFFP but is yet unknown beyond the area.

(Larson et al. 2021 – ST 819) made a significant contribution to expanding the evolutionary knowledge of plants, investigating the potential for mixing (admixture), a mechanism by which species can acquire new alleles that contribute to originating and maintaining the diversity of tropical plants. The study relied on the accumulated knowledge of the genus *Eschweilera* (Parvifolia clade, Lecythidaceae), which includes species with large and well-distributed populations in the ARIE PDBFF and the Amazon forests in general. The results showed strong evidence that this mechanism occurs among ecologically dominant species, such as *E. coriacea, E. wachenheimii,* and *E. parviflora.* Among other lineages, the authors did not find such evidence.
The study shows that hybridization may play a role in the evolution of the most widespread and ecologically variable Amazonian tree species. Although mixing (admixture) occurs among some *Eschweilera* species, the mechanism has not led to widespread erosion of most species' genetic or morphological identities. Therefore, current species circumscriptions based on morphology provide a valuable characterization of the clade's lineage diversity.

Finally, in September, we launched the book Guide to Amazonian Fruits, Seeds, and Seedlings **(2019 Editora INPA, see ST – 700)**, a revised and expanded publication of the Jabuti award-winning book *Guia de Propágulos e Plântulas da Amazônia*. The new book is richly illustrated and contains detailed information

on the natural history of 75 tree species in the Amazon. All botanical material studied was collected at ARIE PDBFF, Adolpho Ducke Forest Reserve, and INPA's c*ampi*. The book can be purchased free of charge through the INPA repository (https://repositorio.inpa.gov.br/handle/1/36025) or printed at the INPA Press store. The study finished in 2019, but the book's delivery occurred during the suspension of INPA's activities due to the Covid-19 pandemic. Authors and the general public were only able to access the book at the end of the first semester of 2021, and in respect of the limitations of face-to-face activities, the book's launch was via an online format and is accessible at https://www.youtube.com/watch?v=E_olw8hk3-E

(6) Scientific production in networks

Data collected in the permanent plots of the BDFFP are part of a database compiled by networks such as ForestGeo, the most comprehensive network of permanent plots in the world, which in addition to tropical forests, also includes permanent plots of boreal and temperate forests. The article **(Davies et al. 2021 – ST 803)** presents ForestGeo. Another article associated with the BDFFP, produced with data from networks, ForestPlots **(ForestPlots.net; Blundo et al. 2021 – ST 821)**, deals precisely with the importance of such networks for a better understanding of the world's tropical forests. Large patterns associated with global climate change can be recorded and understood more efficiently. Ultimately, data from permanent plots in networks provide time-series information that can be long-lived and spatially distributed across forests worldwide. Similarly, **Lembrechts et al. (2022 – ST 829)** used network data to release maps with information on soil temperature at a global scale.

TECHNICAL SERIES OF PUBLICATIONS (TS) - 2021

The 32 articles listed below were published or accepted for publication in high-impact scientific journals in 2021. The number preceeding each reference corresponds to the number granted in the publication shortly after the journal's acceptance. The complete list of publications composes the Technical Series (TS) of Publications of the BDFFP (see supplementary material). Most of the articles published in 2021 came from the results gathered from students' process of completing their dissertations and thesis.

797. **Anjos, C. S.;** Souza, F. C.; Costa, G. N.; Malta, J. C. O. & Zuanon, J. **2021**. Tadpoles of *Boana geographica* (Spix, 1824) (Anura: Hylidae) parasitized by *Argulus* sp. (Branchiura: Argulidae) in a Central Amazonia Forest stream. *Herpetology Notes*, 14: 335-339.

799. **Rutt, C.L.** & Stouffer. P. C. **2021**. Seasonal dynamics of flock interaction networks across a human-modified landscape in lowland Amazonian rainforest. *Ecological Applications*, 31(2) e02235. doi.org/10.1002/eap.2235

803. **Davies, S. J.;** Abiem, I.; Salim, K. A.; Aguilar, S.; Allen, D.; Alonso, A.; Anderson-Teixeira, K.; Andrade, A.; Arellano, G.; Ashton, P. S.; Baker, P. J.;

Baker, M. E.; Baltzer, J. L.; Basset, Y.; Bissiengou, P.; Bohlman, S.; Bourg, N. A.; Brockelman, W. Y.; Bunyavejchewin, S.; Burslem, D. F. R. P.; Cao, M.; Cárdenas, D.; Chang, L.; Chang-Yang, C.; Chao, K.; Chao, W.; Chapman, H.; Chen, Y.; Chisholm, R. A.; Chu, C.; Chuyong, G.; Clay, K.; Comita, L. S.; Condit, R.; Cordell, S.; Dattaraja, H. S.; Oliveira, A. A.; Ouden, J. D.; Detto, M.; Dick, C.; Du, X.; Duque, A.; Ediriweera, S.; Ellis, E. C.; Obiang, N. L. E.; Esufali, S.; Ewango, C. E. N.; Fernando, E. S.; Filip, J.; Fischer, G. A.; Foster, R.; Giambelluca, T.; Giardina, C.; Gilbert, G. S.; Gonzalez-Akre, E.; Gunatilleke, I. A. U. N.; Gunatilleke, C. V. S.; Hao, Z.; Hau, B. C. H.; He, F.; Ni, H.; Howe, R. W.; Hubbell, S.; Huth, A.; Inman-Narahari, F.; Itoh, A.; Janík, D.; Jansen, P. A.; Jiang, M.; Johnson, D. J.; Jones, F. J.; Kanzaki, M.; Kenfack, D.; Kiratiprayoon, S.; Král, K.; Krizel, L.; Lao, S.; Larson, A. J.; Li, Y.; Li., X.; Litton, C. M.; Liu, Y.; Liu, S.; Lum, S. K. Y.; Luskin, M. S.; Lutz, J. A.; Luu, H. T.; Ma, K.; Makana, J.; Malhi, Y.; Martin, A.; McCarthy, C.; McMahon, S. M.; McShea, J. W.; Memiaghe, H.; Mi, X.; Mitre, D.; Mohamad, M.; Monks, L.; Muller-Landau, H. C.; Musili, P. M.; Myers, J. A.; Nathalang, A.; Ngo, K. M.; Norden, N.; Novotny, V.; O'Brien, M. J.; Orwig, D.; Ostertag, R.; Papathanassiou, K.; Parker, G. G.; Pérez, R.; Perfecto, I.; Phillips, R. P.; Pongpattananurak, N.; Pretxsch, H.; Ren, H.; Reynolds, G.; Rodriguez, L. J.; Russo, S. E.; Sack, L.; Sang, W.; Shue, J.; Singh, A.; Song, G. M.; Sukumar, R.; Sun, I.; Suresh, H. S.; Sewnson, N. G.; Tan, S.; Thomas, S. C.; Thomas, D.; Thompson, J.; Turner, B. L.; Uowolo, A.; Uriarte, M.; Valencia, R.; Vandermeer, J.; Vicentini, A.; Visser, M.; Vrska, T.; Wang, X.; Wang, X.; Weiblen, G. D.; Whitfeld, T. J. S.; Wolf, A.; Wright, S. J.; Xu, H.; Yao, T. L.; Yap, S. L.; Ye, W.; Yu, M.; Zhang, M.; Zhu, D.; Zhu, L.; Zimmerman, J. K. & Zuleta, D. **2021**. ForestGEO: Understanding Forest diversity and dynamics through a global observatory network. *Biological Conservation* 253: 108907. doi.org/10.1016/j.biocon.2020.108907.

805. Jirinec, V.; Rodrigues, P. F. & Amaral, B. **2021.** Adjustable leg harness for attaching tags to small and medium-sized birds. *Journal of Field Ornithology* 92(1): 77–87. doi.org/10.1111/jofo.12353.

806. Vasconcelos, C. C.; Ferraz, I. D. K.; Adrianzén, M. U.; Camargo, J. L. C. & Terra-Araujo, M. H. **2021.** *Chromolocuma brevipedicellata* (Sapotaceae, Chrysophylloideae), a new tree species from central Amazonia, Brazil. *Brittonia* (Accepted).

807. Rutt, C. L.; Kaller, M. D. & Stouffer. P. C. **2021.** Disturbed Amazonian forests support diminished breeding bird communities. *Ornithological Applications* Vol. 123, no 2, pp. 1-15. DOI: 10.1093/ornithapp/duab003.

808. Sierra, A. M; Bastos, C. D. B. & Zartam, C. E. **2021.** Two new species of *Ceratolejeunea* (Lejeuneaceae) and six noteworthy records for the Brazilian Amazon. *Bryophyte Diversity and Evolution* (Accepted).

809. Appel, G.; Tavares, V.; Assis, R. & Bobrowiec, P. E. D. **2021.** Natural Roosts used by bats in Central Amazonia, Brazil. *Mastozoologia Neotropical* (Accepted).

810. Gaem, P. H.; Lucas, E.; Andrade, A.; Vicentini, A. & Mazine, F. F. **2021** A taxonomic account of Myrcia (Myrtaceae) at the sites of the Biological Dynamics of Forest Fragments Project, Amazonas, Brazil. *Rodriguésia* (Accepted).

811. Sobroza, T. V.; Gordo, M. G.; Pequeno, P. A. C. L.; Dunn, J. C.; Spironello, W. R.; Rabelo, R. M. & Barnett, A. P. **2021**. Convergent character displacement in sympatric tamarin calls (*Saguinus* spp.). *Behavioral Ecology and Sociobiology* (Accepted).

812. Silva, I. M. S.; Calvi, G. P.; Baskin, C. C.; Santos, G. R.; Leal Filho, N. & Ferraz, I. D. K. **2021**. Response of central Amazon rainforest soil seed banks to

climate change - Simulation of global warming. *Forest Ecology and Management* (Accepted).

813. **Appel, G**.; López-Baucells, A.; Rocha, R.; Meyer, C. F. J. & Bobrowiec, P. E. D. **2021.** Habitat disturbance trumps moonlight effects on the activity of tropical insectivorous bats. *Animal Conservation* doi.org/10.1111/acv.12706.

814. **Camargo, R**.; Burnham, R. & Mansano, V. **2021.** *Deguelia tenuiflora* (Leguminosae, Papilionoideae), a remarkable new species from the Brazilian Amazon. *Rodriguésia* (Accepted).

815. **Aramuni, F**.; Bosholn, M.; Tolentino, M.; Rampini; Hernández-Rangel, S. M.; Kaefer, I. L. & Anciães, M. **2021**. Social and environmental cues drive the intra-population variation in courtship behavior of a neotropical lekking bird. *Acta Ethologica*. doi.org/10.1007/s10211-021-00371-0**.**

816. **López-Baucells, A**.; Yoh, N.; Rocha, R.; Bobrowiec, P. E. D.; Palmeirim, J. M. & Meyer, C. F. J. **2021**. Optimizing bat bioacoustic surveys in human-modified neotropical landscapes. *Ecological Applications*. doi.org/10.1002/eap.2366.

817. **Sobroza, T. V**.; Pequeno, P. A. C. L.; Gordo, M.; Kinap, N. M.; Barnett, A. P. & Spironello, W. R. **2021**. Does co-occurrence drive vertical niche partitioning in parapatric tamarins (*Saguinus* spp.)? *Austral Ecology* (Accepted).

818. **Albiero-Júnior, A**.; Venegas-González, A.; Camargo, J. L. C.; Roig, F. A. & Tomazello-Filho, M. **2021**. Forest fragmentation and edge effects temporarily favored understory and midstory tree growth. *Trees* (Accepted).

819. **Larson, D. A.;** Vargas, O. M.; Vicentini, A. & Dick, C. W. **2021.** Admixture may be extensive among hyperdominant Amazon rainforest tree species. *New Phylologist* 231 (Accepted).

820. **Montoya, Q. V.;** Martiarena, M. J. S.; Júnior, R. B.; Gerardo, N. M. & Rodrigues, A. **2021**. Fungi inhabiting attine ant colonies: reassessment of the genus *Escovopsis* and description of *Luteomyces* and *Sympodiorosea* gens.nov. *IMA Fungus* (Accepted).

821. **ForestPlots.net; Blundo, C**. et al. **2021**. Taking the pulse of Earth's tropical forests using networks of highly distributed plots. *Biological Conservation*, https://doi.org/10.1016/j.biocon.2020.108849.

822. **Jirinec, V.**; Burner, R. C.; Amaral, B. R.; Bierregaard Jr., R. O.; Fernández-Arevallo, G.; Hernández-Palma, A.; Johnson, E. I.; Lovejoy, T. E.; Powell, L. L.; Rutt, C. L.; Wolfe, J. D. & Stouffer, P. C. **2021.** Morphological consequences of climate change for resident birds in intact Amazonian rainforest. *Science Advances* 7 eabk1743.
DOI: 10.1126/sciadv.abk1743.

823. **Farneda, F. Z.;** Rocha, R.; Aninta, S. G.; López-Baucells, A.; Sampaio, E.; Palmeirim, J.; Bobrowiec, P. E. D.; Dambros, C. & Meyer, C. F. J. **2021**. Bat phylogenetic responses to regenerating Amazonian forests. *Journal of Applied Ecology* 00:1-11. DOI:10.1111/1365-2664.14041.

824. **Scott, E. R**.; Uriarte, M. & Bruna, E. M. **2021**. Delayed effects of climate on vital rates lead to demographic divergence in Amazonian Forest fragments. *Global Change Biology* (In press).
https://doi.org/10.1101/2021.06.28.450186

825. **Vitek, J.**; Rodrigues, P.; Amaral, B. & Stouffer, P. **2021**. Light and temperature niches of ground-foraging Amazonian insectivorous birds. *Ecology* (Accepted).

826. **Gaem, P. H**.; Andrade, A.; Mazine, F. F. & Vicentini, A. **2021**. Tree species delimitation in tropical forest inventories: perspectives from a

taxonomically challenging case study. *Forest Ecology and Management* 505 (2021) 119900 doi.org/10.1016/j.foreco.2021.119900.

827. Dantas-Torres, F.; Picelli, A. M.; Sales, K. G. S.; de Sousa-Paula, L. C.; Zeballos, P. A. M.; Kaefer, I. L.; Viana, L. A. & Pessoa, F. 2021. Ticks on reptiles and amphibians in Central Amazonia, with notes on rickettsial infections. Experimental and Applied Acarology. doi.org/10.1007/s10493-021-00682-8

828. **Aquino, K. K. S.**; Baccaro, F. B.; Appel, G.; Henriques, A. L.; Bobrowiec, P. E. D. & Borges, S. **2021** Forest fragments, primary and secondary forests harbour similiar arthropod assemblages after 40 years of landscape regeneration in the Central Amazon. *Agricultural and Forest Entomology* 2021;1-11. DOI: 10.1111/afe.12481

829. **Lembrechts** *et al*. **2022**. Global maps of soil temperature. *Global Change Biology* (Accepted).

830. **Rodrigues, P.**; Powell, L.; Wolfe, J.; Rutt, C.; Johnson, E.; Mokross, K. & Stouffer, P. **2022**. Sociality and morphology differentiate niches of 13 sympatric Amazonian woodcreepers (Dendrocolaptinae). *Ornithology* (Accepted).

831. **Nunes, M.**; Vincent, G.; Nelson, B.; Calders, K.; Oliveira, R.; Huete, A; Smith, M.; Stark, S. & Maeda, E. **2022.** Forest fragmentation impacts the seasonality of Amazonian evergreen canopies. *Nature* (Accepted).

832. **Souza, T.** *et al.* **2022**. Amazon forest dynamics according water table depth and climate. *Global Ecology and Biogeography* (In revision).

833. **Maeda, E. E.**; Calders, K.; Nunes, M.; Moura, Y. M.; Raumonen, P.; Tuomisto, H.; Verley, P.; Vincent, G.; Zuquim & Camargo, J. L. **2022**. Shifts in structural diversity of Amazonian Forest edges detected using terrestrial laser scanning. *Remote Sensing of Environment*. doi.org/10.1016/j.rse.2022.112895.

LONG-TERM PROJECTS´ ACTIVITIES – RESEARCHERS

1. Project Basic Information

- **Amazon Fertilization Experiment - AFEX**
- Start Date - May 2017 - current.

2. Team

- Principal Investigator: Carlos Alberto Nobre Quesada - INPA
- Collaborator Researchers: Iain Hartley - University of Exeter – UK, José Luís Camargo PDBFF/INPA
- Master's Degree Students: Bruna Lima - INPA
- Ph.D. Degree Students: **INPA** - Sheila Trierveiler, Gyovanni Ribeiro, Felipe Antonieto, Lara Siebert, Hellem Cunha, Jéssica Rosa, Bárbara Brum and Cláudio Santos Neto. **Universidade Federal de Minas Gerais (UFMG)** - Raffaello Di Ponzio

- Technicians and Assistants: **INPA** - Jefferson Gonçalves Cruz, Francisco Oliveira and Nivia Lopes.

3.1 Summary of the activities in 2021

- Two fertilization campaigns - April and June.
- Tree annual census - May;
- Collection of dendrometric bands - October.
- Collection of phenology tree data (few months only because of the suspension of fieldwork due to Covid-19)

3.2. Products associated with the BDFFP

Published scientific articles:

- **TS 801 - Lugli, L. F.**; Rosa, J. S.; Andersen, K. M., Di Ponzio, R.; Almeida, R. V.; Pires, M.; Cordeiro, A. L.; Cunha, H. F. V.; Martins, N. P.; Assis, R. L.; Moraes, A. C. M.; Souza, S. T.; Aragão, L. E. O. C.; Camargo, J. L.; Fuchslueger, L.; Schaap, K. J.; Valverde-Barrantes, O.; Meir, P.; Quesada, C. A.; Mercado, L. M. & Hartley, I. P. **2020.** Rapid responses of root traits and productivity to phosphorus and cation additions in a tropical lowland forest in Amazonia. *New Phytologist* doi:10.1111/NPH.17154.
- **Nakhavali, Mahdi** *et al*. "Representation of phosphorus cycle in Joint UK Land Environment Simulator (vn5. 5_JULES-CNP). *Geoscientific Model Development Discussions* (2021): 1-24.

Submitted scientific publications

- **Cunha, H.** *et al*. Direct evidence for phosphorus limitation on Amazon Forest productivity. *Nature* (submitted).
- **Trierveiler, S.** *et al.* Trophic interactions and resource availability regulate the community structure of litter dwelling invertebrates. *Plos One* (submitted).

4. Approved projects

- CHAMADA CNPq/MCTI/FNDCT Nº 18/2021 - UNIVERSAL - R$ 165.000,00

5. Plans for 2022

- Three fertilization campaigns;
- Litter biweekly collections;
- Retake the quarterly root collection.
- Carry out the grad student's fieldwork campaigns: Bábarba, Bruna, Lara, Felipe, Raffaello and Jéssica.

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1. Project Basic Information

- **Diversity, abundance, and consequences of forest fragmentation in lianas in the Amazon**

- Start Date - 2018 - current.

2. Team

- Principal Investigator: Robyn J. Burnham;
- Collaborator Researchers: Isolde Ferraz - INPA; José Luís Camargo – BDFFP/INPA.
- Master's Degree Students: Isabela Andrade Ferreira - INPA;
- Ph.D. Degree Students: Paulo Piovesan - INPA.
- Technicians and Assistants: João Batista da Silva and José Adailton - BDFFP/INPA.

3.1 Summary of activities carried out in 2021:

- Except for the end of the year when we resumed the census of lianas in Porto Alegre reserves, we did not carry out field activities due to the Covid-19 pandemic. Isabela Ferreira joined the Graduate Program in Botany at INPA in the middle of the year, and soon after, Alexandra Ferreira became part of the team. Thamires Souza joined the team at the end of 2021.
- At some intervals, when it was possible to enter the INPA *campus*, we organized the liana samples in the laboratory and the datasheets in homing office.
- Paulo Piovesan advanced in the first publication of the doctorate and should submit the article in early 2022.

4. **Plans for 2022**

- Continue the botanical identifications of lianas in the second semester.
- Fieldwork to collect more samples.
- Publish the first article.

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1. Project Basic Information

- **Bird diversity at the BDFFP**
- Start Date: 2019 - current.

2. Team

- Principal Investigator: David Luther - George Mason University
- Collaborator Researchers: Tom Lovejoy - George Mason University; Philip Stouffer - Lousiana State University.
- Master's Degree Students: Lara Kazo - George Mason University
- Ph.D. Degree Students: Tovah Seigel and Charlie Coddington - George Mason University.

- Technicians and Assistants: Justin Cooper - George Mason University
- Postdoctoral Fellow: Cameron Rutt - George Mason University

3.1 Summary of activities carried out in 2021:

- Analyze preexisting bird data from the BDFFP.
- Write manuscripts for publication.

3.2. Products associated with the BDFFP

- Submitted scientific publications
- **Kazo L**, T Lovejoy, and DA Luther. 2021. Effects of forest fragmentation on body condition of understory birds at the Biological Dynamics of Forest Fragments Project in Amazonia. *Biotropica* (under review).
- **Rutt C**, P Stouffer, DA Luther. 2021. Long-term capture data reveal Amazonian birds shift daily activity patterns. *Ecology* (under review).

3.3. Participation in scientific events:

- Talk or other form of presentation
- Title - Limited evidence for distance decay across terra firme rainforest in Amazonia at the American Ornithological Society annual conference.

4. Plans for 2022

Collaboration with Paulo Bobroweic to study terrestrial vertebrate diversity with camera traps and acoustic recorders at the BDFFP (starting in May or June).

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1. Project Basic Information

- **Microclimate and tree growth monitoring with dendrometers**
- Start Date: 2018 - current.

2. Team

- Principal Investigator: José Luís Camargo and Rita Mesquita - INPA;
- Collaborator Researchers: Arildo de Souza Dias.

3.1 Summary of activities carried out in 2021:

- Continuation of microclimatic and tree growth monitoring with dendrometers.

- During the year, there was a continuation of the analysis of previous data to produce an article. Arildo Dias is leading this process.

3.2. Products associated with the BDFFP

Published scientific articles:

- ST 829. Global maps of soil temperature. https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.16060

4. Plans for 2022

- Maintenance of the microclimate field stations.
- Maintenance of the dendrometry bands
- Continue writing and publishing works related to the aforementioned project.

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1. Project Basic Information

- **Quantification of microclimate change mechanisms at forest edges using vertical canopy structure data obtained with terrestrial LiDAR**
- Start Date: 2019 - current.

2. Team

- Principal Investigator: Eduardo Maeda - University of Helsinki / University of Hong Kong.
- Collaborator Researchers: José Luís Camargo - INPA;
- Postdoctoral Fellow: Matheus Nunes - University of Helsinki.

3.1 Summary of activities carried out in 2021:

- No activity at the BDFFP was carried out during this period, due to travel restrictions caused by the COVID-19 pandemic.

3.2. Published scientific articles

- **TS 833 - Maeda, E. E.**; Calders, K.; Nunes, M.; Moura, Y. M.; Raumonen, P.; Tuomisto, H.; Verley, P.; Vincent, G.; Zuquim & Camargo, J. L. 2022. Shifts in structural diversity of Amazonian Forest edges detected using terrestrial laser scanning. *Remote Sensing of Environment*. https://doi.org/10.1016/j.rse.2022.112895.

- **TS 831 - Nunes, M**., Camargo, J.L., Vincent, G., Calders, K., Oliveira, R., Huete, A., Moura, Y., Nelson, B., Smith, M., Stark, S., Maeda, E.E. (2022) "Fragmentation disrupts the seasonality of Amazonian evergreen forests" Nature Communications.

4. Plans for 2022

- Data collection from microclimate sensors installed in 2019 at Dimona and Colosso reserves.

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1. Project Basic Information

- **The impact of fragmentation on the forest phenology in Central Amazon**
- Start Date: 2019 - current.

2. Team

- Principal Investigator: Eduardo Maeda - University of Helsinki / University of Hong Kong.
- Collaborator Researchers: José Luís Camargo - INPA;
- Postdoctoral Fellows - Matheus Henrique Nunes - University of Helsinki.

3.1 Summary of activities carried out in 2021:

- Analysis and manuscript writing based on terrestrial LiDAR phenology data collected between April and October 2019 within the BDFFP research areas.

3.2. Published scientific articles

- **TS 831 - Nunes, M.**; Vincent, G.; Nelson, B.; Calders, K.; Oliveira, R.; Huete, A; Smith, M.; Stark, S. & Maeda, E. **2022**. Forest fragmentation impacts the seasonality of Amazonian evergreen canopies. *Nature* (Accepted).

4. Plans for 2022

Based on the same phenology database collected with Lidar, Matheus Nunes will emphasize a study that considers the effect of forest fragmentation on tree architecture.

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1. Project Basic Information

- **Demographic and genetic studies in the Brazil nut family (Lecythidaceae)**
- Start Date: 2017 - current.

2. Team

- Principal Investigator: Christopher Dick - University of Michigan.
- Collaborator Researchers: Alberto Vicentini - INPA;
- Undergraduate Student: Nicolli Cabello - Federal University of São Carlos
- Technicians and Assistants: Paulo Apóstolo Lima Assunção;
- Postdoctoral Fellow: Bruno Garcia Luize, USP.

3.1 Summary of activities carried out in 2021:

- Writing up the results of the recensus (2019) of the Lecythidaceae plot in Km 41.
- Samples collection for genetic analyses.
- Completion of a study of hybridization of trees in the Km 41 plot.
- Presently working on a taxonomic revision of the family based largely on above cited samples and other ones.
- Currently training INPA student Priscila Souza on lab techniques at the University of Michigan.

3.2. Published scientific articles

- **TS 819 - Larson, D. A.**; Vargas, O. M.; Vicentini, A. & Dick, C. W. 2021. Admixture may be extensive among hyperdominant Amazon rainforest tree species. *New Phylologist* 231 (Accepted).

3.3. Submitted scientific articles

- **TS 834 - Milton, T.**, P. Assunção, N. Cabello, S. Mori, A. A. de Oliveira, P. Souza, A. Vicentini, C. W. Dick. 2022. Biomass and demographic dynamics of the Brazil- *Forest Ecology and Management* (in press).

4. Plans for 2022

No plans for 2022. But if we are still welcome to do work in Km 41 we will possibly apply for a project to extend our sampling of Lecythidaceae and do a similar phylogenetic study of Sapotaceae

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1. Project Basic Information

- ***Pioneiras* and Regenera-SinBiose Projects**
- Start Date - 1991 - current.

2. Team

- Principal Investigator: Rita Mesquita - INPA
- Collaborator Researchers: Tony Vizcarra - INPA; Ana Catarina Jakovac - UFSC; Paulo Massoca - GIZ and Bruce Williamson - LSU.
- Postdoctoral fellow: Andre Giles (Regenera-SinBiose).

3.1 Summary of activities carried out in 2021:

- The group continues to analyze data resulting from long-term monitoring in primary and secondary vegetation plots and study vegetation dynamics in the face of changes in land use and climate. In 2021, the group published articles dealing with natural regeneration in secondary forests, one of which (multidimensional tropical forest recovery) had great visibility in the media, being among the top seventh subjects in the Washington Post and third in the Austrian Public Radio.
- It was not possible for the second consecutive year to carry out the annual measurements that have been made for 26 years, due to the COVID 19 pandemic.

3.2. Published scientific articles

- **Poorter, L.;** Craven, D.; Jakovac, C. C.; van der Sande, M. T.; Amissah, L.; Bongers, F.; Chazdon, R. L.; Mesquita, R. *et al*. **2021**. Multidimensional tropical forest recovery. *Science* 374, no. 6573 (2): 1370-1376.
- **Jakovac, A. C. C**.; Junqueira, A.; Crouzeilles, R.; Peña-Claros, M.; Mesquita, R. & Bongers, F. 2021. The role of land-use history in driving successional pathways and its implications for the restoration of tropical forests. *Biological Reviews*, v. 000, p. 001-21.
- **TS 829 - Lembrechts** et al. 2021. Global maps of soil temperature. *Global Change Biology*, v. 18, p. GCB16060.

3.3. Submitted Articles

- Rosenfield, M. F.; Jakovac, C. C.; Vieira, D. L. M.; Poorter, L.; Brancalion, P. H. S.; Vieira, I. C. G.; de Almeida, D. R. A.; Massoca, P.; Schietti, J.; Albernaz, A. L. M.; Ferreira, M. & Mesquita, R. C. G. 2022. The Ecological integrity of secondary forests: concepts and indicators. *Biological Reviews* (*in review*).

3.4. Articles in preparation

- **Jakovac, C**.; Giles, G.; Rosenfield, M.; Schietti, J.; Massoca, P. E. S.; Peña-Claros, M.; Wagner, F.; Brancalion, P. H. S.; Espírito-Santo, M. M.; Vieira, G.; Aragão, L.; Vieira, D. L. M.; Albernaz, A. L. M.; Almeida, D. R. A.; Oliveira Jr, L.; Ferreira, M.; Poorter, L.; Vieira, I. C. G. & Mesquita, R. C. G. The

ecological integrity of Amazonian secondary forests: measuring, quantifying and upscaling (*in prep*.).

- **Massoca, P. E.**; Rosenfield, M.; Jakovac, C. C.; Albernaz, A. L. M.; Almeida, D. R. A.; Ferreira, M.; Brancalion, P. H. S.; Vieira, D. L. M.; Espirito-Santo, M. M.; Vieira, I. C. G. & Mesquita, R. C. G. The regulation of forest regeneration in Brazil and its implications for the use, management, and conservation of second-growth forests in Amazonia (*in prep*.)

3.4. **General publications**

- Boletim SinBiose: *Regeneração natural pode recuperar serviços ecossistêmicos na Floresta Amazônica?* Catarina C. Jakovac, Paulo Massoca & Rita Mesquita. Website Cnpq/SinBiose. https://www.gov.br/cnpq/pt-br/sinbiose/regeneracao-natural-pode-recuperar-servicos-ecossistemicos-na-floresta-amazonica
- Tropical forests can recover surprisingly quickly on deforested lands – and letting them regrow naturally is an effective and low-cost way to slow climate change. Robin Chazdon, Bruno Herault, Catarina Jakovac, Lourens Poorter. Website "The Conversation" https://theconversation.com/tropical-forests-can-recover-surprisingly-quickly-on-deforested-lands-and-letting-them-regrow-naturally-is-an-effective-and-low-cost-way-to-slow-climate-change-173302

3.5. Participation in scientific events: talk title or other forms of presentation

- Organizition of the event: Mesquita, R. C. G.; Barros, C. & GUTIERREZ, D. *Roda de Mulheres* - INPA - Dia Internacional da Mulher 2021. 2021. (Outro).
- Lecture: Pereira, H.; Mesquita, R. C. G.; Simonetti, S.; Marinelli, C. E.; Egler, D.; Rebelo, G. X Seminário de Áreas Protegidas para a Inclusão Social e V ELAPIS. 2021. (Congress).
- Mesquita, R. C. G.; Barros, C.; Gutierrez, D.; Buzaglo, A. & Zanusso, F. Semana Nacional de Ciência e Tecnologia - a transversalidade da C, T&I para o planeta. 2021.

4. Approved projects

- *Intercâmbios juvenis* - Fapeam in 2021;
- Continuity of previous projects: SinBiose; Museu na Floresta and PCE.

5. Plans for 2022

- Remeasurement trees on the *Pioneiras* project transects.

1. Project Basic Information

- **Natural history of tropical trees: phenology, fruits, seeds, and seedlings**
- Start Date: 2003 - current.

2. Team

- Principal Investigator: Isolde Ferraz – INPA and José Luís Camargo – BDFFP/INPA.
- Collaborator Assistants: Daniel Silva and Milena Barrera
- Technicians and Assistants: Osmaildo Ferreira da Silva and Alexandre Oliveira dos Santos

3.1 Summary of activities carried out in 2021:

- Field activities were suspended in 2021 due to the Covid-19 pandemic.
- Revision of the phenology data in the virtual herbaria
- Cultivation of tree seedlings in the plant nursery during the year
- Description of seedling development and seedling in the plant nursery
- Organization of the book release session (virtual)

3.2. Published scientific articles

- **TS 700 - Ferraz, I. D. K**.; Camargo, J. L. C.; Mesquita, M. R.; Santos, B. A.; Brum, H. D. & Albuquerque, M. C. F. 2019. Guide to Amazonian Fruits, Seeds & Seedlings. Ferraz, I. D. K & Camargo, J. L. C. (Eds.). Editora INPA, Manaus - Brasil. 226pp.
- The authors finished the revision of the book in Dec. 2019, and in April 2020, at the beginning of the pandemic suspension, the book was published and delivered at the INPA´s Publisher House. Authors received the book only at the beginning of 2021. The virtual launch session was in September.

4. Plans for 2022

- By 2022 we hope to re-start the monthly phenological observation and collect botanical material to work on describing fruits, seeds, and seedlings and measurements of the dendrometry bands. Also, to compose the pages of other species for the second volume of the guide of Amazonian Fruits, Seeds, and Seedlings.

SCIENTIFIC DIVULGATION

Part of the scientific production and reviews gained prominence in the media, reaching a wider audience.
To see the material released in more detail about press releases and reports in the media, see Supplementary Material – **Scientific Dissemination – BDFFP 2021**.

Deforestation & Coloring of Butterflies

Access the news here: https://oglobo.globo.com/sociedade/meio-ambiente/amazonia-sem-cor-com-desmatamento-borboletas-coloridas-dao-lugar-as-pardas-cinzentas-24997680.

Also, here https://brasil.elpais.com/opiniao/2021-05-05/maria-preciso-te-contar-sobre-bolsonaro-o-fazedor-de-orfaos.html.

(ST – 789) Spaniol, R.L.; et al. 2020. Discolouring the Amazon Rainforest: How deforestation is affecting butterfly coloration. *Biodiversity and Conservation.* doi.org/10.1007/s10531-020-01999-3

Download the article at: https://link.springer.com/article/10.1007/s10531-020-01999-3

Forest Fragments, Secondary Forests, Moonlight, and Bats

Access the news here: https://revistapesquisa.fapesp.br/morcegos-evitam-florestas-deterioradas/
(ST – 813) Appel *et al*. 2021. Habitat disturbance trumps moonlight effects on the activity of tropical insectivorous bats. Animal Conservation doi.org/10.1111/acv.12706.

(ST – 823) Farneda, F. Z. et al. 2021. Bat phylogenetic responses to regenerating Amazonian forests. *Journal of Applied Ecology* 00:1-11. DOI:10.1111/1365-2664.14041.

(ST – 735) Mokross, K. *et al.* 2018. What can mixed-species flock movement tell us about the value of Amazonian secondary forests? Insights from spatial behavior. *Biotropica*. 50(4):664-673. DOI:10.1111/btp.12557

Climate change vs. Birds

Access the full article through the Pesquisa FAPESP link:
https://revistapesquisa.fapesp.br/clima-modifica-o-corpo-das-aves/

(ST – 822) Jirinec, V. *et al.* 2021. Morphological consequences of climate change for resident birds in the intact Amazonian rainforest. Science Advances 7 eabk1743. https://www.science.org/doi/10.1126/sciadv.abk1743

Morphological consequences in climate change for resident birds in intact Amazonian rainforest, Science Advances: https://www.science.org/doi/10.1126/sciadv.abk1743

Rio Negro Honorable Mention to Ocírio Juruna, BDFFP Parataxonomist and Field Assistant

On December 14, 2021, the parataxonomist Ocírio Pereira, affectionately known as Juruna or Deputado, member of the BDFFP Research Group, received Inpa's highest honor, the Rio Negro Honorable Mention. The medal is offered every two years to Brazilians or foreigners who have dedicated themselves or provided relevant services to the science development and scientific and technological research in the Amazon.

Juruna was the first field assistant honored by the mention and states that the medal was an important recognition for the entire class of research assistants:

"I am very proud to receive this medal. I'm passing on what I've learned to new students, and I do it with much love."

Juruna with the other distinguished researchers during the event at INPA. Left to right: Eliana Feldberg; Albertina Lima, Juruna (Ocírio Pereira), and Maria Tereza Piedade some Inpa's researchers awarded the medal Rio Negro (Photo: Ériko Xavier).

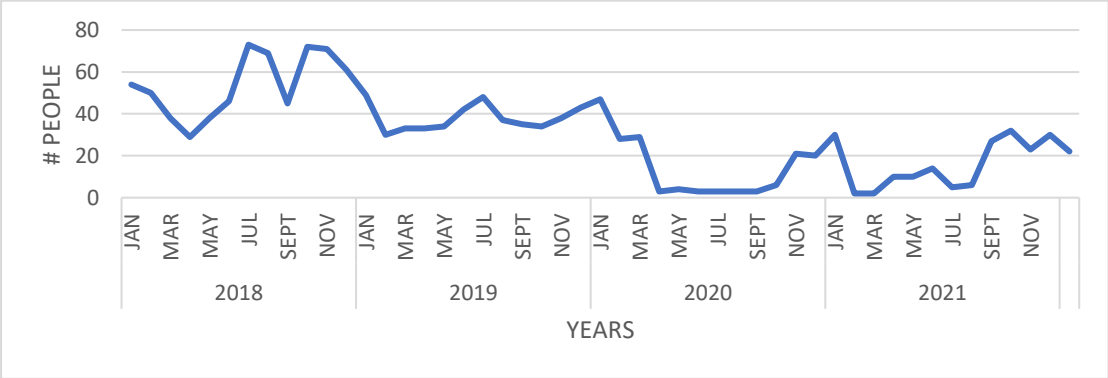
The BDFFP Research Group is proud to have Juruna as part of the group for over 30 years. Juruna's knowledge of the Amazon rainforest, especially about the herpetofauna and flora of palm trees, enabled many students and researchers to carry out relevant research in several areas of knowledge such as Ecology, Systematics, and Taxonomy. His contributions to society, science, and the conservation of the Amazon rainforest are invaluable!

FREQUENCY OF FIELD VISITATION

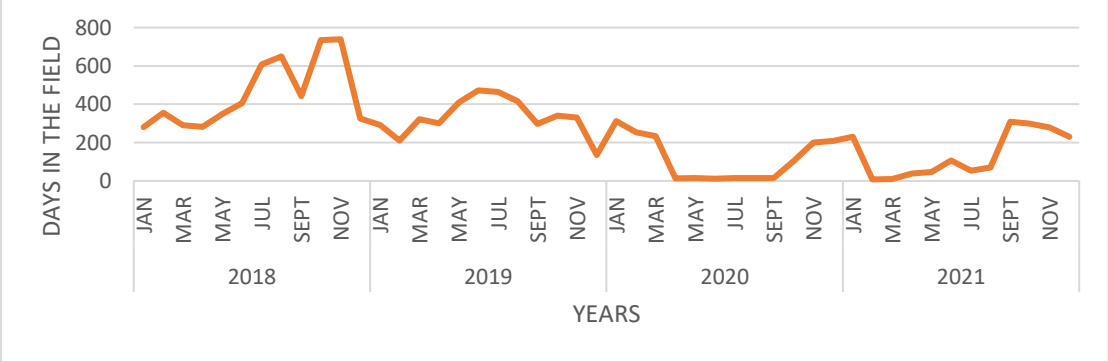
In addition to field attendance in 2021, the graphs below show the visitation frequency associated with ARIE PDBFF field activities since 2018. We included other years to show the effect of suspending field activities during the COVD-19 pandemic.

The number of people and the number of days they stayed in the field were higher in 2018 when we received students for the Ecology of the Amazon Forest (EFA) field course and the regular presence of technicians, students, and researchers. Lower values in 2019 are related to the cancellation of the course due to a lack of resources.

In 2020 and 2021, the values fall more sharply due to suspensions of activities caused by the consequences of the COVD-19. There was only monitoring and maintenance of camps and roads during the period. Only at the end of 2020, the beginning of 2021, and after September 2021 did few researchers and students return to the field.



Number of people who attended the ARIE PDBFF per month from 2018 to 2021.



The cumulative number of days each person stayed at the ARIE PDBFF from 2018 to 2021.

MAINTENANCE: Camps, roads, and equipment

The visitation frequency in the camps is high, and there are rarely periods without any technician, student, or researcher attending the ARIE PDBFF. Thus, we never need to implement a routine to monitor PDBFF facilities and reserves. With the suspension of activities in 2020 and 2021, there was a need to include a new work routine.

Small teams of technicians had to monitor the facilities of the PDBFF, the access roads, and reserves that are part of the ARIE. Often, the visits were extended to carry out tests on the functioning of generators and other equipment and mainly maintenance of campsites and roads. The table below shows the records on monitoring frequency and where it takes place.

2021 - BDFFP MAINTENANCE & MONITORING: CAMPS, EQUIPMENT, ROADS

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEPT		OCT		NOV		DEC	
MONITORING (1) & MAINTANANCE (2):																								
CAMPS:	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Dimona (DI)	✓		✓		✓		✓		✓		✓	✓	✓		✓		✓		✓		✓			
Porto Alegre (PA)	✓		✓		✓		✓		✓		✓	✓	✓	✓	✓		✓		✓		✓			
Cabo Frio (CF)	✓		✓		✓		✓		✓		✓		✓		✓	✓	✓	✓	✓		✓			
Colosso (CO)	✓		✓		✓		✓		✓		✓		✓	✓	✓	✓	✓	✓	✓		✓			
Gavião (GA)	✓		✓		✓		✓		✓		✓		✓		✓		✓	✓	✓	✓	✓			✓
KM 37 (37)	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓			✓
KM 41 (41)	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓	✓		
ROADS:																								
ZF-03								✓		✓		✓		✓		✓		✓				✓		✓
DIMONA						✓		✓								✓				✓				✓
PORTO ALEGRE												✓		✓										
COLOSSO-CABO FRIO																								
EQUIPAMENT:						(CO)						(PA)												
PLANT GENERATOR	✓		✓		✓	✓	✓		✓		✓	✓	✓		✓		✓		✓		✓		✓	
WATER PUMPS	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓	
OTHERS																								
VEHICLES		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓

RESOURCE IMPLEMENTATION

In the table below are the amounts planned in the budget, the expenses incurred, and the percentage implemented during the year 2021.

Balance of Expenses – 2021 ALFA In US$ dollar (4,95)

	Expenses JAN - DEC 2021	**Budget (planned)**		**Budget (expenses)**	**Implemented**
Salaries	222.788,99	226.095,19		3.306,20	98,5
Benefits + Costs	152.409,51	155.680,74		3.271,23	97,9
Office	10.028,28	17.116,69		7.088,41	58,6
Transport	15.402,69	15.296,15	-	106,54	100,7
Maintenance + Services	14.010,63	26.795,00		12.784,37	52,3
Total	**414.640,09**	**440.983,77**		**26.343,68**	**94,0**

Field Activities Supporting Program Thomas Lovejoy

Below are expenses related to the Thomas Lovejoy Fieldwork Support Program for students and research assistants in 2021. The Program received funds from the Paul and Maxine Frohring Foundation, which aimed to assist students in times of a pandemic.

More than 43% was spent in 2021 (see table below) out of US$100,000 transferred at the end of 2020; the support made it possible to maintain students and assistants even during the suspension of field activities. When protection measures were relaxed, especially after September, scheduled field activities resumed. But, in general, students have adapted to carrying out some activities in remote work.

	In US$ dollar (5,05)
Balance of Expenses: Thomas Lovejoy Support Program for Students & Research Assistants	
Categories	**Expenses**
Students & Assistants	36.900,00
Food	4.691,26
Field material	1.326,64
Supporting services	200,00
Bank taxes	324,99
Total	**43.442,89**

FINANCING SOURCES - ALFA/PDBFF

The amounts presented above come from the transfer of resources from the Amazon Biodiversity Center (ABC), a partner institution that raises, manages, and transfers resources monthly to cover the current expenses of the ALFA/BDFFP. The table shows that expenses are not associated with research and academic training. In 2021, amounts spent on research were raised and brought by researchers from the BDFFP Research Group through public notices promoted by Brazilian and foreign funding agencies. The Thomas Lovejoy Fieldwork Support Program provided resources to support field activities for students and research assistants (see below).

As a result of the suspension of face-to-face activities due to the Covid-19 pandemic, there were no expenses on academic training activities.

Expenses for the operation and maintenance of the office, camps, roads, reserves, and trails were less than the planned values due to the suspension of field activities for most of the year and the emptying of the office due to the need to work from home.

SUPPLEMENTARY MATERIAL (attached)

- Technical Series of Publications
- Technical Series of Thesis and Dissertations
- Scientific Divulgation