




SÃO PAULO RESEARCH
FOUNDATION

SCIENCE OF THE AMAZON



THE SÃO PAULO RESEARCH FOUNDATION AND AMAZON RESEARCH



The São Paulo Research Foundation (FAPESP) has been providing continuous support to research projects that study the Amazon region under different and complementary perspectives. Many of these research projects are jointly funded with other organizations, and FAPESP is proud to be a partner to the Amazon Research Foundation (FAPEAM), the United States Department of Energy – Office of Science, the National Science Foundation (NSF), the Belmont Forum, and the UK Natural Environment Research Council (NERC).

Knowing and understanding the Amazon is an essential step to ensure its conservation as a national treasure. This folder provides a brief description of the 2014 portfolio of research projects that study the Amazon rainforest, both from biotic and abiotic points of views.

Covering over five and a half million square kilometers (1.4 billion acres), the Amazon basin hosts the largest tropical rainforest in the world. Given its distribution throughout such a large geographical area, this highly complex biome displays unique characteristics that are of extreme relevance to the planet, attracting the attention and the concern of nations worldwide.

The Amazon basin houses rivers and streams that are responsible for approximately 20% of the world's total river discharges into the oceans, representing one of the most important sources of freshwater in the world. Part of this abundance in fresh water is due to the peculiar structure of the Amazon soil, rich in decomposing organic matter, which soaks up moisture, that is slowly released to the rivers and the atmosphere. The cycle associated with moisture-release into the atmosphere and its return to the ground, as rain, is believed to play a crucial role in regulating climate-systems at both regional and global levels. Thus, deforestation, besides being a source of increase in greenhouse gas emissions, may result in the disruption of this water cycle, contributing to temperature increases and droughts.

The Amazon rainforest contains the largest biodiversity in the world, with more than 2.5 million catalogued species, including invertebrates, birds, mammals, amphibians, reptiles and fish, along with tens of thousands of different plant species. Such diversity is expected to provide new feedstocks and/or become an important source of genes that may be used, for example, to fortify modern plant varieties against current vulnerabilities to pests, diseases, or climate changes.

Although less than 1% of the plants present in tropical forests have been tested for pharmaceutical properties, recent studies have shown that approximately 25% of the currently available natural medicines have been discovered in rainforests, reinforcing the necessity of continuing efforts towards bioprospection of natural products from the Amazon's biodiversity. In this sense, a large number of such medicines have been originally discovered by indigenous tribes, reinforcing the importance of studying the native peoples of the Amazon region and the impacts that the recent contact with modern civilization have played in the development of their culture and way of life.

More than one half of the Amazon rainforest is located within Brazilian borders, and the implementation of efforts dedicated to the study and conservation of the Amazon rainforest have long been a major concern of the Brazilian society. While deforestation rates have reduced over the last 10 years, the protection and conservation of the Amazon rainforest remains an important issue in the country.



FAPESP: SUPPORT FOR RESEARCH IN SÃO PAULO

São Paulo Research Foundation (FAPESP) promotes scientific research in the State of São Paulo, Brazil. Through a robust program of fellowships and research grants, it supports fundamental and applied research.

Created in 1962, the foundation is entitled by the State Constitution to 1 per cent of the tax revenues of the State of São Paulo. FAPESP has a sizable endowment and its expenditures in 2013 were R\$ 1.085 billion (approximately US\$ 500 million). 37% of the expenditures supported fundamental research; 10% supported research infrastructure; and 53% supported application oriented research, in many cases performed in small businesses or in joint research performed by academia and industry. The percentage invested in applied research has been growing in recent years, consistently with the foundation's mandate to foster the scientific and technological development in the State of São Paulo.

In 2013, FAPESP received a total 13,272 requests for scholarships, representing a 10.58% increase from 2012, in addition to 6,798 requests for regular research grants and grants for special programs and technological innovation research programs, constituting a total of 20,070 requests. These requests were processed over an average of six weeks, which is considered excellent by international standards for research-sponsoring agencies.

One of FAPESP's goals is the broadening and diversification of the research system in the State of São Paulo, strengthening the existing centers of excellence, by supporting their research, and stimulating the creation of new centers or research groups tackling new lines of activity. This is achieved mainly by funding the Young Investigators Awards, the BIOTA-FAPESP Program, the FAPESP Bioenergy Research Program (BIOEN), the FAPESP Research Program on Global Climate Change (RPGCC), the Research, Innovation and Dissemination Centers (RIDC) program, and the Thematic Projects. All of these have in their teams, in addition to experienced scientists, young researchers as post-doctoral fellows, from Brazil and abroad.

INTERNATIONAL COLLABORATION

FAPESP has a large number of agreements with foreign funding agencies, research performing organizations and companies to co-select and co-fund cooperative research. The opportunities for funding related to each agreement are announced on FAPESP's website (www.fapesp.br/en/agreements).

Besides the above, scientists supported by FAPESP grants and fellowships are encouraged by the foundation to develop international collaborations through the following institutional instruments:

- a) Most research grants and fellowships awarded by FAPESP include funds that can be used, at the discretion of the PI and according to FAPESP's rules, for international research collaboration.
- b) FAPESP's **Visiting Researcher Program (VRP)** grants for foreign scientists are selected using a peer review system. These grants cover stipends and travel expenses for foreign scientists visiting colleagues in higher education and research institutions in the State of São Paulo, Brazil, for periods from two weeks to one year.



- c) FAPESP's **Research Fellowships Abroad (BPE)** support scientists associated to higher education and research institutions in the State of São Paulo, Brazil, for stays from one month to one year in qualified research institutions abroad. Funding covers fellowships and travel expenses.
- d) The **São Paulo Schools of Advanced Science (SPSAS)** support the organization of short schools (1 to 3 weeks), targeting recent scientific advances, and presented in higher education and research institutions in the State of São Paulo, Brazil.
- e) Through the **Research Internships Abroad (BEPE)**, FAPESP offers to all of its fellowship holders in the State of São Paulo the opportunity to spend from 4 to 12 months as research interns in foreign high profile research centers, working in a theme associated to the research project the candidate is developing in São Paulo.

SCIENTIFIC OPPORTUNITIES IN SÃO PAULO, BRAZIL

Brazil is one of the four main emerging nations. More than ten thousand doctorate level scientists are formed yearly and the country ranks 13th in the number of scientific papers published.

The State of São Paulo, with 42 million people and 34% of Brazil's GDP responds about half of the science created in Brazil. The state hosts important universities, like the University of São Paulo (USP), the University of Campinas (Unicamp), the São Paulo State University (UNESP), the Federal University of São Paulo (UNIFESP), the Federal University of ABC (ABC is a metropolitan region in São Paulo), the Federal University of São Carlos (UFSCar), the Aeronautics Institute of Technology (ITA) and the National Institute for Space Research (INPE).

Universities in the State of São Paulo have strong graduate programs: the University of São Paulo forms two thousand doctorates every year, the University of Campinas forms eight hundred and the São Paulo State University, six hundred.

In addition to the three state universities and the three federal universities of international research level, the state has 19 research institutes and most of Brazilian industrial R&D. The state houses more than 130 thousand undergraduate students. São Paulo alone produces more scientific papers than any country in Latin America, except for Brazil.





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XINGU PROJECT - INTEGRATING LAND USE PLANNING AND WATER GOVERNANCE IN AMAZONIA: TOWARDS IMPROVED FRESHWATER SECURITY IN THE AGRICULTURAL FRONTIER OF MATO GROSSO

Principal Investigator (PI): Alex Vladimir Krusche

Center of Nuclear Energy in Agriculture / University of São Paulo (USP)

FAPESP # 2013/50180-5 | Term: Sep 2013 to Aug 2017 | FAPESP Research Program on Global Climate Change (RPGCC)

Belmont Forum Agreement

US PI: Christopher Neill

co-PIs: Maria Victoria Ramos Ballester, Maria Elisa Garavelo

Sponsors: FAPESP/NSERC/DFG/NSF

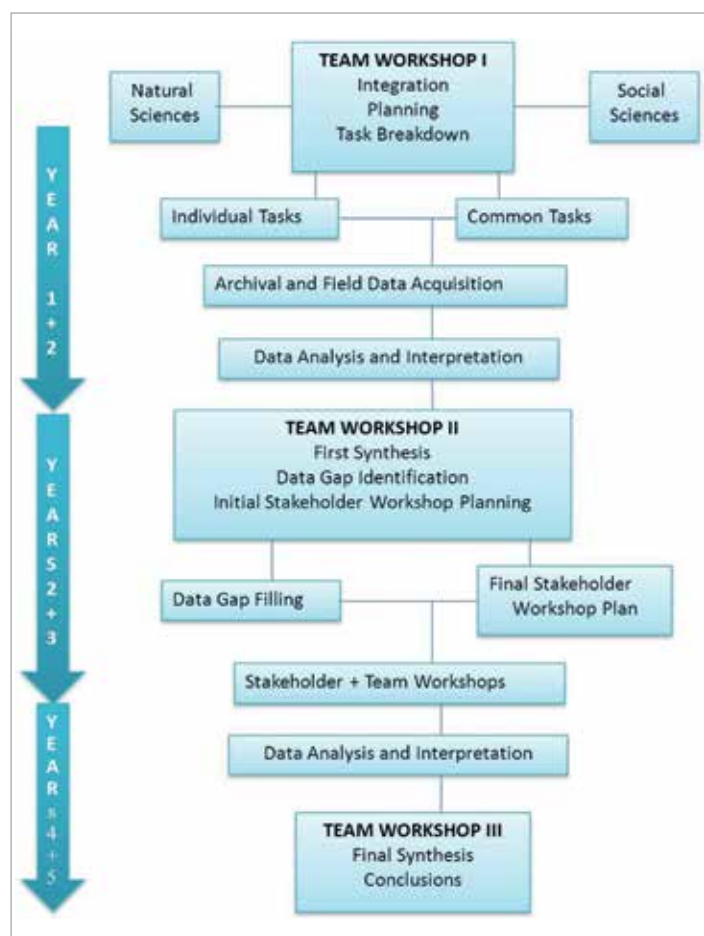


Figure 1. The flowchart shows the activities timeline for the project

Freshwater resources comprise a fundamental connection between human society and ecosystem functions. Within watersheds with significant agroecosystem components, strategies for sustainable water allocation between urban and agricultural needs while maintaining ecological flow requirements represents an unresolved tension that is growing due to increasing population pressures and global climate change. While there is still much to understand regarding global change issues and their impacts on freshwater security, there is a concurrent need to improve frameworks, related to water governance to ensure adequate provisioning of water among competing but not always equally valid demands. It is only through the development and successful application of water governance frameworks, considering biophysical drivers, upstream/downstream connections, and trends and uncertainties in freshwater resources due to local pressures and global change, that we may improve the adaptive capacity of socio-ecological systems and water-based ecosystem services. This project has assembled a team of natural and social scientists in order to co-evaluate freshwater security issues within an area of global significance that is undergoing rapid change, both demographically and related to water use and freshwater vulnerability.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The team developing an interdisciplinary framework to bridge the gaps between natural and social science to examine the overarching general question of: What approaches to water resource governance, land management, and information transfer among regions and among water use sectors will improve the sustainability and equity of water resources within socio-environmental systems, and ensure the well-being of ecosystems and humans? The Upper Xingu basin in Mato Grosso, Brazil provides a test bed for evaluating strategies for integrating water governance and land use planning with research to evaluate land-use impacts on water quantity and water quality in upstream and downstream regions that differ in water use sectors (farmers versus urban users). The main goal of this project is to identify how impacts from land conversion, cropland expansion and intensification of both crop and animal production interact to affect regional evapotranspiration, rainfall generation, river flooding and water quality and stream habitats. This will allow us to identify thresholds of change that will endanger agricultural production, livelihoods of non-agricultural settlers and the region's new urban population and infrastructure. The research will survey the effects of this on (1) soybean farmers, (2) cattle ranchers, (3) small-scale farm families, (4) rural non-agriculturists, including fishers, and (5) urban residents, to map their roles as stakeholders. And also conduct current water use surveys among the different stakeholder groups, accompanied by questions on desired aspects for future freshwater security, to identify targets for desirable outcomes of water governance strategies. These targets, together with the information on land use drivers, water quantity and quality and predicted scenarios for global changes will be incorporated into a fully integrated and interactive geospatially oriented socio-ecological model, that can serve as framework for future water governance that enhances Freshwater security in such systems.

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BIODIVERSITY AND ECOSYSTEM FUNCTIONING IN DEGRADED AND RECOVERING AMAZONIAN AND ATLANTIC FORESTS

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Biology Institute / University of Campinas (UNICAMP)

FAPESP # 2012/51872-5 | Term: Aug 2013 to Jul 2017 | BIOTA-FAPESP Program

RCUK Agreement

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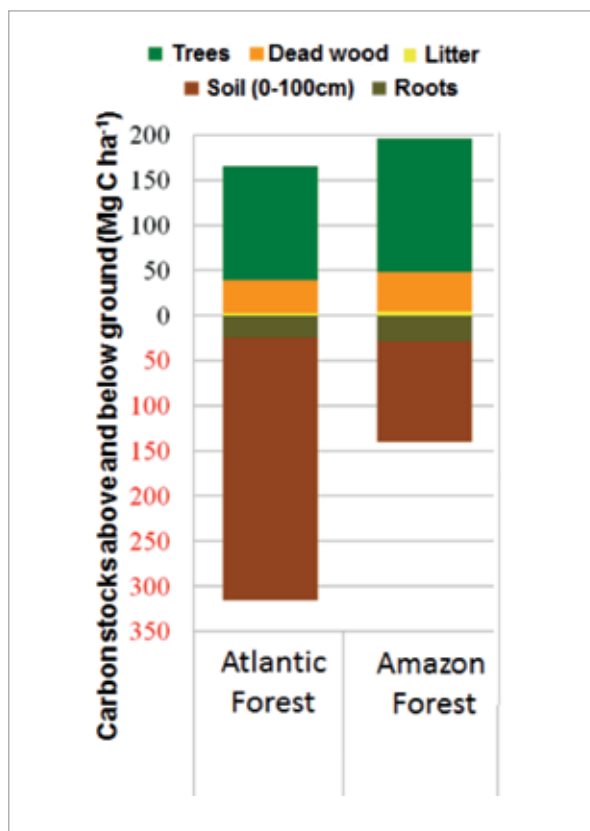


Figure 1. Above and below ground stocks of Carbon in well preserved areas of Atlantic and Amazon Forests

This project aims to deliver a step-change in the understanding of the consequences of forest degradation and regeneration for biodiversity and associated ecological processes and services in Amazon and Atlantic Forests.

The goals are:

- 1) to establish the first intensive network of long-term monitoring sites along a gradient from intact to severely altered forests in the Brazilian Amazon, and significantly enhance the existing network of modified and intact sites in the Atlantic Forest;
- 2) to complement these intensive-sites with a network of extensive study plots across multiple river catchments in the Amazon and the Atlantic Forest, enabling to answer questions about changes in biodiversity, functional traits and carbon stocks at the landscape level; and
- 3) to develop an integrated research framework that links the data and process understanding from both intensive and extensive observations of human-modified gradients to multi-scale ecosystem models. These will provide a platform for testing and informing policy options at the level of municipalities, states and the entire biomes.

The project will conduct sampling in both the Atlantic and Amazonian forests, focussing on four types of forest along a broad disturbance gradient, capturing the endpoints of degradation (from undisturbed forests to those regenerating after clear-felling and farming activities) and the two predominant degradation processes, selective logging and fires. The Intensive study will be performed in two plots set: Biota program plots in the Serra do Mar State Park, South-eastern Brazilian Atlantic Forest; and Santarém-Belterra region, Amazonian Forest. Within the wider Amazon forest, the team will also make use of two existing permanent plots set created in degraded forests to test the generality of the findings in the Santarem region, Acre and Paragominas.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

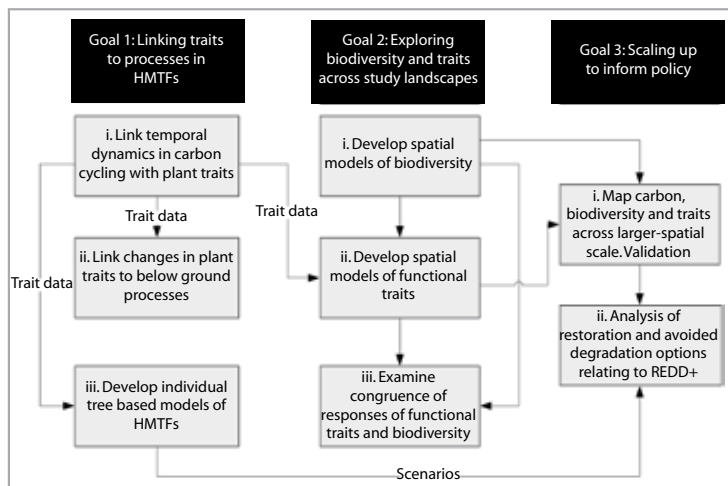


Figure 2. A conceptual model of the work packages to address the three main goals of the project. Arrows denote the flow of data and project outputs between key objectives. HMTFs = Human Modified Tropical Forests; REDD+ = Reducing Emissions from Avoided Deforestation and Forest Degradation

There are two main results to be reported so far:

- a) the diversity of trees per hectare is much higher in the well preserved areas of Atlantic Forest (up to 180 species per hectare) than in the Amazon Forest (up to 120 per hectare);
- b) in the well preserver plots of Atlantic Forest the belowground stock of carbon is significantly higher than that registered in the well preserved areas of the Amazon Forest (Figure 1).

Therefore, in the Atlantic Forest, immediate carbon release to the atmosphere will be more sensitive to climate change, with global warming speeding up decomposition of organic matter accumulated below ground, than in the Amazon, where slash and burnt are the major factors affecting immediate carbon release to atmosphere.

Figure 2 summarizes the conceptual model of the work packages to address the three main goals of the project. The expected results will contribute to the development of meaningful hypotheses about the functional consequences of changes in plant and bird communities, used here as biodiversity surrogates, following human-modification of tropical forests.

The project will leave an important legacy, both in knowledge and infrastructure, which will continue to allow improvements in the understanding of HMTFs beyond the end of project, since the studied plots will be converted into long-term monitoring sites across the Amazon and Atlantic Forest.

Within this specific call for proposals, data and results will also be compared with those of the SAFE Project in Malaysia.

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THE SISBIOTA-DIPTERA BRAZILIAN NETWORK. A LONG TERM SURVEY OF DIPTERA FROM UNEXPLORED CENTRAL AREAS OF BRAZIL

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FAPESP # 2010/52314-0 | Term: Mar 2011 to Feb 2014 | BIOTA-FAPESP Program

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Figure 1. Field work in the State of Rondonia

The true flies (Diptera) are one of the four-megadiverse orders of insects, with more than 120.000 extant species, immediately familiar because they are ubiquitous and cosmopolitan, and they have had tremendous impacts on human civilization. They transmit important diseases, such as malaria, yellow fever, leishmaniasis and sleeping sickness, to humans and animals. Flies are among the most abundant arthropods found in biodiversity surveys and have a wide variety of feeding strategies. The menu of fly diets comprises nearly the complete insect smorgasbord: blood feeders, endo- and ectoparasites of vertebrates, gall makers, larval and adult predators, leaf miners, parasitoids, pollinators, saprophages, and wood borers. Magnifying this ecological diversity, Diptera have a complex holometabolous life cycle,

and their larvae (maggots) and adults have entirely different anatomy and behavior, separate ecological requirements, and occupy different niches. The SISBIOTA-BRASIL is a three-year multimillion-dollar research program of the Brazilian government to document plants and animals in endangered/understudied areas and biomes in Brazil. Even in the most studied areas in Brazil, distributional patterns of invertebrates and plants are insufficiently known and the historical events that generated those patterns are even more poorly known. This deficiency brings implications and impediments for conservation policies and for the understanding of evolutionary processes. Conservation decisions are largely dependent upon precise knowledge of the taxonomic and geographic distribution of species. Inside this premise and concerning, the team proposed an ambitious research project to study the Diptera of Central Brazilian areas, in the States of Rondônia, Mato Grosso and Mato Grosso do Sul, which are characterized by four important biomes of the South American continent: Amazon Forest, Cerrado (Brazilian Savannah), Pantanal and Chaco. Besides the ecological relevance, those areas historically lacks satisfactory entomological surveys; therefore, they are much underrepresented in the main collections, and also are being exponentially destroyed by the enlargement of the livestock and agricultural areas. This project involves 24 researchers from 15 different Brazilian institutions, and gathers 36 graduate and undergraduate students and 10 technicians. The project scope comprehends taxonomic, phylogenetic and biogeographical aspects of the studied families. So far, the team have analyzed nearly 300,000 specimens of Diptera, which are being collected with standardized methods along the sampled areas.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

In order to survey one of the big four order of insects, in four different biomes, a research network was consolidated. From August 2011 to December 2013, beyond the permanent traps the team left in the field, 13 expeditions were conducted with an average of 10 members in each one. The most important legacy of this project is the collection, unprecedented in the history of Brazilian entomology, which is being formed. The central region of Brazil lacks large entomological inventories and, because of that, it is still very little known. Partial results showed that a huge portion of the Neotropical fauna of Diptera is truly unknown. Just to illustrate, the researchers choose one of the most striking case: the family Cecidomyiidae. The Cecidomyiidae are mosquitoes whose larvae form galls (tumors) in plants, where they feed and spend most of their life cycle. Before starting this project, there was not a single record of species of this family for the three



Figure 2. A female specimen of *Ligya klugii* (Wiedemann), 1830 sunning herself

studied states. Over the past three years, the team identified over 250 species of host plants with more than 200 kinds of Cecidomyiidae galls (plant tumors), which should result in about 90% of new species and 10% of new records of species, already known, for the studied states.

A project of this nature will continue to generate results for an undetermined

period beyond the expiration of its term. The main numbers are: 9 published papers, 23 in press, and other 37 in preparation. 56 families were recognized, 246 new species are being described and 421 new geographic records are being assigned, so far.

The team also believes that extension activities and the dissemination of results are of paramount importance to projects of scientific research such as the Sisbiota-Diptera. To make the results and news available for the public and for researchers with different degrees of expertise and interest on Diptera, profiles were built for Sisbiota-Diptera on social networks (<http://facebook.com/sisbiotadiptera> and <http://twitter.com/sisbiotadiptera>). Additionally, a blog, bringing longer texts, photos of the expeditions and links, was also created (<http://sisbiotadiptera.blogspot.com>) and is widely publicized in discussions forums in Brazil and abroad.

MAIN PUBLICATIONS

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DIVERSITY AND ECOLOGY OF TADPOLES FROM CENTRAL AMAZONIA

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FAPESP # 2010/52321-7 | Term: Mar 2011 to Jun 2014 | BIOTA-FAPESP Program

co-PIs: Marcelo Menin, Luis Cesar Schiesari



Figure 1. From left to right, clockwise: 1) stream and 2) streamside pond, both inside a solid ground forest; 3) floodplain lake with a flooded forest in the background and floating meadows in the first plan; 4) tadpole of the foam nesting frog *Leptodactylus knudseni* found in an isolated pond inside the solid ground forest

The Neotropical region presents the richest fauna of anurans amphibians (frogs, toads and treefrogs) in the world. Especially diverse faunas occur in warm and moist tropical locations, as in the Amazon Basin: about 600 species are known from this region, but several studies indicate that these numbers are clearly underestimated. A question of central interest for community ecologists is how is possible the coexistence of species, in particular in 'biodiversity hotspots' such as tropical rainforests. Ecological and evolutionary processes operating at different temporal and spatial scales influence community structure and species distribution. However, relatively few are the studies on Amazonian anuran communities, and many of them are restricted to breeding site choice and breeding phenology based on male calling activity. The larval phase (tadpoles), recognized in many species as the period in the life cycle when most of

mortality occurs and thus important in the regulation of adult populations, has been comparatively neglected in field and taxonomic studies. Recent research projects are increasing our knowledge about tadpole assemblages in the Neotropics, including Central Amazonia, where aspects of taxonomy, morphology, natural history and ecology have been investigated. However, they answer only a small fraction of the interesting questions about tadpoles and their life histories. This project focuses on the species composition, habitat use, natural history and ecology of the tadpole communities of "terra firme" forests and floodplain lakes in Central Amazonia, which present high diversity of species, reproductive modes, and larval eco-morphotypes. Special attention is given to morphological characteristics, development and the patterns in resource utilization; moreover, the effects of biotic (predation) and abiotic factors (habitat structure and water quality) that contribute to current community structure were determined.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

This research project began in 2011 with the title “Tadpoles of Atlantic Forest, Amazonia, Pantanal, Cerrado (Brazilian Savannah) and Transition Zones: Morphological Characteristics, Spatial Distribution and Diversity Patterns” (SISBIOTA Program, CNPq 563075/2010-4; FAPESP 10/52321-7). In the Central Amazonia, the team collected tadpoles of 68 anuran species belonging to 8 families and 23 genera. The most common developmental site was free water, including lentic (ponds and phytotelms) or lotic (streams). Of the 68 species for which enough data are available, 19 species occur in isolated forest ponds, 25 in streamside ponds, eight in streams inside forest, three in phytotelms, 21 in lentic or lotic water bodies in forest edge, 16 in the várzea lake, and six species present a complete endotrophic development or terrestrial development (away from water in the leaf litter, burrows, or subterranean chambers). These latter tadpoles have different degrees of reduction of structures associated with feeding, swimming and respiration. Tadpoles exhibited great morphological diversity, from tadpoles with generalized morphology to highly specialized, such as the species found in the streams. Much of this morphological variation involves differences in body shape, size and shape of the fins and structures of oral disc, some of them directly associated with the use of the available resources. A great variety of organisms was found preying upon the tadpoles, including invertebrates (belostomatids, dragonfly naiads) as well as Vertebrates (fish, tadpoles). The community structure of tadpoles occurring at streamside ponds was determined by characteristics of the habitat, such as number of ponds, floodplain width, and quality of the water and also by the abundance of predators (invertebrates and vertebrates). On the other hand, the tadpole communities in the várzea lake were structured by characteristics of the water and by spatial factors. These results indicates that the tadpole communities of the principal habitat types of the Amazonia (“terra firme” forests and “várzea” floodplains) were determined by different processes (niche-based and spatial), possibly demanding different actions to conservation of the anuran diversity in these habitats.



Figure 2. From left to right: 1) tadpole school of the treefrog *Hypsiboas geographicus* in a streamside pond; 2) lateral view, dorsal view and oral disc of the tadpole of *Leptodactylus rhodomystax*

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GENETIC STRUCTURE AND MATING SYSTEM OF LOCAL VARIETIES AND WILD POPULATIONS OF ANNATTO (*BIXA ORELLANA* L.) IN BRAZILIAN AMAZONIA AND CENTRAL BRAZIL USING MICROSATELLITE MARKERS

Principal Investigator (PI): Elizabeth Ann Veasey

Higher School of Agriculture "Luiz de Queiroz" / University of São Paulo (USP)

FAPESP # 2012/08307-5 | Term: Aug 2012 to Jan 2015

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Figure 1. Annatto (*Bixa orellana*) grown in the germplasm bank of Instituto Agronômico (IAC) (Dequigiovanni, 2013)

The annatto (*Bixa orellana* L.) has great economic importance because it is the only source of a natural pigment, bixin, used as a natural dye in the pharmaceutical, textile, dairy, food, beverage, paint and cosmetic industries. This project aims to study the genetic diversity and structure, as well as the reproductive system of local varieties and wild populations of annatto in Brazil. For that, microsatellite primers will be developed for the species by means of a microsatellite-enriched genomic library. Local varieties of annatto will be collected along two axes in the Amazon Basin - north-south (Rio Mamore, Madeira, Negro and White) and west-east (Rio Solimões and Amazonas), in the surroundings of Belém, in Central Brasil (Cuiabá - Porto Velho), as well as wild populations collected in the states of Amazonas, Rondônia and Roraima, to detect possible centers of diversity. The mating system will be studied with a hierarchical design of fruit and individuals from wild and cultivated populations of annatto. Various parameters of genetic diversity and population structure will be estimated. Bayesian analyses, plus cluster and principal coordinate analyses will be conducted in order to evaluate the relationship among the accessions and populations. For the reproductive system study, 10 plants will be used of a wild population and a local variety population, where 20 progenies will be evaluated per plant. From this analysis, multilocus and single locus outcrossing rates will be estimated, as well as other related parameters. Information about genetic diversity and structure and the reproductive system will help to guide future prospectations for breeding programs, as well as plan for the *in situ* and *ex situ* conservation of annatto in Brazil.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Annatto (*Bixa orellana*) (Figure 1), which belongs to the family Bixaceae, is a tropical crop originated from the Americas, most probably from the Amazon region. The project aims to evaluate, using molecular markers, a collection of 200 samples of annatto (*Bixa orellana*) obtained in home gardens of riverine communities of agriculturists in the Amazon along the rivers: upper Rio Madeira; Rio Mamore; Rio Madeira-Purus, near Manaus; Rio Negro, near Barcelos; Rio Solimões; Rio Amazonas; and Rio Branco in Roraima. A total of 375 samples were also collected during the project in the State of Rondônia, including 193 cultivated varieties collected in 22 farmers households, 167 wild accessions, not domesticated, and 18 materials where it was not possible to determine the stage of domestication. The 200 samples obtained in the States of Amazonas and Roraima were collected by researchers from the National Institute of Amazonian Research (INPA), and the remainder by ESALQ/USP researchers in the State of Rondônia. For each population leaves, were sampled from several individual plants and geographic coordinates registered. In Rondônia, samples were collected in the municipalities of Corumbiara, Pimenteiras do Oeste, Cerejeiras, Cabixi, Rolim de Moura, São Domingos do Guaporé, São Francisco do Guaporé, Ji-Paraná, Ariquemes, Rio Crespo and Porto Velho. Interestingly, the wild accessions of annatto were all observed occurring at the edge of small streams, always in open areas where plants were exposed to the sun for most of the day. Another collection is scheduled to be held in the State of Para, near the city of Belém, to make the sampling more representatives. However, excessive rainfall in the region is delaying the timing of such collections. The annatto samples collected will be evaluated with microsatellite markers. For this, microsatellite primers were developed for the species *Bixa orellana* through an enriched genomic DNA library. A total of 24 primers were developed, and they will be used to evaluate the collected samples up to December 2014. The project is being conducted with the collaboration of researchers from INPA and Federal University of Amazonas, both in Manaus, AM, where part of the genetic analyses will be held, from the Agronomic Institute (IAC), in Campinas, SP, from Pólo Apta Centro Sul (APTA) and from ESALQ/USP, both in Piracicaba, SP. One of the objectives of the project is to assess the level of genetic variability among the sampled regions. Another aim is to compare the level of genetic diversity among wild and cultivated varieties of annatto, with molecular markers, and also to compare the reproductive system of both cultivated and wild varieties. Morphological differences were observed among the annatto varieties collected, such as fruits or capsules with yellow, yellowish red, red, green and pink colors. Fruits were also observed with different shapes, such as flat capsules and heart-shaped capsules. And the main difference observed between cultivated and wild varieties is the fruit size, with capsules of wild varieties of much smaller size in comparison with cultivated varieties, and lower number of seeds in the wild varieties.

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PRODUCTION OF SPECIAL LIPIDS BY ENZYMATIC INTERESTERIFICATION OF EXOTIC OILS FROM AMAZON: ASSESSING THE BIOCHEMICAL POTENTIAL OF NEW PRODUCTS

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co-PIs: Ana Paula Badan Ribeiro, Paula Speranza, Juliana Alves Macedo

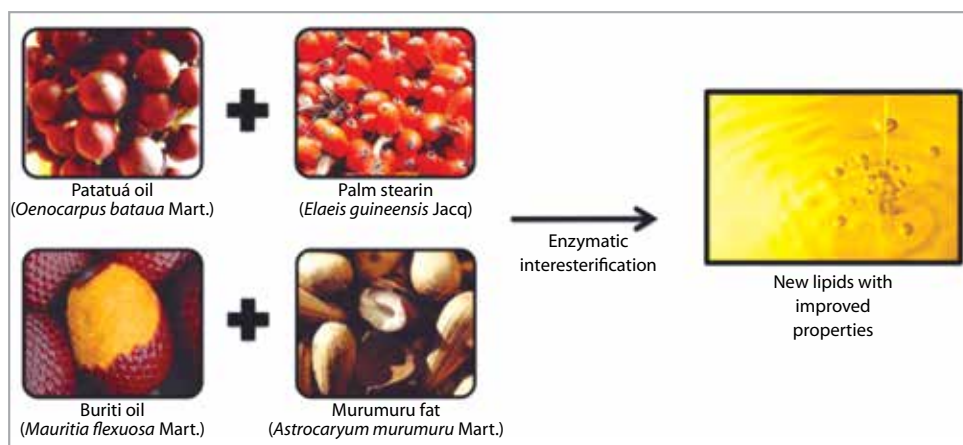


Figure 1. Enzymatic interesterification of the Amazonian oils

The enzymatic interesterification is used to restructure triacylglycerol, inducing exchange of the fatty acid in the glycerol structure. The changes in the original triacylglycerol composition can modify the physical, chemical and biological properties of the produced lipid, increasing its potential application.

Due to the mild reaction conditions and the specificity of lipases, the enzymatic interesterification is an appropriate technique for the production of interesterified lipids for functional and medicinal applications. The oils and fats from Amazonian in this context are highlighted; these oils, although they are popularly known for their potential use, are underexplored. The use of these oils and fats in enzymatic interesterification reactions can promote the formation of new lipid structures whose characteristics are most appropriate to apply them in cosmetics, pharmaceuticals and foods products. However, although this technique is already used for some time, the number of lipases used is still limited; few are able to act effectively. The conditions under which reactions occur and variations in the types of substrates require that these enzymes are robust and have different specificities. The search for new lipases with these characteristics is still a major challenge in these reactions. Thus, this study aimed to produce, characterize and evaluate the biological properties of interesterified Amazonian oils produced by different lipases. Two blends of Amazonian oils are subjected to enzymatic interesterification: the first one is composed by buriti oil and murumuru fat and the second one is composed by patauá oil and palm stearin. The interesterification reactions are catalyzed by two microbial lipases in three different enzymatic systems: one with a commercial lipase Lipozyme-TL-IM (Novozymes); a second with a lipase from the microorganism *Rhizopus sp.*; and the third with a mixture of both lipases (commercial and *Rhizopus sp.*).

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

For the buriti/murumuru blend, depending on the enzyme used, the lipids produced presented different characteristics. The lipase from *Rhizopus sp.* besides being specific for the sn-1,3 positions of triacylglycerol was specific for the type of fatty acids (unsaturated). The commercial lipase was specific only for the type of fatty acids (unsaturated), while the use of both enzymes showed no synergistic effect in this blend; the results were intermediate to those obtained with the individual enzymes. In the three enzymatic systems, there was a reduction in the types of triacylglycerols with formation of predominantly mono- and di-unsaturated lipids. For the patauá:palm stearin blend, the type of lipase used to catalyze the reaction also influenced the type of lipid formed. The lipase from *Rhizopus sp.* is specific for the type of fatty acid (unsaturated), while commercial lipase showed no specificity to this blend. In the system with both enzymes, no synergistic effect

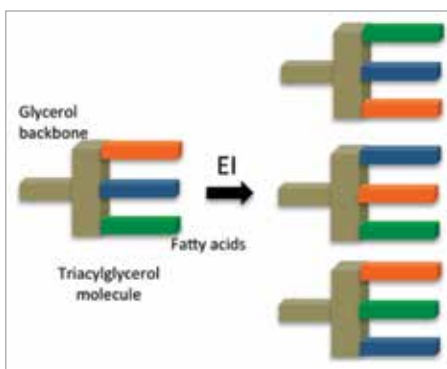


Figure 2. Specificity of lipases for enzymatic interesterification reactions

was observed; the results obtained were similar to those obtained with the enzyme from *Rhizopus sp.* With the three enzymatic systems, there was a reduction in the types of triacylglycerols with the formation of predominantly mono- and di-unsaturated lipids. The buriti/murumuru and patauá/palm stearin blends, after interesterification, maintained the high concentration of tocopherols, carotenoids and phenolics, indicating that the interesterification did not influence the concentration of minor compounds. Interesterification of these oils and fats influence the physical characteristics of emulsions and these characteristics influence the antimicrobial activity of these lipids. Emulsions produced with interesterified lipids showed lower droplet size and higher antimicrobial activity (bactericidal effect); emulsions produced with non-interesterified blends showed larger droplet size and lower antimicrobial activity (bacteriostatic effect). Therefore, lipases were able to catalyze the interesterification reactions between Amazonian oils, indicating the potential of these catalysts in these reactions. Lipid fractions obtained showed antimicrobial activity, which encourages more detailed biological studies. Enzymatic interesterification of the Amazonian oils can expand the range of applications, ensuring a greater supply of ingredients for the development of products that have broad technological and functional properties.

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NET ECOSYSTEM EXCHANGE OF THE LOWER AMAZON RIVER – FROM LAND TO THE OCEAN AND ATMOSPHERE

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FAPESP # 2012/51187-0 | Term: May 2013 to Apr 2017 | FAPESP Research Program on Global Climate Change (RPGCC)

São Paulo Excellence Chair (SPEC)

co-PI: Alex Vladimir Krusche



Figure 1. The B/M Mirage, at the Macapá "south" channel

Recent research rejects the traditional perspective that rivers are simply passive pipes exporting material to the ocean. In fact, processes occurring in rivers play a critical role transporting and recycling carbon and nutrients, not only within watersheds but also in marine receiving waters. This paradigm shift results from new knowledge that rivers and other inland waters outgas immense quantities of CO₂ to the atmosphere. Globally, inland waters process, transport and bury ~2.7 Pg C y⁻¹, which nearly equals the current estimate of the terrestrial sink for anthropogenic C (2.8 Pg C y⁻¹). Hence, carbon cycling in rivers relocates and/or mitigates terrestrial sequestration. Depending on the magnitude of these riverine fluxes, the global terrestrial CO₂ sink may prove to be smaller than presently estimated because rivers may be mobilizing and remineralizing a significant component of the pool that is currently considered to be sequestered in soils. The impact of fluvial nutrient delivery on the carbon balance of coastal plumes is becoming increasingly recognized. For example, the entire tropical North Atlantic Ocean is generally considered a net source of ~30 Tg C y⁻¹ to the atmosphere, but there is a C sink of ~28 Tg C y⁻¹ in the Amazon plume, likely due to nutrient inputs from the Amazon. This effectively reverses the normal tropical surface ocean condition and leads to CO₂ uptake in areas that would otherwise be outgassing. However, calculating the magnitude of this is dependent on knowing the river end members of nutrients, DIC and alkalinity, but that end member is currently very poorly constrained, with no high quality data available. TROCAS seeks to unravel the sequence of processes and source(s) of terrestrially-derived organic matter (OM) that culminate in the immense CO₂ outgassing to the atmosphere from tropical rivers world-wide, with an immediate focus on the lower Amazon River. What are the sources and magnitudes of carbon of terrestrial origin, by fraction, relative to aquatic sources from phytoplankton and macrophytes, in the different sectors of the river system? How much carbon is discharged to the ocean, relative to the atmosphere?

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The strategy for *TROCAS* is to mobilize a river boat-laboratory, to conduct cruises over the lower Amazon, from Macapá to Óbidos and back to Macapá. The B/M *Mirage* was set up with the necessary generators and electrical networks, freezer and refrigerators, air-conditioned lab enclosures and sleeping quarters, outboard support boat, etc to support the cruises. Sophisticated sampling and laboratory equipment were installed. The first cruise, *TROCAS I*, was conducted, April 26-May 10, 2014, with a team of 8 scientists and 4 crewmembers. The timing coincided with historic high flow of the Amazon, resulting in direct measurements for the highest flow ever measured of freshwater to the ocean (335,000 m³/s). Full main stem cross sections were conducted at Óbidos, Almeirim and the Macapá North and South channels. Stations were taken in the Tapajós and Xingú rivers, with spot samples from várzea waters. At each main stem station, ADCP profiles (to measure discharge) were taken (for the tidally influenced lower river, repeat transects over 13 hours detailed the tidal cycle), along with measurements of micrometeorology and the optical properties of the different

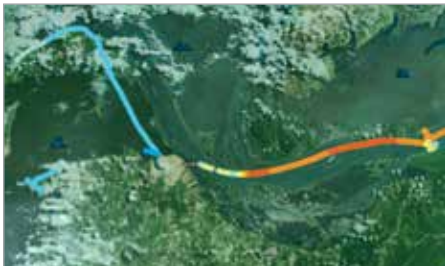


Figure 2. Continuous in-river profiles of pCO₂ from Óbidos to below Santarém

water masses (for future remote sensing calibration). A winch-deployed submersible pump took water samples from the surface and 50% of depth. Chemistry samples were taken for routine parameters (O₂ etc) and detailed organics. A continuous flow sampling

system was setup, making continuous pCO₂ profiling up and down the river possible. With an instrumented incubator system and a Picarro field-portable isotope analyzer, measurements of the δ¹³C value of respired and outgassed CO₂ and CH₄ were made. Determining the organic compounds fueling respiration by quantifying organic compounds present before and after incubations using ultra-high resolution mass spectrometry-based metabolomics is a key strategic element. Stable isotope probing experiments were conducted, with the equilibrated closed incubator system connected to the isotope analyzer. Preliminary results imply that a significant proportion of the natural lignin that is degraded in the river is converted to CO₂ and subsequently outgassed from the river. The natural abundance of *in situ* dissolved oxygen isotopes (δ¹⁸O-O₂) under steady-state conditions provide an estimate of metabolic state integrated over a distance of upstream river-reach that contributes to oxygen dynamics at a given site. Results will be integrated with coupled modeling system. The VIC basin hydrology model and the SIsBaHia hydrodynamic model will be used to integrate results for evaluating the terms of Net Ecosystem Exchange.

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ASSEMBLY AND EVOLUTION OF THE AMAZONIAN BIOTA AND ITS ENVIRONMENT: AN INTEGRATED APPROACH

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FAPESP # 2012/50260-6 | Term: Sep 2012 to Aug 2017 | BIOTA-FAPESP Program

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Figure 1. Amazonian flora and fauna

The Amazon is one of the most bio diverse areas on Earth; however, little is still known about the processes that led to such great diversity. Indeed, many uncertainties remain about its geologic history, age of formation, and extension of its terrestrial and aquatic systems. For instance, while some models claim that the Amazon was established during mid-Miocene, others established its origin in the Pleistocene. The resolution of these historical uncertainties and a better understanding of how the Amazonian biota has responded to past paleogeographic/climatic events are of extreme importance for a better understanding of the processes associated with the generation and maintenance of its biodiversity. This knowledge is also vital for predicting the future of this extremely important biome. This project aims to achieve a new evolutionary and environmental synthesis of Amazonia biodiversity, integrating findings from phylogenetics, historical biogeography, phylogeography, remote sensing, geology and biogeochemical cycles, from the Neogene to present. New geological data and biological studies with plants, butterflies, birds and primates will help solve several uncertainties on the mechanisms responsible for the diversification, spatial organization and dynamics of Amazonia over the last 20 million years. This project aims to answer:

- (1) How species diversity is distributed and organized at varying spatial scales into common distribution patterns?
- (2) What has been the phylogenetic history and pattern of diversification of Amazonian taxa?
- (3) What has been the paleogeographical history of the Amazonian drainage system and terrestrial tropical Amazonia, particularly in the west, and since the latest Neogene when the world became cooler and drier and the effects of climate forcing more pronounced?
- (4) To what extent do large-changes in ecosystem structure relate to the distribution of species and ecosystem diversity?
- (5) How did the history of Amazonia influence global-scale changes in biogeochemical cycling?

TRACING THE DISPERSAL OF SWEET AND BITTER MANIOC IN BRAZILIAN AMAZONIA WITH CHLOROPLAST AND NUCLEAR GENETIC MARKERS

Principal Investigator (PI): Maria Imaculada Zucchi

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FAPESP # 2013/00003-0 | Term: Jun 2013 to May 2015

co-PIs: Alessandro Alves-Pereira, Charles R. Clement, Doriane P. Rodrigues, Elizabeth Ann Veasey, José B. Pinheiro



Figure 1. Domesticated manioc is an herbaceous shrub that store large amounts of starch in its tuberous roots

Manioc or cassava (*Manihot esculenta* ssp. *esculenta* Crantz) was domesticated in the southwestern Amazon basin and currently is the main source of calories for more than 800 million people in the world, especially in the tropics. After its initial domestication, divergent selection pressures gave rise to two major groups of varieties (sweet and bitter manioc), which differ in their contents of toxic compounds (cyanogenic glucosides). Although there is some overlap, especially in Brazilian Amazonia, these groups of varieties have distinct patterns of distribution, which may be the outcome of limited processes of contact and interchange between varieties during the crop's domestication and dispersal history. The evolutionary history of a crop may be partly understood by studying the organization of its genetic diversity within and among its domesticated populations. Few studies have evaluated how the genetic diversity of manioc is organized across its geographic distribution, and there are no genomic

population studies with manioc varieties. The main goal of this research is to evaluate, with different molecular markers, the genomic and genetic diversity and structure, and the phylogeography of manioc varieties traditionally grown along the major rivers of Brazilian Amazonia. The current genetic diversity and structure will be evaluated with nuclear microsatellites markers (ncSSR), while historical patterns of the organization of genetic diversity (phylogeography) will be evaluated with chloroplast microsatellites (cpSSR). Novel information on the genomic basis for the distinction between sweet and bitter varieties, as well as possible distinct patterns of dispersal, will be generated with SNPs detected with Restriction-site associated DNA sequencing (RAD-seq). We expect to contribute to the understanding of manioc's dispersal across the Amazon basin after its initial domestication, as well as to the understanding of the genomic basis for the differentiation between sweet and bitter manioc. This information may help identify centers of genetic diversity of the crop, which in turn may be useful for the management and conservation of its genetic resources, and also for manioc's numerous breeding programs.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

A total of 38 municipalities along five major rivers of the Brazilian Amazon basin (Madeira, Negro, Branco, Solimões and Amazonas) in four different states (Amazonas, Pará, Rondônia and Roraima) were visited. A total of 542 manioc varieties were sampled (307 bitter, 219 sweet, and 17 non-designated), and also 28 plants of *Manihot esculenta* ssp. *flabellifolia*, the wild relative of manioc. Due to the high costs of the RAD-seq technique, 87 individuals were selected for SNP discovery, which is being carried at the moment. The current genetic diversity and structure is also being evaluated. Ten ncSSR markers were tested, and all were polymorphic. Results of a preliminary trial with 68 individuals showed that the ncSSR revealed high values of genetic diversity, with an average of five alleles per locus (ranging from two to eight), and average expected heterozygosity of 0.630, ranging from 0.098 to 0.793 over loci. These preliminary results show the potential of these ncSSR markers for detecting genetic variation of manioc varieties from different localities. For the phylogeographic analysis, ten universal cpSSR loci for dicotyledonous species were tested, and three of them were polymorphic. The analyses showed that the groups of sweet and bitter varieties had similar levels of genetic and haplotypic diversity, and that both were more diverse than the group of wild plants, probably because only three municipalities were visited where wild plants could be collected. There were no chlorotypes (combinations of different cpSSR alleles) associated specifically with bitter or sweet varieties, nor to the major river basins. Instead, the most frequent chlorotype was shared by sweet and bitter varieties. All wild plants, except one, shared another chlorotype that differed by two alleles from the cultivated varieties' most common chlorotype. Due to these results, the genetic divergence found between the groups of sweet and bitter varieties was very low ($F_{ST} = 0.001$), in contrast to that found between the groups of cultivated varieties in relation to the wild plant group ($F_{ST} = 0.76$). The low level of genetic divergence between sweet and bitter manioc, and the absence of associations of chlorotypes with groups of manioc varieties, is probably due to the features of the traditional management employed by the communities of farmers in Amazonia. This management permits gene flow between manioc plants in the fields, and also genotype flow, since exchange of varieties among different farm families, communities, and municipalities is a common and widespread practice of traditional manioc cultivation in Amazonia. We expect a significant increment of information about the genetic diversity present in our manioc sample once the screening with ncSSR and SNP markers detected with the RAD-seq technique are completed. Our chosen ncSSR loci revealed considerable variation within a subset of the sample. The forth-coming RAD-seq essays, which typically reveal hundreds to thousands of markers with SNP variation, should expand this variation significantly, so we may expect that the final results of this project will provide robust evidence on how genetic diversity of manioc varieties is organized across different localities.

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THE ORIGIN OF THE EMERGING POPULATIONS OF THE BRACHIARIA COLLAR ROT PATHOGEN (*RHIZOCTONIA SOLANI* AG-1 IA) IN THE AMAZON AND ITS POTENTIAL FOR ADAPTATION TO ANOTHER BRAZILIAN AGROECOSYSTEM

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FAPESP # 2011/50150-3 | Term: Apr 2012 to Sep 2014 | BIOTA-FAPESP Program

co-PIs: Lina Maria Ramos Molina, Edisson Chavarro Mesa, Danilo Augusto dos Santos Pereira

Emerging plant pathogens are pathogens that have been recently introduced, discovered or newly recognized; have newly evolved; have increased in incidence, expanded geographically or in host range; or have changed pathogenic properties. An emerging fungal pathogen has the potential to become endemic, epidemic and even pandemic in nature. Devastating new fungal diseases are constantly emerging from the ecosystem. Using evolutionary theory and phylogeographical approaches, our goal is to provide a framework for evaluating the emergence of new pathogens considering the adaptability to environmental changes and the fit between new pathogen invaders and the new combinations of host/environment. We have chosen a system to study the emergence of a devastating fungal disease in Brazil: the originally rice-infecting pathogen *Rhizoctonia solani* AG-1 IA, which has a worldwide distribution and emerged as a Brachiaria pathogen in the Brazilian Amazon and the Colombian Llanos. The questions we ask in this proposal are:

- i. Was the emergence of this disease due to the introduction of the pathogen into new environments or have host-shifts occurred between geographically overlapping host species?
- ii. Was the emergence of this disease facilitated by environmental changes, such as changing habitats (eg, crop replacement, crop rotation)?
- iii. Considering the pathogen's potential for host-shifts, the corresponding hosts' susceptibility, and the fact that the pathogen has already emerged independently twice, is it possible to predict the patterns of emergence of this disease in a new agroecosystem?

Our prediction is that in Sao Paulo's Vale do Paraiba region (where Brachiaria and rice crops are geographically contiguous or overlapping) the local populations of *R. solani* AG-1 IA could also emerge as a Brachiaria pathogen.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Our first objective was to determine the etiology of the Brachiaria collar rot to determine the relative importance of the main *Rhizoctonia* species associated as pathogen of crop in the Brazilian Amazon biome and in the Colombian Llanos. In the Colombian Llanos: the soilborne basidiomycetous fungus *Rhizoctonia solani* anastomosis group AG-1 IA was the major pathogen associated with collar rot of the brachiaria grasses *B. brizantha* cv. Toledo and Brachiaria "Mulato" hybrid. In the Brazilian Amazon, we also found that *R. solani* AG-1 IA was the major *Rhizoctonia*-like pathogen associated with Brachiaria's collar rot in Rondônia State, while in Pará, besides *R. solani* AG-1 IA, we also detected the association of *R. oryzae* and *R. zea*. This information is extremely relevant to Brachiaria breeding programs aimed at selection for disease resistance because it indicated that the disease might be caused by a complex of pathogens. Unprecedentedly in Brazil, our study reported the association of *R. solani* AG-1 IF with leaf blight diseases on soybeans and cowpea, two sympatric crops to Brachiaria pastures in the Amazon (Roraima State). *R. solani* AG-1 IF was also pathogenic to Brachiaria. In this study we also asked the following question: Was the emergence of this disease due to host-shifts or host-jumps occurred between geographically overlapping host species? To address this question, sympatric host-distinct populations of *R. solani* AG-1 IA from Brachiaria and rice in the Colombian Llanos or Brachiaria and soybean in the Brazilian Amazon (N = 335 isolates) were genotyped using nine microsatellite (SSR) loci. Patterns of historical asymmetrical migration between pathogen populations indicated the probable origin of current populations that infect Brachiaria in Colombia was from populations that originally infected rice. In Brazil, in contrast, we could not establish such a clear asymmetric migration route since migration rates among populations were all similar in magnitude (average of 12.8 migrants/generation). However, these high migration rates suggested that the pathogen had the ability to jump between a Poaceae and a Fabaceae host. We also determined whether adaptation to infect Brachiaria promoted phenotypic differences on populations of *R. solani* AG-1 IA originated from distinct hosts. The Brachiaria-infecting *R. solani* AG-1 IA populations were still cross-pathogenic to rice and these populations were also capable of infecting both cowpea and soybeans.

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PHYLOGEOGRAPHY AND POPULATIONAL GENETIC STRUCTURE OF NEOTROPICAL SPIDER SPECIES (ARACHNIDA, ARANEAE)

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FAPESP # 2012/02526-7 | Term: Dec 2012 to Nov 2014



Figure 1. *Nephila clavipes* (photo by J.R.Trigo)

There is a general agreement that the evolutionary history of Neotropical diversity is very complex and still poorly understood. The two main Neotropical rainforests, the Amazon and the Atlantic, are separated by a zone of open vegetation known as dry diagonal, comprising the Caatinga, Cerrado (Brazilian Savannah) and Chaco, which had been considered a restriction for species migrations. However, vegetation maps show forest fragments through the dry area, suggesting the two forests were connected in the past. Some findings have supported this hypothesis, although the studies are still scarce in Brazil, only a few taxa have been already investigated and most studies focus on a single biome. The study of species with broad geographic ranges can provide interesting information about the history of Neotropical biodiversity. Phylogeographic studies of non-model organisms using a great number of loci are now possible with the new methods of DNA sequencing together with bio computational tools. The objective of the project is to provide inferences about the evolutionary history of the main Neotropical biomes, by a comparative phylogeography study of spider species that can be found in most parts of Neotropics and that have a phylogenetic history in this region: *Araneus venatrix*, *A. omnicolor* and *Argiope argentata* (Araneidae), *Aglaoctenus lagotis*, *A. castaneus* and *A. oblongus* (Lycosidae) and *Nephila clavipes* and *N. sexpunctata* (Nephilidae).

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

We aimed to cover the main biomes, sampling on 56 sites along the Brazilian Amazonia, the Atlantic Rainforest, the Cerrado (Brazilian Savannah) and the Chaco. So far, we have analyzed partial sequences of nuclear ITS2 for *A.venatrix* and partial sequences of mitochondrial COI gene for all species. The development of nuclear markers is in progress.

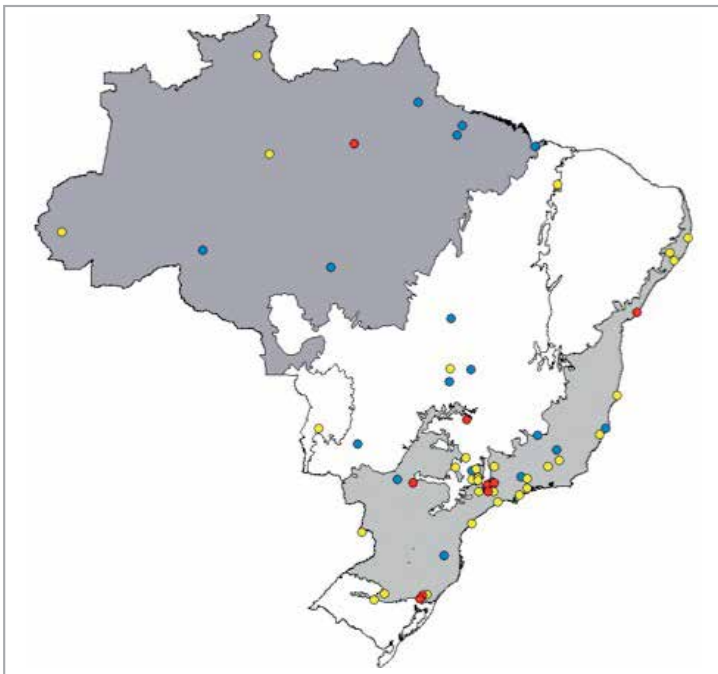


Figure 2. Sample sites in Brazil

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BIODIVERSITY AND ENDEMIC PATTERNS OF MAJOIDEA (CRUSTACEA, DECAPODA, BRACHYURA) IN BRAZIL

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FAPESP # 2013/01201-0 | Term: Jun 2013 to May 2015 | BIOTA-FAPESP Program

co-PI: Marcos Domingos Siqueira Tavares

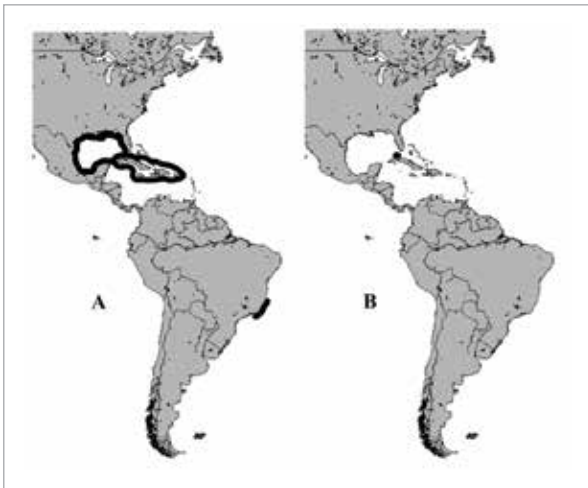


Figure 1. Distributional pattern of *Collodes armatus* Rathbun, 1898. A, previous records for this species. B, known locality where this species is found after analyzing the museum material

The order Decapoda is the most diverse group within Crustacea. In this context, the infraorder Brachyura has, approximately, 6,900 known species. Within the Brachyura, the superfamily Majoidea is a large group and shows great morphological diversity, including the biggest known arthropods and very small species. Several species of this superfamily have a great ecological importance, mainly in the maintenance of the reef environments where they are commonly found. Among the Brachyura, roughly 400 marine species are found on the Brazilian coast. Specifically for Majoidea, this number is approximately 80, with 44 presenting a disjunctive distribution between the Caribbean Sea and Western South Atlantic. The idea that disjunctive patterns of distribution between the Caribbean Sea and Western South Atlantic are common is largely widespread in the scientific literature. However, these patterns remain untested for many groups, which make difficult to interpret such patterns as natural or resulting from low taxonomic resolution. Besides the low taxonomic resolution, three possibilities can explain such patterns:

- (i) the low quantity of sampled material in the region;
- (ii) natural pattern with the mouth of the Amazon River acting as a biogeographical barrier;
- (iii) and the possibility of these species are formed by complexes difficult to identify.

The present project aims to evaluate in large scale the biodiversity and the endemic patterns of Majoidea in the Western Atlantic Ocean, with the Brazilian coast as a priority, through detailed morphological studies of the Majoidea species. In addition, specific objective are to describe possible new genus and species and establish synonymies, upgrade the distribution patterns of the species studied, and recognize possible complexes of species.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Until now, 23 of the 44 Majoidea species, with disjoint distribution between the Caribbean and Brazilian waters, were studied from material deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP), National Museum of Natural History, Smithsonian Institution (USNM) and Museu Nacional do Rio de Janeiro (MNRJ). Differences found among the studied species suggest that at least five of them cannot be considered the same species in the two studied area. Additionally, no less than other four species do not occur in Brazilian waters, as suggested by previous studies. That is the case for *Collodes armatus* (Figure 1) which was thought to occur in all Gulf of Mexico, Antilles and in the states of Espírito Santo and Rio de Janeiro in Brazil (Figure 1 A). However, studying the material from different areas, we believe that this species is known only in the type locality (Figure 1B) and the other records are related to misidentification problems. This pattern is expected to be found for other analyzed species, especially for those who have disjoint distribution in the Amazon area. The next step in this project is to study the material from the North region of Brazil, visiting the Museu Paraense Emílio Goeldi (MPEG). In that region, the Amazon River forms a very important bio geographical barrier, and beyond that, we observe a low number of specific studies about the decapod fauna of that area. Both hypotheses are being carefully analyzed to determine if this pattern of distribution is natural or specific studies targeting the decapods fauna of the area needs to be improved. Furthermore, we found two new species and a new genus of the Hymenosomatidae, a family with old controversies about its inclusion in Majoidea. We studied material from several states of the Northeastern region of Brazil and Rio de Janeiro. Despite of being a large group, Hymenosomatidae comprises several very small and cryptic poorly studied species, especially in Brazil, with several species known from their type material only. Our findings suggest that this group could be much more numerous and abundant than previously thought.

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NEUTRAL WIND AND TEMPERATURE MEASUREMENTS IN THE UPPER ATMOSPHERE AND IONOSPHERE IN THE BRAZILIAN AMAZON REGION

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FAPESP Process 2011/51661-1 | Term: Aug 2012 to Jul 2014

co-PIs: José Augusto Bittencourt, Daniele Cristina Amorim

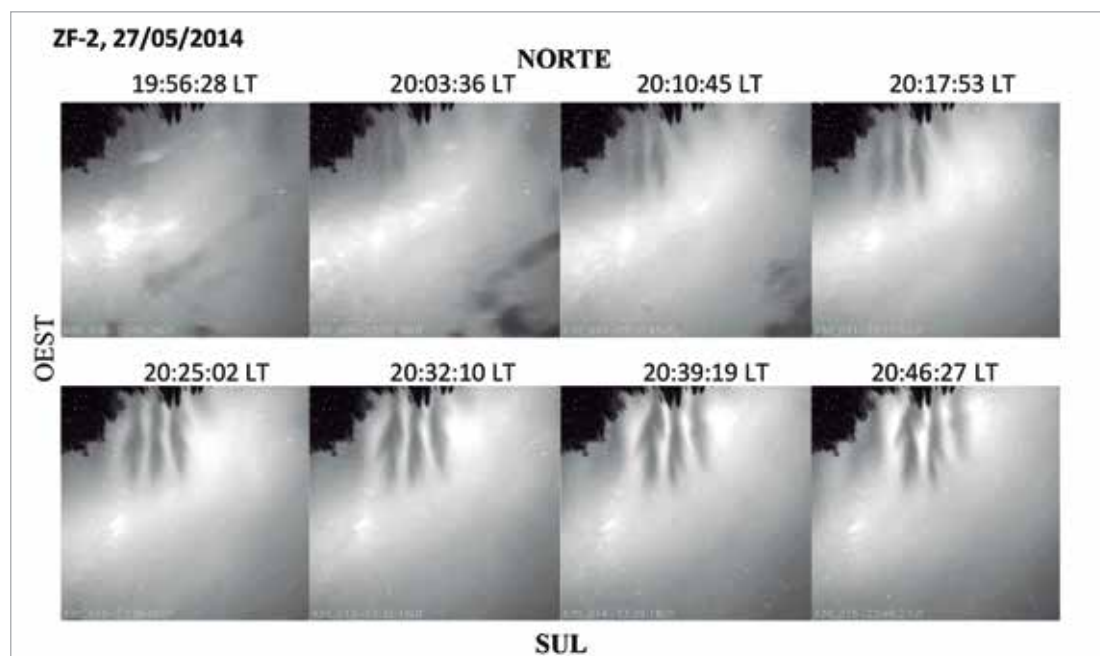
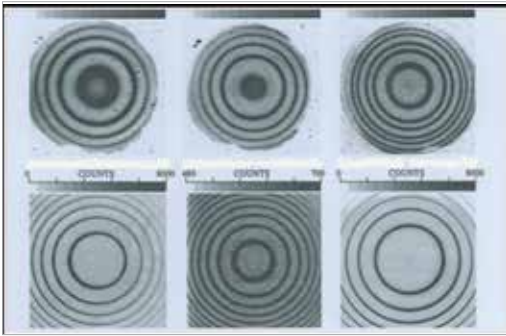


Figure 1. Plasma bubble structure in the OI 630 nm airglow emission. Data were recorded from ZF-2 in the Amazon region, 27/05/2014

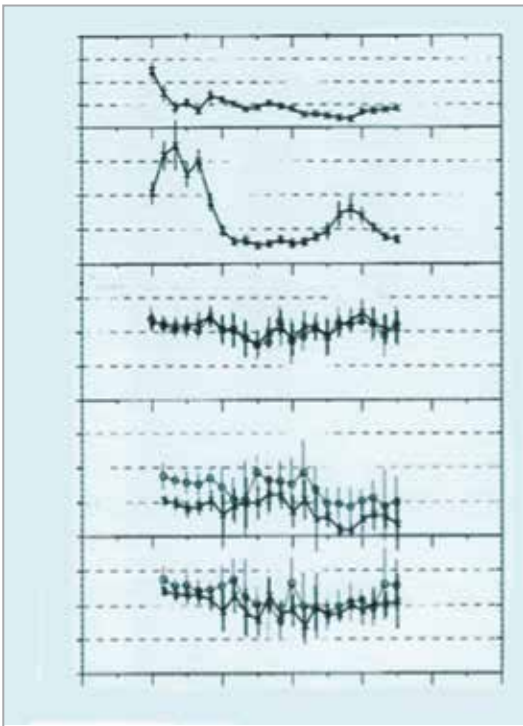
The wind and temperature measurement in the upper atmosphere and ionosphere are important not only for a good understanding of the dynamics of the ionosphere, but also to their effects on the dynamics of neutral atmosphere. In addition, ionospheric wind and temperature are essential input parameters for modelling the tropical thermosphere and ionosphere. Observation of the OI 630 nm nightglow emission using the Fabry-Perot interferometer is an important tool to measure temperature and wind. We have developed a new three-channel Fabry-Perot (FPI) with three thermoelectric-cooled CCD detectors to measure neutral winds and temperature for wavelengths OI 630.0 nm (200-300km), 557.7 nm (96 km) and 839.9 nm (OH, 86 km) simultaneously with a time resolution of 20 min, using three cooled CCD detectors. The fringe drift that is due to changes in temperature of the etalon is monitored with a frequency-stabilized He-Ne laser. The system is fully automated and has been in operation since June 2014 at the ZF-2 Observatory in the Amazon region. It is fully automated and controlled by personal computers.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES



Examples of the fringes on June 28, 2014. In the upward, from left to right, we have airglow emissions in the 630 nm, 557.7 nm and 839.9 nm respectively.

The exposure times used to produce the airglow fringes were 16 min for all channels; those used for the laser fringes were 3 min for channels 1 and 2 and 5 for channels 3. For channels 1 (630.0 nm and 632.8 nm) and 2 (557.7 and 543.5 nm), upward is south and left is west; for channel 3 (839.9 and 840.0 nm), upward is south and right is west. In the bottom, we have the laser fringes.



Wind, temperature, and intensities of airglow and sky-background emissions by the Fabry-Perot interferometer for 630 nm airglow on June 28, 2014. Thick and thin curves correspond to the values obtained from the inner and the outer fringes, respectively. Error bars of the wind velocities indicate the average fitting error of the sinusoidal function; those of the temperature, intensity, and background indicate the standard deviations of the values for 16 azimuthal sectors.

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IMPACT OF DEFORESTATION ON MERCURY EMISSIONS IN TROPICAL FOREST FROM THE AMAZONIAN REGION

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FAPESP # 2010/19040-4 | Term: Apr 2011 to Mar 2014

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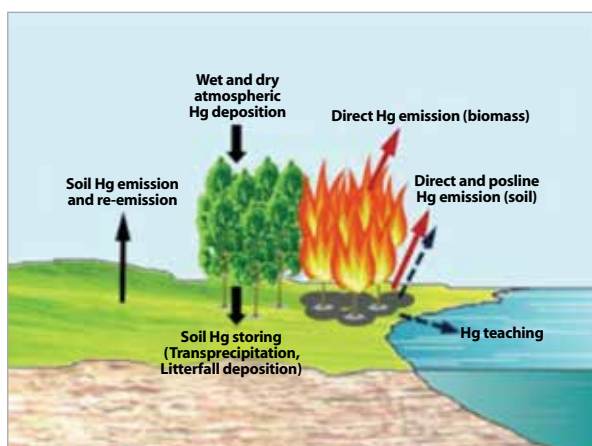


Figure 1. Impact of forest fire on the mercury cycle in forest ecosystems

Forest ecosystems are a sink of atmospheric mercury, trapping the metal in the canopy, and storing it in the forest floor after litter fall, therefore limiting its mobility in the environment and its availability to enter the aquatic food chain. In many regions, deforestation is destabilizing the entire ecosystem and among other impacts, it has been suggested that the mercury (Hg) biogeochemical cycle is strongly affected. In the Amazonian region, clearing and biomass burning are part of the land conversion process that follows colonization and can lead to Hg remobilization in a local, regional or global scale. In burned forests, Hg remobilization and its transfer toward atmosphere and aquatic system can be due to many processes: 1) volatilization of Hg present in superficial soil and in the biomass during the fire; 2) emission of Hg from soils after deforestation; 3) leaching of Hg from soil after the forest is lost. Although the importance of Hg emissions to the atmosphere from biomass burning was first recognized in the Amazonian region, published data for this region are still scarce and differ by over one order of magnitude: 6 to 108 Mg yr⁻¹. These large variations can be due to many factors such as the difference in the spatial distribution of above ground live biomass, the lack of data on soil emissions (during the fire and post deforestation), and the differences in methodologies used for emissions estimates. In order to address this lack of data, a large study was begun more than ten years ago which aimed at quantifying the consumption and emission parameters of Amazonian forest clearing fires, including Hg emissions. In the present project, field experiments were performed in Rio Branco (Acre State) in collaboration with the FAPESP thematic project (2008/04490-4) "Biomass combustion in the Amazonian forest". Analytical methods for mercury determination in different matrices were optimized and validated. Mercury emissions during fires were calculated based on the change in the Hg pool before and after the fire experiment and from soils after burning were assessed by using Teflon dynamic flux chambers.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

It was calculated that the thermal emission of mercury due to forest fire (so called "direct emission") totaled 4.1 ± 1.4 g Hg ha^{-1} , with the main component (78%) originating from litterfall and the soil O-horizon, and only 14% of the emissions originating from live biomass. This finding is in agreement with a similar study previously performed with the same methodology in Alta Floresta (Mato Grosso state). When considering the fuel burned loading, the emission factor ranged from 40 to 53 $\mu\text{g Hg kg}^{-1}$. The research suggests that, among the many factors able to influence Hg emission factor estimates for Amazonian forest burning, the burned fuel loading can be a critical point. The phenomenon of long-term release of mercury post deforestation was also assessed by monitoring soil Hg emissions using a Teflon dynamic surface flux chamber in the intact forest and in the adjacent field site both before and after the field site was cleared by burning. Daytime emission of gaseous mercury from soil averaged 0.33 ± 0.09 ng $\text{m}^{-2} \text{h}^{-1}$ in the intact forest and 74.9 ± 0.73 ng $\text{m}^{-2} \text{h}^{-1}$ after burning of the cut forest, showing that the removal of the forest cover significantly affected soil mercury flux. Deforested soil was estimated to release an additional 2.30 g $\text{ha}^{-1} \text{yr}^{-1}$ of gaseous mercury to the atmosphere, which represents an additional 50% of the mercury load released during the fire itself – a finding previously unreported in the literature. When considering an average annual deforestation rate of the Brazilian Amazon of 1.5×10^6 ha yr^{-1} for the 2000-2012 period (<http://www.obt.inpe.br/prodes/index.php>), and the overall Hg emission factor (6.4 g ha^{-1}), it can be estimated that ~ 9.6 Mg of Hg were emitted to the atmosphere each year. Thus forest fires and soil mercury emissions following forest loss may be a significant source of atmospheric mercury, at least at a regional scale; and further research is needed to more accurately estimate Hg losses from deforested ecosystems and to assess the impact of these emissions on local and regional ecosystems.

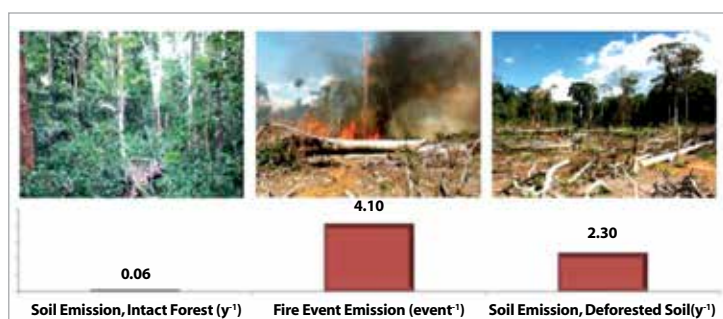


Figure 2. Annual projected atmospheric Hg emissions in forest and deforested areas

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QUANTIFICATION AND DYNAMICS OF CARBON ASSOCIATED WITH DEEP SPODIC HORIZONS OF AMAZON FOREST SOILS, TOWARDS POSSIBLE CLIMATIC CHANGED

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FAPESP # 2011/03250-2 | Term: Jun 2011 to May 2013

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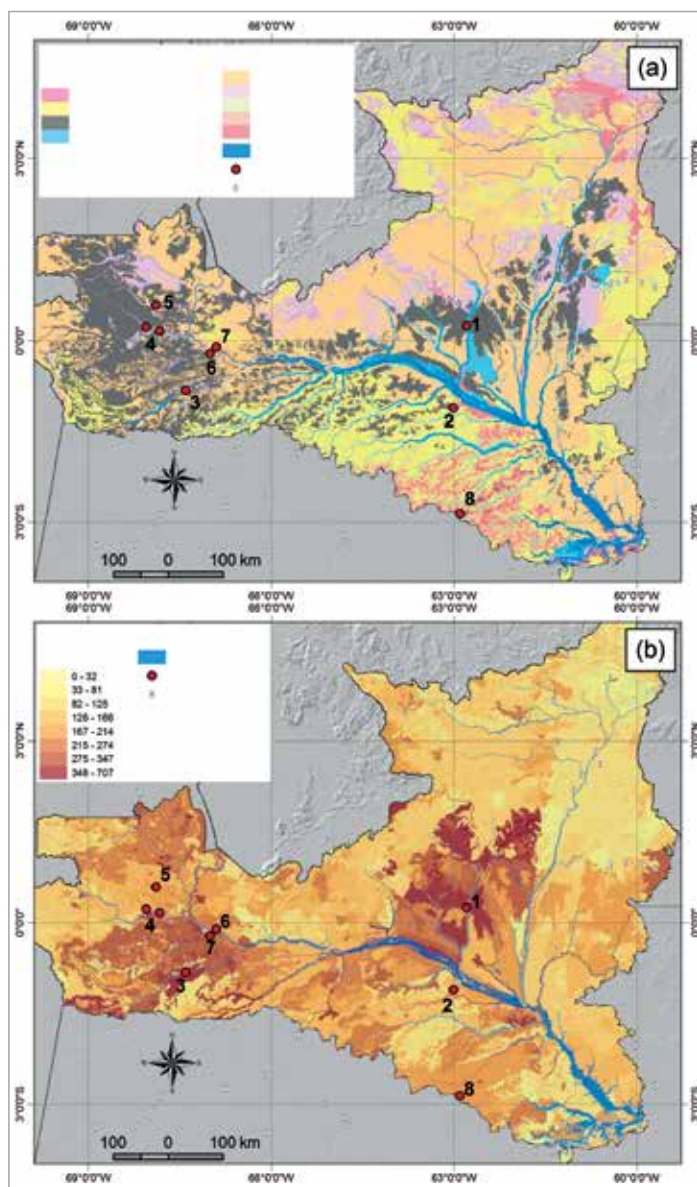


Figure 1. Soil (a) and Carbon stock (b) maps for High Rio Negro Basin. Podzols cover 22.2 % of the total area of Rio Negro basin, evidencing their importance for the quantification of carbon stock and their vulnerability toward the climatic changes. Map of Carbon stock based on data from the Project and compiled from RADAMBRASIL (1977) and IBGE (2008). The red points represent the 8 sampling areas. Elaborated by Pereira, O. J. R. (2014)

The quantification of carbon (C) stock in natural environment and the evaluation of its sensibility towards the climatic changes or land use represent a research domain in great expansion. The Amazon Region presents a large area of podzol, characterized by the presence of thick sandy horizons, overlaying more clayey horizons. The organic matter formed on the surface is transferred, by percolating waters, through the sandy horizons. Then, it is accumulated in the transition of the sandy and clayey horizons, at a depth varying from 1 to 3 meters, forming deep spodic horizons. Recent studies carried out in the Amazon Region, by part of the team-work of this project, has shown that the podzols can store over 13,6 Pg C in the deep Bh horizons. The question is to know the stability of these soils face to land use or climatic changes. In the case of the Bh horizon, the desiccation of these soils, normally saturated, could lead to a partial or total mineralization of the organic matter, resulting in the emission of a large amount of greenhouse effect gases. Therefore, the project aims to estimate the C stock in forest PS, the tax of CO₂ emission and evaluate its vulnerability under different land use and climatic conditions. It would be necessary:

- (i) to produce maps with C content, using the estimated stock, obtained by field data crossing, pedological maps and satellite image;
- (ii) to collect samples for the evaluation of organic matter vulnerability towards C mineralization, by means of quantifying the metabolism by microorganisms;
- (iii) to associate the results regarding the organic matter vulnerability with the C content maps to produce maps of C vulnerability.

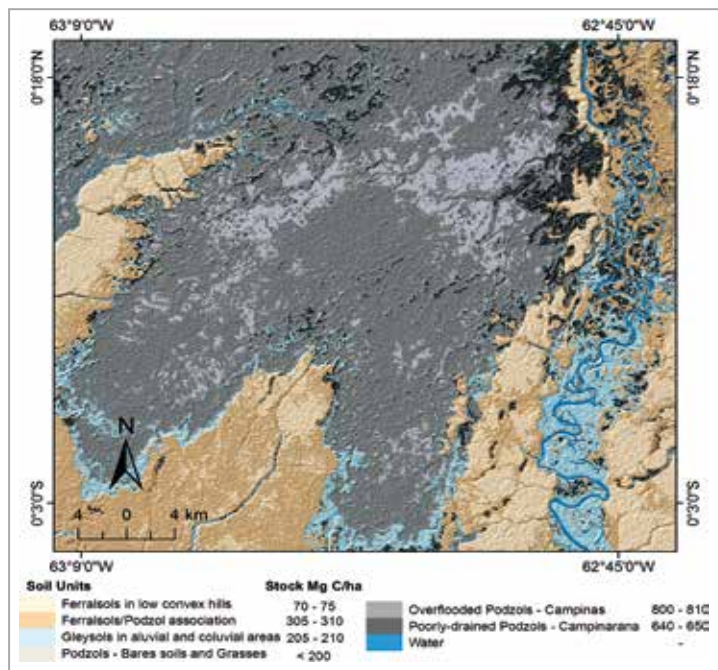
SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Eight areas were studied, resulting in the C stock map, shown in *Figure 1B*. Area 1 was selected as an example (*Figure 1*). It was shown that upper and deep soil organic matter (SOM) rich podzol horizons can vary laterally in thickness and C content, indicating that C stored in podzols is sensible to local environmental variables as soil moisture, topography, hydrological regime, geologic substratum and vegetation cover, and to regional variables like temperature and rainfall. In the area 1, 3 main situations were studied: Dense rainforest over podzols and ferralsols; the areas with better drainage (forest over low hill ferralsols and well drained podzol) have the highest C content in the topsoil (O and A horizons); podzols present a deep Bh horizon, with lower C content. 2) transition to poorly-drained podzol area; Bh show higher C content and higher thickness, exceeding 3m in Campinarana areas; 3) over flooded podzol areas, where a deep Bh was indicated. This group corresponds to herbaceous and bare soils areas. The presence of podzol in such areas was not considered in previous studies. The upper horizons in bare soil areas present low SOM content. Bare podzol areas store some C in deep Bh in smaller amounts as compared to vegetated one, probably due to low production, in topsoils, of humic substances likely to accumulate in deep Bh.

On the basis of clustering analysis and the soil map derived from the multisensor image composition, the higher C amount was found in the poorly-drained podzol areas, the lower amounts in the bare soils areas and intermediate amounts in the over flooded podzol areas. Regarding the area distribution and the soil organic carbon (SOC) stored down to 4m deep, the over flooded podzol represent 44,5 % of the area and 71,8% SOC (41% in the upper

0.5m and 30.5% in spodic horizons). The poorly-drained podzol account for

Figure 2. Soil map illustrating the association between soil types and C stock in Mg C ha⁻¹ (Megagram of carbon per hectare). Elaborated by Pereira, O. J. R. 2014



8% of the area and 10.6% SOC. The remaining mapping units represent 41.7% of the area and 17% SOC. Regions of non-podzolic soils (acrisols, ferralsols and alluvial gleysols) store less than 1% SOC in horizons deeper than 0.5 m. Previous C stock maps for these regions estimated that the podzol areas store about 380 Mg C ha⁻¹, which is much lower than our estimation of 720 Mg C ha⁻¹ as average C stock. The related stock represents an important C pool at a regional and global scale.

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BRIDGING LAND-SURFACE FLUXES AND AEROSOL CONCENTRATIONS TO TRIGGERING CONVECTIVE RAINFALL – THE GOAMAZON BOUNDARY LAYER EXPERIMENT (GOBLE)

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FAPESP # 2013/50529-8 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

US PI: Marcelo Chamecki (Pennsylvania State University)

Brazil co-PI: Antonio Ocimar Manzi (National Institute for Amazonia Research)

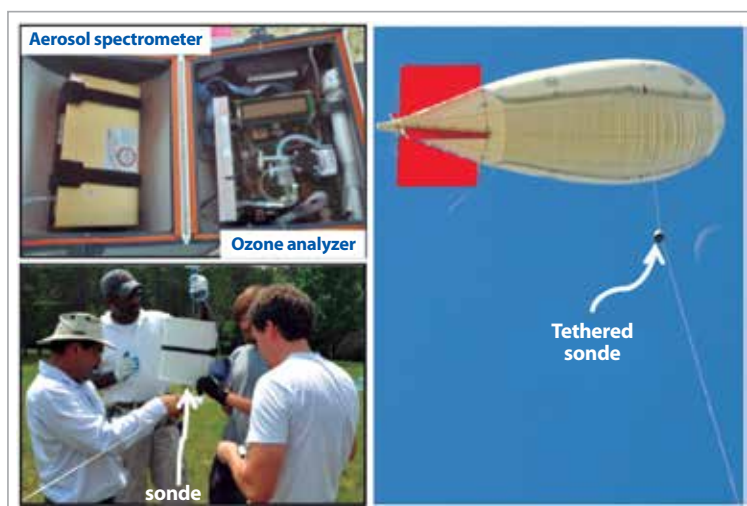


Figure 1. With the deployment of tethered balloons and flux towers, project researchers will determine the vertical distribution of plant-emitted hydrocarbons, aerosols, and cloud condensation nuclei under different thermodynamic states of the boundary layer in Amazonia.

Credits: M. Chamecki and J. Fuentes

The GOAmazon Boundary Layer Experiment (GOBLE) aims to study the lifecycle of secondary aerosols in pristine and polluted conditions in the atmospheric boundary layer (ABL) of Amazonia. The investigation spans the biological and physical conditions influencing emissions and reactions of precursors (biogenic and anthropogenic volatile organic compounds, VOCs), formation, transport of aerosols out of the ABL and their role on cloud formation and precipitation triggers.

A combination of measurements of turbulent energy, trace gas and aerosol fluxes, boundary-layer profiles with tethered balloons and model simulations will be performed for two regions in Central Amazonia: a region with (clean air) pristine forest landscape and a region largely influenced by the plume of pollution near the city of Manaus.

With innovative measurements of the vertical distribution of aerosols and cloud-condensation nuclei in the ABL and a more detailed description of dynamics and thermodynamics of the tropical stable and convective boundary layers interacting with the surface, we aim to better understand how the forest land cover influences cumulus initiation, with emphasis on how boundary-layer air is injected into the cloud layers, and how these processes are altered under the influence of pollutant outflow from a megacity like Manaus.

The project will produce new data and numerical simulations of the budgets of trace gases and aerosols in the boundary layer. This large dataset will inform innovative parameterizations to improve a Brazilian Earth System Model (BESM), currently under development in the Brazilian scientific community.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Field activities started in combination with the GOAMAZON / ARM Mobility Facility in Amazonia (AMFA) measurements in February 2014. A tethered balloon was initially deployed about 500 m away from the GoAmazon site T3, and later moved to the T1 site (pristine rainforest reserve). With the instruments on board of the tethered sonde (Figure 1), the researchers study the vertical variability of ozone, aerosol size characteristics and associated concentrations, and meteorological conditions. The balloon can be flown to an altitude of 1800 m, and two additional balloons will be purchased for a more complete experiment in 2015, reaching a full description of the dynamics and thermodynamics of the boundary layer in 'undisturbed' pristine rainforest regions and 'polluted' by the outflow of Manaus city.

The research group also mounted instruments on the flux tower at the T1 (ZF2) site to investigate vertical variability of trace gases and aerosols. To learn the degree of chemical reactions and atmospheric transport of trace gases within the forest canopy, an array of ten sonic anemometers was placed on the towers. Levels of atmospheric turbulence within and above the canopy are providing the necessary information to estimate air parcel residence times and rates of trace gas deposition within the forest canopy. Also, plant-emitted hydrocarbons, aerosols, and cloud condensation nuclei are studied within and above the canopy, with the deployment of a Proton Transfer Reaction Mass Spectrometer (PTR-MS) and Gas chromatograph coupled with a mass selective detector (using canister samples), and a cloud condensation nuclei (CCN) counter that provides the concentration of particles that influence cloud formation. (Figure 2)

Figure 2. Atmospheric turbulence studies within and above the forest provide information to determine transport and chemistry of hydrocarbons, and deposition rates and transport of aerosols to the cloud layer. Ten sonic anemometers provide the necessary information to couple with air chemistry and associated aerosol formation.

Credits: M. Chamecki and J. Fuentes



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REMOTE SENSING APPLIED TO THE MODELLING OF ANTHROPOGENIC IMPACTS ON WETLANDS AND AQUATIC SYSTEMS IN THE SOLIMÕES/AMAZON FLOODPLAIN

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FAPESP # 2011/23594-8 | Term: Apr 2012 to Nov 2014

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João Sarkis Yunes, Maycira Costa, Thiago Sanna Freire Silva

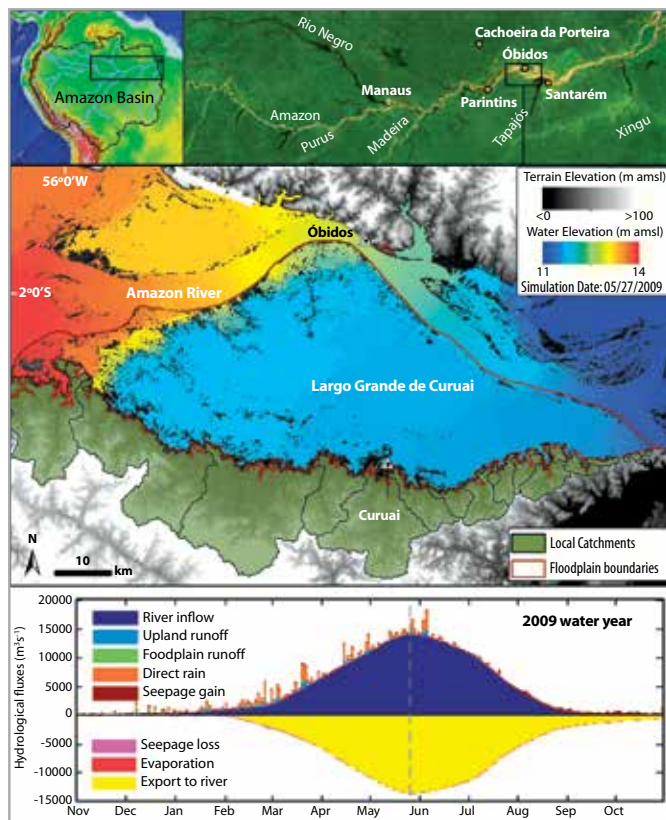


Figure 1. Location of the Amazon River mainstem floodplain within its basin (top right). Overview of the Amazon River in its lower reach (top left). Floodplain encompassing the Lago Grande de Curuai. LISFLOOD-FP simulation of water elevation during peak discharge of the extreme high flood year of 2009 (middle). Floodplain daily hydrological exchanges (bottom). Water balance components are stacked to allow interpretation of total fluxes.

Courtesy Dr Conrado Rudorff

The Solimões-Amazon floodplain, locally known as “várzea”, is a landscape characterized by natural extremes in water level along the hydrological year. This water level oscillation, in interaction with floodplain topography, shapes the floodplain biogeochemical cycles, imposes biota adaptations and economic and social activity of the human population. Floodplain lakes functioning and its response to anthropogenic impacts are poorly understood because there are only few lakes, which have been studied. Conservative estimates indicate the existence of over 10 thousand lakes larger than one hectare in the Solimões/Amazon varzea alone. From which, around one percent has been already studied. In the Mamirauá Sustainable Development Reserve (RDSM) for instance, in a single sector, there are more than 100 lakes with distinct origins, shapes and dimensions, which respond to extreme variability in water properties and in fish abundance. Further than this natural variability, those wetlands and associated aquatic systems are also subjected to direct and indirect anthropogenic impacts. Direct impacts are related to floodplain forest removal and cattle rising, which respond for more than 50 % of the deforestation of the lower Amazon River flooded forest. Indirect impacts are related to climate changes and the intensification of the hydrological cycle in the Amazon Basin, which are responsible for extreme events, such as the 2005 and 2009 floodplain draught and successive extreme floods in the last decade. Due to complex processes

acting upon different space and time scales, the project faces the challenge of uncoupling the signs of human impact out of the natural variability at wider scales. In order to overcome those challenges, the project integrates remote sensing and *in situ* data collection to feed numerical modelling to provide key information on the inherent optical properties of floodplain aquatic systems; on the carbon, nutrient and sediment budgets; on changes in water velocity in response to deforestation; on varzea population wellbeing in response to direct and indirect anthropogenic impacts.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Optical characterization of Curuai Lake indicates that it represents a non-algal particle (NAP) dominated aquatic system during the falling limb of the hydrograph. The high NAP absorption dominates total absorption and single scattering albedo values indicating the dominance of scattering processes. However, the influence of the colored dissolved organic matter (CDOM) in the blue range and phytoplankton related to absorption peaks of Chl-a in 440 and 676 nm. Results also showed that additional efforts should be taken to improve the closure between *in situ* remote sensing reflectance (*In situ* Rrs) and numerically modelled remote sensing reflectance (mol Rrs) by improving the correction methods for the measurements of inherent optical properties. Underwater light environment is fundamental for the biological processes within the floodplain. In NAP dominated systems, light availability is reduced and

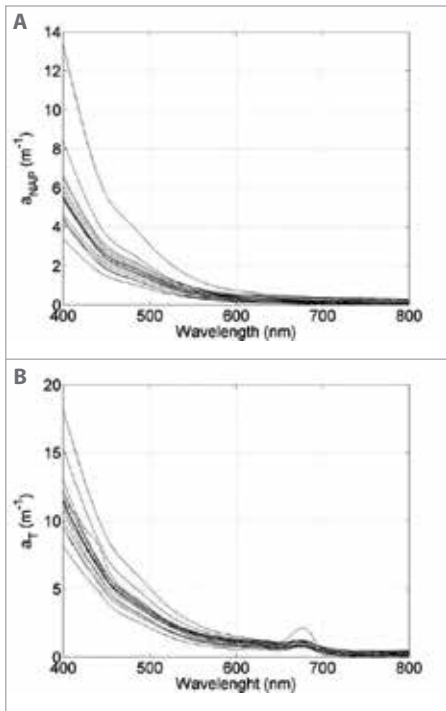


Figure 2. A: NAP Absorption Coefficient. B: Total Absorption Coefficient. Courtesy : Lino Augusto S. Carvalho

may impair aquatic system primary productivity. Simulations of floodplain inundation using the LISFLOOD-FP model revealed that the dominant source of inflow to Curuai Lake alternates seasonally between direct rain and local runoff (November, Amazon R. (December through August), and seepage (September and October). The average annual inflow from the Amazon R. was 43.3 km³ (ranging from 15.3 to 134.2 km³), corresponding to 82% of inputs from all sources. Overbank flow represents 93 %

of the total inflow to the floodplain from mid-rising water through mid-receding water (February to August) what indicates the importance of the flooded forest in controlling the velocity of the water flow into the floodplain and the flow capacity to transport sediments. The figure shows LISFLOOD-FP simulation of water elevation during peak discharge of 2009 and floodplain daily hydrological exchanges. Water balance components are stacked to allow interpretation of total fluxes.

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MODIFICATIONS BY ANTHROPOGENIC POLLUTION OF THE NATURAL ATMOSPHERIC CHEMISTRY AND PARTICLE MICROPHYSICS OF THE TROPICAL RAINFOREST DURING THE GOAMAZON INTENSIVE OPERATING PERIODS (IOPS)

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FAPESP # 2013/50510-5 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

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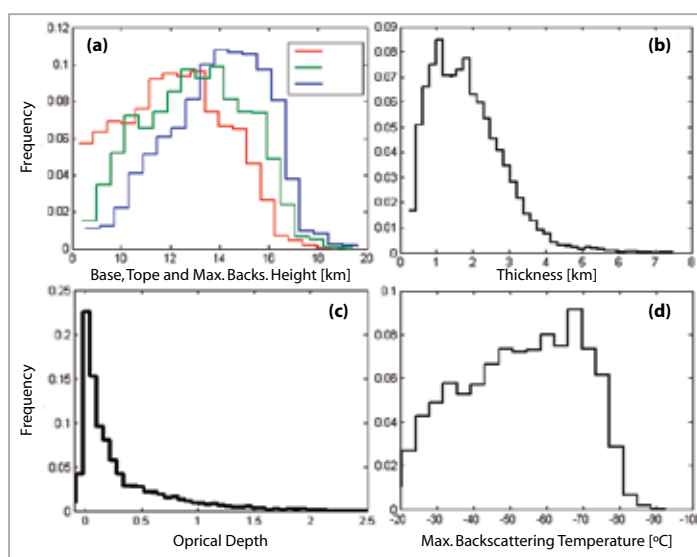


Figure 1. Normalized frequency histograms with the macro and microphysical properties of the cirrus clouds from one year of observations showing in a) base (red), top (blue) and maximum backscattering (green) heights; in b) cirrus thickness; in c) cirrus optical depth, and in d) temperature of the cirrus max backscattering height. GoAmazon T0 experimental site, Embrapa, Rio Preto do Eva-AM. Source: Gouveia et al, OPA, 2014

The effects of aerosol particles on cloud microphysical properties, cloud cover, precipitation, and regional climate are significant. The Amazon region is particularly susceptible to changes in number-diameter distributions of the atmospheric particle population $n(d)$ because of the low background concentrations and high water vapor levels, indicating a regime of cloud properties that is highly sensitive to aerosol microphysics. A particle-limited regime means that for modest to vigorous updrafts the cloud droplet number concentration (CDNC) is dominated by cloud condensation nuclei (CCN) number instead of updraft velocity. This natural regime, different from most other continental areas world-

wide, is expected to be disrupted by the interaction of Manaus urban plume with the natural aerosol population.

Manaus, a city of two million people and growing rapidly, is an isolated, highly polluted urban area located in the central Amazon basin with clean conditions in the surrounding 2000 km. The city's urban plume is about 20-25 km wide, resembling the dimension of the city itself, with distinct clean air on both sides of the pollution plume. As a combined consequence of the meteorology, emissions, and chemistry, the fetch of the main research site T3, north of Manacapuru and about 80 km from Manaus, oscillates between the extremes of (a) a pristine atmosphere when the Manaus pollution plume meanders somewhat north or south and (b) heavy pollution and the interactions of that pollution with the natural environment when the plume conforms to its mean flow. The GoAmazon campaign, taking place around Manaus-Brazil from January 2014 to

December 2015, seeks to quantify and understand how aerosol and cloud life cycles in a particularly clean background in the tropics are influenced by pollutant outflow from a large tropical city, all in the context of addressing the susceptibility of cloud-aerosol-precipitation interactions to present-day and future pollution in the tropics.

As a Brazil-USA collaboration, the goals of this project are (i) to measure and mechanistically understand the factors affecting $n(d)$ over a tropical rainforest, especially the effects of anthropogenic pollution as a perturbation to natural state, and (ii) to develop and implement an upscaling analysis from this new data set and knowledge of $n(d)$ to prognosticate possible climatic impacts of present-day urban pollution and possibly greater pollution in the future.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

It was observed significant changes in the physics and chemistry of the atmospheric aerosol particles at the research sites T2 and T3 under the influence of the Manaus plume. High concentrations of SO_2 , NO_x , and soot, among other pollutants were measured. Very strong formation of photochemical pollution was observed, e.g., a threefold increase in ozone mixing ratios downwind of Manaus while peak NO concentrations of >10 ppb near Manaus drop precipitously with travel distance. Particle number and mass concentrations are 10 to 100 times greater in the pollution plume compared to the times when pristine conditions prevail.

Continuous measurement of the aerosol vertical distribution at sites T_0 (upwind) and T_2 (downwind from Manaus) combined with back trajectories from NOAA's Hysplit model and INPE's fire detection maps allowed the clear identification of layers with long range biomass burning transport aloft of the Manaus plume layer. It was also used the LIDAR measurements to identify cloud layers and was observed a persistent cirrus cover of 60% over the region. Evaluation of its radiative impact is underway. Additional measurements of size-resolved effective hygroscopicity parameter k , obtained from a cloud condensation nuclei counter coupled to a differential mobility analyzer, are being performed up and downwind from Manaus. Results indicate a lower hygroscopicity under polluted conditions, with mean value around 0.15, than under clean conditions, with a mean value around 0.25. Under natural conditions, it was possible to identify peaks of large sea salt particles with organic coating, while small particles seems to be pure organic. The activation fraction and hygroscopicity under different conditions are being compared as a function of particle size and analyzed together with an aerosol chemical speciation monitor.

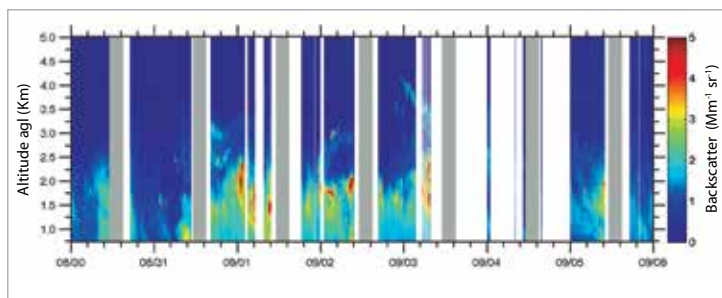


Figure 2. Vertical distribution of the aerosol backscatter coefficient ($\text{Mm}^{-1} \text{sr}^{-1}$) during a week of measurements at GoAmazon T0 experimental site, Embrapa, Rio Preto do Eva-AM, showing the long range transport of biomass burning smoke. Source: Barbosa et al, AMT, 2014

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CARBON TRACKER AND WATER AVAILABILITY: CONTROLS OF LAND USE AND CLIMATE CHANGES

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FAPESP # 2008/58120-3 | Term: Oct 2009 to Mar 2014 | FAPESP Research Program on Global Climate Change (RPGCC)

co-PI: Luciana Vanni Gatti

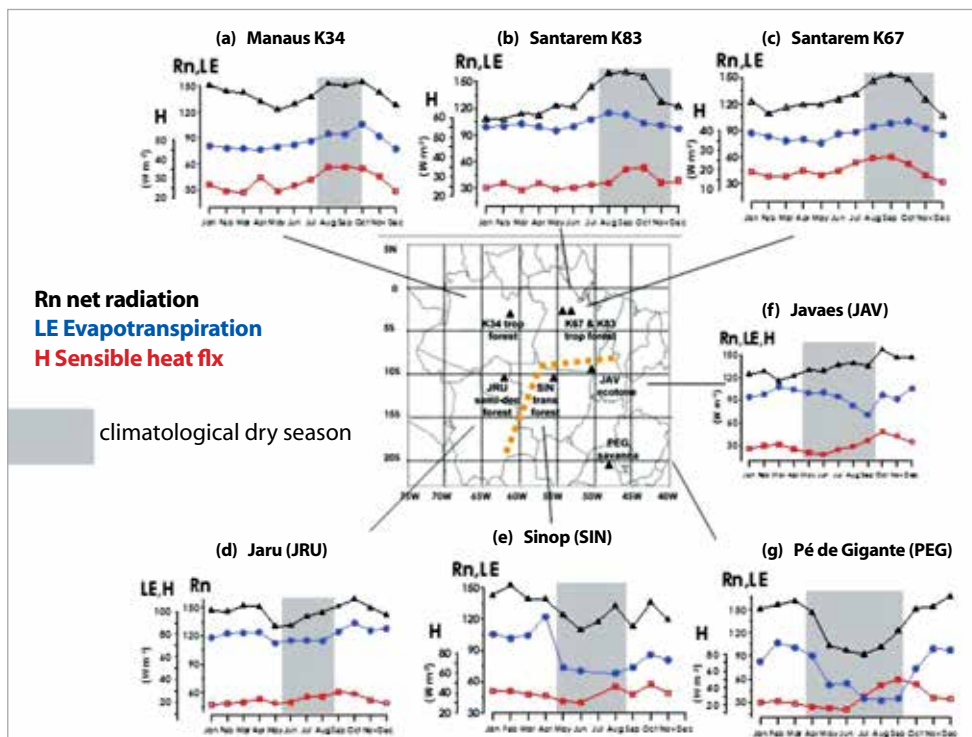


Figure 1. Mean monthly latent heat flux (LE) (R_n) and sensible heat flux (H) (all in Wm^{-2}) for the flux tower sites in Brazil, namely (a) Manaus K34, (b) Santarem K83, (c) Santarem K67, (d) Rondonia Jaru, (e) Mato Grosso Sinop, (f) Tocantins Javaés (g) Santa Rita Pé de Gigante (climatological dry season is shaded). Source: Rocha et al. (2009)

This project focuses on the investigation of the consequences of the climate variability and the land use changes in the functioning of ecosystems, with emphasis on the water and carbon cycles, especially in the Amazonian and Cerrado (Brazilian Savannah) biomes. The aim is to measure and interpret greenhouse gases, CO_2 fluxes and hydrometeorological exchanges at large and regional scale in Brazil, both due to climate variability and land use changes, using consistent field measurements and numerical modeling of the land-atmosphere system.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Measurements of surface net radiation, latent and sensible heat flux at seven flux tower sites in the domain of Brazilian Amazon and Cerrado biomes (Figure 1), showed remarkably the mean annual sensible heat flux ranged from 20 to 38 Wm⁻², lower during the wet season and higher in the late dry season, consistent with the variation of net radiation and soil moisture. The sites were easily divided into two functional groups based on the seasonal latent heat flux: tropical forest and savanna. At the northern sites (Manaus and Santarem), monthly evapotranspiration was fairly constant during the wet season and ranged from 2.8 to 3.6 mm d⁻¹, which progressively increased along the dry season up to 4 mm d⁻¹ and dominated by net radiation and vapor density deficit. The western semideciduous forest in Rondonia present similarities with the forest group, with evapotranspiration varying little though concurrent with net radiation year round,

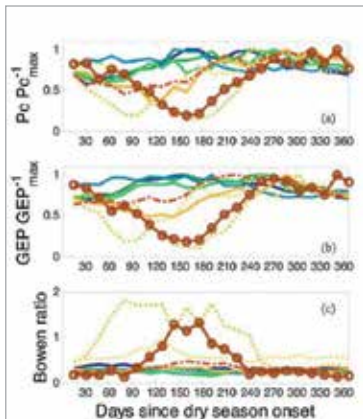


Figure 2. 16-day average normalized (a) photosynthetic capacity P_c/P_{cmax} , (b) gross ecosystem productivity GEP/GEP_{max} time series set to the start of the dry season at each tower site for the flux tower sites in Brazil, namely (a) Manaus K34, (b) Santarem K83, (c) Santarem K67, (d) Rondonia Jaru, (e) Mato Grosso Sinop, (f) Tocantins Javaés (g) Santa Rita Pé de Gigante (climatological dry season is shaded). Source: Restrepo-Coupe et al. (2013)

which peaked in the dry-to-wet season transition. At the southern and eastern sites, where precipitation was below 1700 mm yr⁻¹, seasonal evapotranspiration was limited by soil moisture and ranged from 3 to 4 mm d⁻¹ in the wet season, and decreased to 2.5 mm d⁻¹ (transitional forest in Mato Grosso and floodplain forest in Tocantins) and to 1 mm d⁻¹ in the São Paulo cerrado. The seasonal pattern of Amazonian forest photosynthetic activity was investigated in the flux tower sites (Figure 2), and it is found that degree of water limitation (as indicated by the seasonality of the Bowen ratio) predicts seasonal patterns of photosynthesis. In Amazonian forests near the Equator, water limitation is absent, and gross ecosystem productivity exhibited increasing levels of activity as the dry season progressed, a likely consequence of allocation to growth of new leaves. In contrast, in the Southern flank of Amazonia, pasture converted from forest, and mixed forest-grass savanna, exhibited a dry-season decline in productivity, consistent with increasing water limitation. The gross ecosystem productivity showed no relationship with photosynthetically active radiation, instead followed largely the phenology of canopy photosynthetic capacity.

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USING THE GOAMAZON-CHUVA MEASUREMENTS TO UNDERSTAND WHAT CAUSES THE BIASES IN THE ONSET OF THE RAINY SEASON IN AMAZONIA IN CLIMATE MODELS

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FAPESP # 2013/50538-7 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

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US co-PIs: Robert Dickinson (The University of Texas), Jonathan Jiang (NASA Jet Propulsion Laboratory), L.Y.R.Liung, Steven Ghan (Pacific Northwest National Laboratory)

The onset of the Amazon rainy season shows a large temporal and spatial variability, delays on the data of the onset may have strong impacts on local agriculture, hydroelectric power generation, as well as on the hydrology of large rivers. Two “once-in-a-century” droughts occurred in 2005 and 2010, and it was shown that on those events the rainy season started later than normal, and also that on the last 10 years the dry season has increased in length by about one month (Figure 1). These events highlight the urgency for improving our understanding and capability to model onset of the rainy season and drought variability, for the present and future

Global climate models run on seasonal climate forecast mode still show large uncertainties on the forecast of onset of the rainy season. As for climate change, the CMIP3 and CMIP5 appear to underestimate the past variability, and also project virtually no future change of the onset of rainy season over the Amazon even when they are forced by strong greenhouse forcing under the RCP8.5 emission scenario.

This proposal aims to explore use of the measurements provided by the Atmospheric Radiation Measurement (ARM) Mobile Facilities (AMF)-GoAmazon project and the Cloud processes of the main precipitation systems in Brazil (CHUVA) Field Experiments, along with global and regional model experiments and data sets from Amazonia, to explore the sources of the above described uncertainty, in order to improve the US CESM and the Brazilian Eta regional Model and the BESM (Brazilian Earth System Model).

Based on previous and ongoing studies, it is hypothesized that the underestimation of changes of the rainy season onset over the Amazon and its climate variability and sensitivity to anthropogenic forcing are in part related to: a) The inadequate

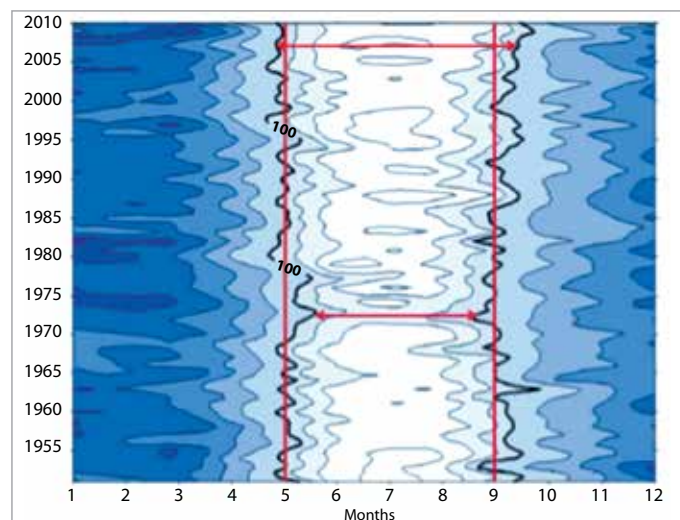


Figure 1. Hovmoller diagram of monthly rainfall from 1951 to 2010 for southern Amazonia. Units are in mm/month. The 100 mm/month isohyet is marked in bold and is an indicator of dry season (modified from Marengo et al 2011)

representation of the types of convection (i.e., maritime versus continental) and their relationships to aerosols, land surface and atmospheric circulation, as represented in climate models; b) Inadequacies of the modeled oceanic variability, land surface processes and their coupling to the atmosphere.

To evaluate these hypotheses, the team proposes to clarify the following questions: a) How would changes of land surface conditions and aerosol influence the intensity and type of the convection over the Amazon? How adequately are these influences represented in NCAR/DOE CESM 1.2/CAM5.3/CLM4.5 climate model and the Eta regional and the BESM models?; b) How would a change of convective type influence the vertical profiles of diabatic heating, surface fluxes and large-scale circulation during the dry to wet season transition? c) What are the relative contributions from uncertainties of the local processes (land surface and aerosols) vs. those of Atlantic and Pacific ITCZ to the underestimation of the variability of the dry season length in CESM and BESM?

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Most studies have attributed the variability of the rainy season onset over Amazonia to the variability of the tropical oceans, such as El Niño–Southern Oscillation (ENSO) and anomalies in the north–south gradient of the tropical Atlantic SST.

The CMIP3 multimodel ensemble simulations that the percentages of the modeled 20-year trends of rainy season onset (an indicator of decadal variability or/and forced change) that agree with the observed trends during 1979–1999 within the range of uncertainty is similar between the 20th century coupled ocean–atmosphere models’ ensemble simulations (CMIP simulations) and the atmospheric models’ ensemble simulations forced by observed SST. Thus, the large discrepancy between the CMIP3 models and the observations is not reduced by use of realistic SSTs in the CMIP simulations. On the other hand, a subgroup of the CMIP ensemble simulations that include black and organic carbon aerosols (AREO

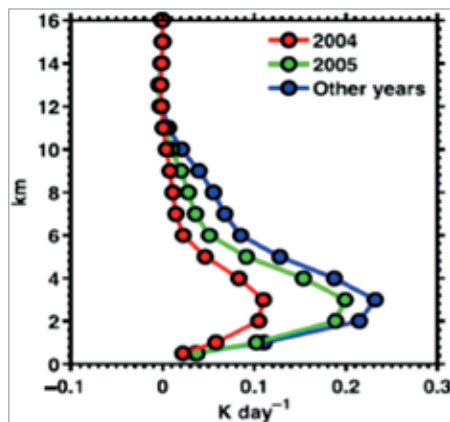


Figure 2. Latent heating profile derived from TRMM over southern Amazonia in JJA of 2004, 2005, and other years’ climatology (1998–2003, 2006–2010). Rainy season onset was strongly delayed over southwestern Amazon in 2004 and 2005, respectively (Source: Fu et al 2013)

simulations) shows a statistically significant greater agreement between the modeled and observed 20-year trends for rainy season onset compared to the AMIP ensemble simulations; land use could also contribute to a greater variability (Ying et al 2014).

The dry to wet transition season is led by an initial increase of continental convective type rainfall, followed by a transition to maritime type rainfall. Such a seasonal change of convective types changes the

diabatic heating profile and drive the atmospheric circulation transition.

This report focuses on ongoing work with the LHP based on TRMM data (Figure 2), on dry years 2004 and 2005 in Amazonia. The late rainy season onsets in October–November 2004 and 2005 are led by shallower and weaker peaks of the diabatic (latent) heating profiles in (latent) heating profiles in June–August, whereas the normal rainy season onset is led by a deeper and stronger latent heating profile, as derived from the TRMM 2004. This link suggests that variation of the diabatic heating profile is an important source of variability for rainy season onset.

Further studies are being performed using CMP3 and 5 models simulations and projections. In particular, we want to know how do aerosols and land surface influence the dry to wet season transition?

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ECOPHYSIOLOGICAL CONTROLS ON AMAZONIAN PRECIPITATION SEASONALITY AND VARIABILITY

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FAPESP # 2013/50531-2 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

US PI: Jung-Eun Lee (Brown University, USA)

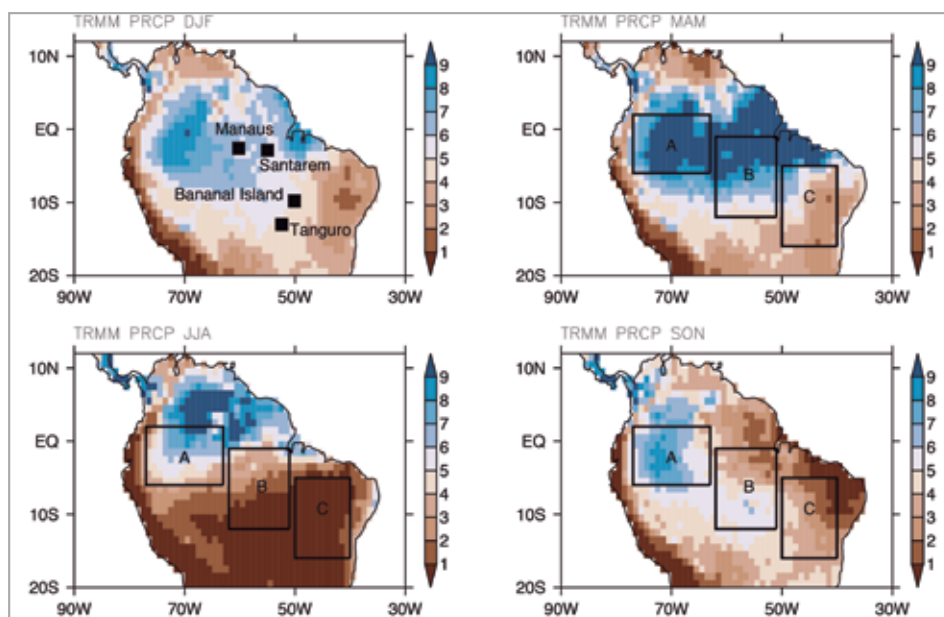
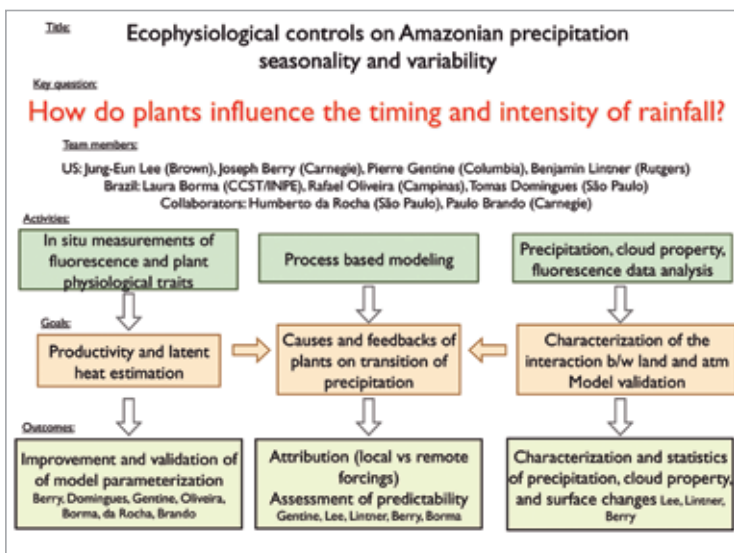


Figure 1. Locations of research sites with mean annual precipitation (mm/day) from TRMM

The Amazon currently plays a critical role in the terrestrial climate system. Over the last decade, Amazonian forests have begun experiencing more frequent dry periods, including two extreme drought episodes in 2005 and 2010. However, the future of the Amazon as projected by current generation climate or earth system models is highly uncertain: how global warming and other aspects of anthropogenic change such as deforestation and degradation will ultimately affect this system is far from clear. A dominant source of uncertainty regarding Amazonian climate and its future evolution is the role of land vegetation – atmosphere coupling, especially interactions between vegetation and precipitating deep convection occurring during the late dry season/early-wet season when land-vegetation-atmosphere coupling has been shown to be stronger. Quantitative understanding of this coupling is critical since forest productivity is sensitive to the duration and intensity of the dry season. Thus, in the present proposal, our principal objective is to address how vegetation influences climate

variability and precipitation over Amazonian rainforest, with an emphasis on plant physiological controls on deep convection triggering along a geographical water stress gradient. To support this objective, our proposed research comprises three interrelated activities:

- (i) *in situ* measurements of plant physiological water stress with a focus on fluorescence as a proxy for water stress and its control on surface energy and water budgets as observed at existing flux tower sites;
- (ii) diagnostic analysis of basin scale plant stress by remote sensing, observed surface turbulent fluxes, boundary layer properties, and cloud cover and precipitation along a moisture gradient; and
- (iii) process- based model studies of the pathways through which the surface energy partitioning (Bowen ratio) and transpiration, as modified by water stress, influence convection both locally and nonlocally.



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UNDERSTANDING THE RESPONSE OF PHOTOSYNTHETIC METABOLISM IN TROPICAL FORESTS TO SEASONAL CLIMATE VARIATION

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FAPESP # 2013/50533-5 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

US PI: Denis Gene Dye (Southwest Geographic Science Center

co-PIs: Liana O. Anderson e Yosio Edemir Shimabukuro (INPE), Luciana Alves (IAC), Rafael Oliveira (Unicamp)

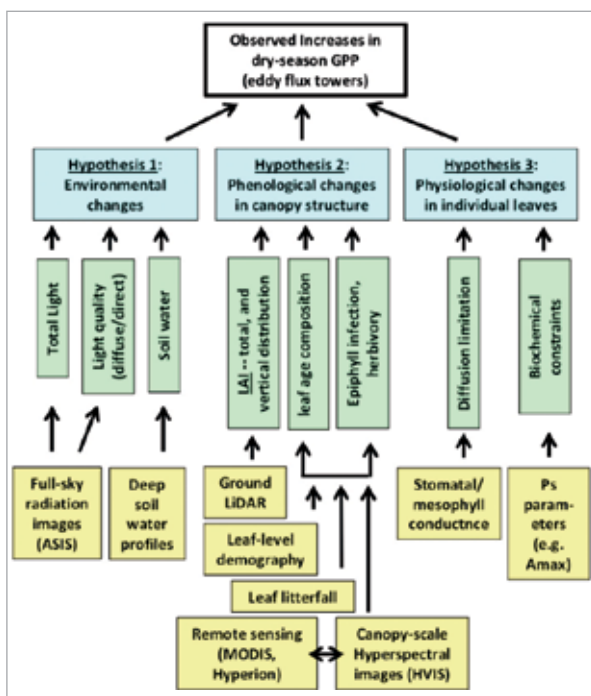


Figure 1. Three general hypotheses (blue boxes) for observed dry season increases in GPP, along with potential mechanisms underlying those hypotheses (green boxes). Yellow boxes show measurements that we will take as part of the research campaign

Tropical forests have a major influence on the global carbon cycle because of their high rates of primary productivity and large stocks of carbon in vegetation and soils. The response of tropical forest ecosystems to a variable and changing climate may introduce strong feedbacks to the global climate system. The response of photosynthetic metabolism to seasonal climate variations provides a first-order test of our understanding of how tropical forest carbon cycling interacts with climate, but there remains uncertainty and debate in the literature about even the basic seasonal patterns of tropical ecosystem photosynthesis, as well as the mechanistic constraints. Models disagree, as do remote sensing measurements: some models and remote sensing indices show widespread declines in photosynthetic metabolism during dry seasons, suggesting that Amazonian forests are driven by water availability, while others show the opposite, suggesting sunlight availability is a key limiting factor. What controls the response of photosynthesis in Amazonian forest to seasonal variations in climate? To answer this question, this project aims to guide improvements in earth system models of tropical forest photosynthesis by collecting and integrating a suite of observations to:

1) test several hypotheses (three core, conceptual hypotheses for explaining observed photosynthetic seasonality and a methodological hypotheses for scaling from leaves to

canopy with hyperspectral cameras), and

2) perform a synthesis activity that applies empirical work to earth system models of terrestrial carbon cycling. The specific aim is to investigate through observations, analysis and modeling, two mechanistically related factors that control these patterns, leaf phenology and photosynthetically active radiation (PAR), and to identify opportunities for reducing uncertainties associated with these factors through model corrections or enhancements. Specifically:

- i) What is the seasonal pattern of the display and properties of leaves in tropical forest canopies observed at tree-to-landscape scales?
- ii) How do solar radiation and other climate factors control these patterns and what should be expect in the future?

To address these questions, it will be used field measurements, ground- and satellite-based remote sensing, and modelling at study sites near Manaus and Santarem in the Amazon region of Brazil. This study is linked to DOE's GoAmazon/ARM campaign, and will add substantial value to GoAmazon.

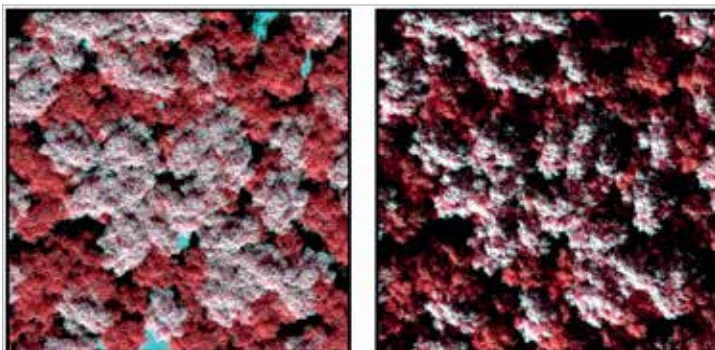
SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

This project envisages to provide an extensive suite of new and unique datasets that enable to fill, through advanced modelling techniques and analysis, critical knowledge gaps in current understanding of what controls the response of canopy photosynthesis and related functions in Amazonian forests to seasonal variation in climate. Three major types of datasets and data products will be delivered:

- (1) *in situ* leaf and tree-scale measurements from intensive ecophysiological and ecohydrological field campaigns,
- (2) time-series observations of leaf-to-crown scale forest reflectance properties and atmospheric radiation from two innovative, ground-based imaging sensors (respectively, the Hyperspectral Vegetation Imaging System and the High Dynamic Range All-Sky Imaging System), and
- (3) results from state-of-the-art models (including DIRSIG model) of 3-dimensional canopy processes for radiative transfer and photosynthesis that integrate and link observations to tropical forest processes.

These data products and the improved knowledge achieved with them will contribute to testing and improving the treatment of tropical forest processes in earth system models. They will contribute data to and leverage related data from of the GOAmazon campaign, and make significant contributions to support the overall goals of GOAmazon. This work will also help establish a foundation for the Next Generation Ecosystem Experiments (NGEE) in the Tropics.

Figure 2. Nadir-view, false-colour composite images for Landsat-like green, red and NIR bands simulated by the DIRSIG model at solar zenith angles of 0 degrees (left) and 45 degrees (right) for a synthetic broadleaf forest with 2 tree species. The spatial extent of each image is ~100 m, with individual crowns and shadow effects visible



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PALEOMAGNETISM OF PROTEROZOIC GEOLOGICAL UNITS FROM THE AMAZONIAN CRATON, AND ITS PARTICIPATION IN THE COLUMBIA, RODINIA, AND GONDWANA SUPERCONTINENTS

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FAPESP # 2011/50887-6 | Term: Oct 2011 to Sep 2014

co-PIs: Franklin Bispo dos Santos, Ricardo Ivan Ferreira da Trindade, Wilson Teixeira, Nelson Joaquim Reis, Sten-Åke Elming, Amarildo Salina Ruiz, Liliane Janikian, Igor Pacca, Eric Tohver, Bruno Perillo

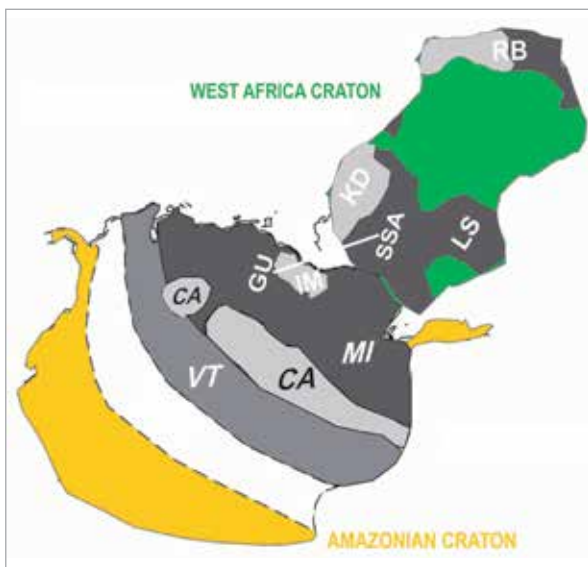


Figure 1. Paleogeography of proto-Amazonian and West African cratons at 1.96 Ga based on paleomagnetic and geological data. The Guri (GU) and Sassandra (SSA) lineaments were aligned in the figure. Symbols as in Bispo-Santos et al. (2014a)

The main purpose of this project is to elucidate the geodynamic evolution of the Amazonian Craton and its interaction with other continental blocks during the Proterozoic, using key paleomagnetic poles, and monomineral Ar-Ar, U-Pb, and Lu-Hf geochronology. Geodynamic models proposed for the craton in global paleogeographic reconstructions (supercontinents) will be tested by the paleomagnetic data. The chosen targets for this study are unmetamorphosed intrusive and extrusive bodies of different ages, located at key areas: felsic and associated mafic rocks from the Sobreiro Formation and Iriri Group (1.88 Ga) and mafic to felsic rocks from the Jamon Suite (1.88 Ga), both situated in the Pará State; volcanic rocks (1.42 Ga) from the Figueira Branca Intrusive Suite and mafic dykes from the Tapirapé Mafic Suite, both situated in the Mato Grosso State; and mafic volcanic rocks from the Alto Candeias Intrusive Suite (1.35 Ga), in the Rondônia State. Paleomagnetic analyses of other geological units that are already in progress will also be a part of this project: Surumu Group (1.98-1.96 Ga), Roraima Supergroup (1.87 Ga) and 1.78 Ga sills cutting these rocks from Roraima State, the Guadalupe Intrusive Suite and the Nova Guarita dyke swarm (1.42 Ga) from northern Mato Grosso State, and mafic dikes (Nova Lacerda region, 1.36-1.38 Ga) and sills (Rio Branco region, 0.98 Ga) cutting the Aguapeí sedimentary rocks in the southwestern Mato Grosso State. Eventually, other units may be studied according to results. At least eight field trips are planned for sampling the different geological units, with the participation of expert geologists in the respective areas.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Paleomagnetic and geochronological data obtained in this project have contributed significantly to elucidate the participation of the Amazonian Craton in the paleogeography of the Columbia and Rodinia Supercontinents, and also in the process of amalgamation of Gondwana. The paleomagnetic study of the 1980-1960 Ma felsic volcanic rocks from the Surumu Group suggests that proto-Azonania and West Africa took part of the same continental mass at about 1960 Ma ago, in a paleogeography where the Guri (Guiana Shield) and Sassandra (West Africa Craton) lineaments were aligned. Several paleomagnetic and geochronological studies were performed in Paleo- to Mesoproterozoic geological units from the Roraima and Mato Grosso States. A well-dated 1789 ± 3 Ma paleomagnetic pole was obtained for sills from the Avanavero magmatism (Roraima State – Guiana Shield). Comparison of this pole with other similar in

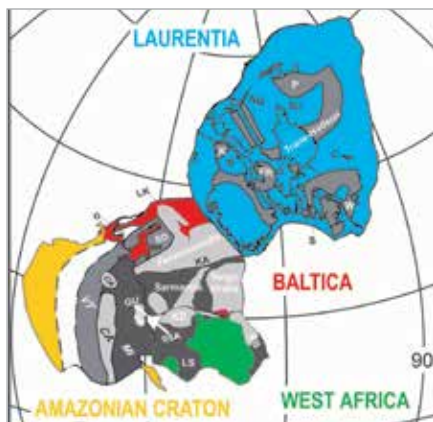


Figure 2. Paleogeography of the nucleus of Columbia Supercontinent at 1.78 Ga based on paleomagnetic and geological data. Symbols as in Bispo-Santos et al. (2014b)

age poles from Baltica and Laurentia corroborates the paleogeographic reconstruction proposed by other authors, where the proto-Azonania/West Africa was directly linked to Baltica/Laurentia, forming the core of Columbia. The paleomagnetic pole obtained for sedimentary rocks from the Fortuna Formation (Aguapeí Group), collected near to Vila Bela (close to the Brazil-Bolivia frontier), with an age of 1150 Ma seems to support a dynamic interaction between the Amazonian Craton and Laurentia along the Sunsás and Grenville belts during the formation of Rodinia. Mafic sills near Rio Branco (MT) cut the sedimentary rocks actually known as belonging to the Vale da Promissão Formation (Aguapeí Group). A recent U-Pb (baddeleyite) dating of one of the sills yielded an age of 1439 ± 4 Ma for these rocks. Both sills and sedimentary rocks yielded similar paleomagnetic poles, and these poles are also similar to the Mesoproterozoic (~1420 Ma) Nova Guarita and Indivaí poles, suggesting an older age for these sedimentary rocks. Finally, paleomagnetic data obtained for alkaline rocks from the Planalto da Serra area (~610 Ma) suggest that final collision of the Amazonian Craton with São Francisco Craton in Gondwana occurred at about 530-525 Ma ago, after the Clymene ocean closure.

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DATING OF KAOLINITES FROM LATERITIC FORMATIONS IN THE RIO NEGRO BASIN: THE IMPORTANCE OF GEOMORPHOLOGICAL EVOLUTION IN THE CENTRAL AMAZON – BRAZIL

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FAPESP # 2012/07600-0 | Term: Dez 2012 to Nov 2014

co-PIs:Thierry Allard, Guilherme Taitson Bueno, Célia Regina Montes



Figure 1.
Soil to be dated, in the Içá Formation, near Barcelos, Amazon State



Figure 2. Samples of soil to be studied. São Gabriel da Cachoeira, Amazon State

A greater understanding is required of the diversity, spatial distribution and function of Amazonian landscapes at both the national and global level. However, scientific research designed to fill this knowledge gap is limited because there is a lack of information on the genesis of the Amazon region, especially of its geological, climatic and geomorphological evolution since the middle Tertiary (Neogene and Quaternary). Determining the age of the material (rocks, sediments, soils) and units of relief may greatly contribute to an understanding of the evolution of Amazonian landscapes. Unfortunately, such efforts in the Amazon region are restricted to only relative dating through the use of correlations between tectonic, sedimentary and geomorphological events and fossiliferous or palynological occurrences. Radiocarbon dating has been performed, but this technique is limited to materials formed in the

most recent periods of the Pleistocene and Holocene. According to most authors, these young materials are restricted to floodplains and fluvial terraces of channels and only represent a small portion of the geological formations of the Amazonian lowlands. The results of radiocarbon dating applied to older materials may lead to erroneous interpretations of the region's history because the range of time recorded by this method is limited. The absence of absolute dating in the region is caused, not only by logistical difficulty in accessing the material as a result of almost continuous vegetation cover and regoliths and rocks that are exposed in stretches on the banks of major rivers and only in the low water season, but also by the nature of the materials that dominate the landscape: highly weathered lateritic formations. Because of the ubiquity of these lateritic formations in different surfaces and compartments of the relief, these formations have been selected as the main material for dating. The Içá Formation is considered to be a more recent geochronological marker, so its sediments, paleosols below the Içá Formation and overlying lateritic formations will also be dated. Little is known of the ages of these lateritic covers, and the study of their genesis and evolution is problematic because there are recurrent difficulties in the dating process as a result of a lack of geochronometers in the formations. This significant scientific problem is the core of the project presented here, which is being developed in the upper Amazon basin. The goal of this project is to implement a dating method based on defects that accumulate in kaolinite as a result of natural radiation. Kaolinite from lateritic formations have been selected according to differences in the kaolinite's parent rock, geomorphological compartments and topographic positions in units of the landscape. The kaolinitic clays of the Içá Formation and paleosols underlying the Içá Formation will also be dated. The results will be discussed in terms of the paleoclimate, geomorphological evolution and geodynamics.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Was there a single climatic event that gave rise to the lateritic formations of the Amazon Basin, or were there different climatic events that caused a multiplicity of ages for these formations? The project is designed to study the long-term natural evolution of the soil and geomorphological heritage and significance of soil ages to promote the conservation of the Amazon geosystem. Several procedures have been used. The ages range from 300,000 years based on isotopes in the decay chain of uranium (Mathieu et al., 1995) and 30 million years based on quartz dissolution (Soli, 1984). The analysis of the isotopic disequilibrium of uranium covers a recent period that is usually less than a million years, and it provides access to the kinetics of change for the carriers of the element (Ivanovich & Harmon, 1992; Dequincey et al., 1999). Additionally, a study that analyzed stable oxygen and hydrogen isotopes found that kaolinite was in equilibrium with existing waters (Giral-Kacmarcik et al., 1998). The dating of manganese oxides using the Ar/Ar method has been performed on weathering cover in the Amazon, and such dating produced ages from the Tertiary (Vasconcelos et al., 1994). The Ar/Ar method is appropriate for the absolute dating of manganese oxides that have potassium, but it cannot be generalized for all laterites. Recently, magnetostratigraphic analyses of iron oxides in cuirasses were able to reconnect paleo-magnetic data to determine changes in paleolatitudes and evaluate the rate of progression of the weathering front (Théveniaut and Freyssinet, 1999). These dating attempts led to diverse results. Although the dating performed by Balan et al. (2005) was restricted to lateritic soils in a small area in the Rio Negro basin, near Manaus, the study showed that kaolinite of different ages may be present in the same lateritic profile and it is not restricted to profiles that represent current weathering conditions. The study also showed that the dating of kaolinite could reveal the prevailing geochemical and climatic conditions on the earth's surface. Studies on regional and specific scales are being developed to spatialize the soil coverage in relation to the geomorphology and substrates as well as to establish the differences between lateritic covers and their modes of formation and evolution and relationships with smaller landscape units (e.g., slope segments). The following goals have already been met:

- pedo-geomorphological mapping has been performed on a regional scale to expose the different environments of the Central Amazon;
- studies of the representative sequences of soils have shown the existence of different lateritic formations; geochemical and mineralogical studies have revealed the formation, transformation, depletion and podzolization of lateritic formations;

All of the steps required for dating kaolinite have been developed for two key sites (Barcelos/Demini River and Santa Izabel do Rio Negro): kaolinite of laterites in Santa Izabel do Rio Negro has been dated using the EPR and the results of the isotope ratio ($\delta^{13}\text{C}$: C3 and C4) of recent soils and sediments in the Içá Formation for the Barcelos/Demini River Site have been analyzed and interpreted.

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INTERACTIONS BETWEEN URBAN AND FOREST EMISSIONS IN MANAUS, AMAZONIA: THE BRAZILIAN COMPONENT OF GOAMAZON

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FAPESP # 2013/05014-0 | Term: Nov 2013 to Oct 2017 | FAPESP Research Program on Global Climate Change (RPGCC)

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Collaborators: Henrique M. J. Barbosa, Luciana V. Rizzo, Theotonio M. Pauliquevis, Gilberto F. Fisch, Edmilson D. Freitas,

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Figure 1. Tiwa GoAmazon station in September 2014

The GoAmazon experiment seeks to understand how traces gases, aerosol particles and cloud life cycles are influenced by pollutant outflow from Manaus in the Amazonian tropical rainforest. We are quantifying the susceptibility to cloud-aerosol-precipitation interactions and the feedbacks among biosphere and atmosphere functioning under the influence of human activities. Manaus is a major urban center with 2 million people with large vehicular and power plant emissions, surrounded by hundreds of kilometers of tropical forests with large emissions of Volatile Organic Compounds (VOC). The reactions of the urban emissions with the natural background forest emissions produces secondary organic aerosol (SOA), ozone and other compounds that influences the Amazonian ecosystem functioning and this interaction is important to regional and global climate change assessments.

A set of detailed aerosol, trace gases and cloud measurements are being performed over six different sampling sites, followed by detailed meteorological transport studies. A large set of measurements will be performed: aerosol optical measurements with spectral light scattering and absorption, aerosol size distribution, aerosol composition for organic and inorganic components, CCN (Cloud Condensation Nuclei), aerosol optical depth, radiation balance, atmospheric vertical thermodynamic structure among many other measurements. Four aerosol mass spectrometers will be deployed to measure organic and inorganic aerosol in several locations. Raman Lidar will measure the vertical distribution of aerosols and water vapor up to 12 Km. Trace gases measurements such as O_3 , CO, CO_2 , CH_4 , SO_2 and detailed VOCs characterization will also be performed. Measurements of cloud properties, including cloud cover fraction, droplet size distribution, precipitation, water vapor and others, will be combined with cloud and precipitation radars for a regional assessment of the complex cloud-aerosol-precipitation relationship. Two aircraft experiments in the dry and wet seasons will look at the large scale impact in clouds, aerosols and trace gases. High resolution BRAMS regional modeling will be performed daily with 2 km resolution with full aerosol and trace gas chemistry. Cloud modeling will integrate aerosol, CCN, water vapor and thermodynamic conditions for a variety of conditions. The GoAmazon measurements and modeling framework will provide a dataset vital to constrain tropical forest model parameterizations for organic aerosols, cloud and convection schemes, coupled to the radiation balance. The analysis will also provide insights into how the Amazonian ecosystem is perturbed by pollution and how they influence climate regionally and globally.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

It was observed remarkable influence of the urban plume of Manaus in the chemistry and physics of the atmosphere downwind of the GoAmazon experimental area. Ozone concentrations are naturally low in Amazonia, with values of around 10 ppb (parts per billion) at mid-day. Under the influence of the Manaus plume and also long range biomass burning emissions, ozone concentrations went of up to 70-80 ppb. The aerosol particle composition is very different from natural conditions, with a much less oxidized component. Black carbon concentrations that are also naturally low in Amazonia shows enhancement of factor of 10 under the influence of the Manaus plume, which impacts strongly on the radiation balance. Carbon monoxide under natural biogenic condition is about 100 ppb, but when impacted can reach 1000 ppb, a similar increase as observed with SO₂ concentrations. The oxidizing capacity of the



Figure 2. Aerial view of the GoAmazon T3 site

atmosphere is much higher downwind of the Manaus plume, observed trough the oxidation products of isoprene, a naturally emitted VOC in Amazonia. Aerosol size distribution shows a much higher amount of nanoparticles that can grow to form CCN (Cloud Condensation Nuclei) and directly influence cloud formation and

precipitation patterns. The large aerosol concentration increases the diffuse light radiation, affecting the photosynthetic rate of the natural forest hundreds of kilometers far from the emissions. Lidar measurements can separate the Manaus plume from the long range transport biomass burning aerosols, that reach 3 km altitude, at the cloud base, directly influencing cloud formation and development. Aircraft measurements shows that the impact of the Manaus pollution plume extends over 200 Km downwind of the urban area. With the high altitude HALO airplane (18 Km) in the experiment, it was observed cloud outflow of aerosols and trace gases in the top of convective clouds. The aircraft measurements also shows significant processing of aerosol particles within clouds and a large reduction of cloud droplet sizes with increasing aerosol and cloud condensation nuclei atmospheric loading. This influences precipitation efficiency and alters the hydrological cycle in Amazonia. Modeling analysis will look at the influence of the particles on precipitation to the outside boundaries of Amazonia.

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MULTI-SCALE PROCESSES DRIVING TROPICAL CONVECTION AND INFLUENCE OF THE AEROSOL

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FAPESP # 2013/50521-7 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

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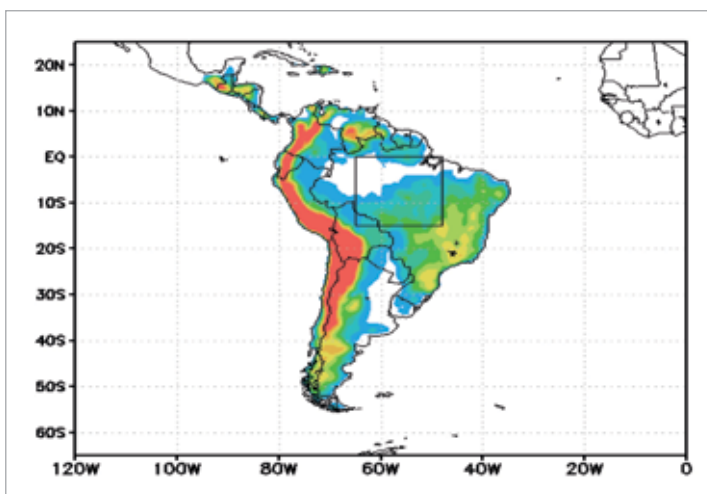


Figure 1. Shows the area over the Amazon region on the South American continent (square line) where most of the model analyses were done

This is a collaborative project between scientists in the US and Brazil and it addresses the fundamental processes that drive tropical deep convection and aerosol effects on these processes. A two-pronged approach is planned for the proposed research: (1) statistical analysis of data from the GOAmazon sites in view of properties of the atmospheric large scale environment that are relevant to convection and its interaction with aerosols, and (2) effects of aerosols on tropical precipitation for clean and polluted situations. *In situ* data collected by the GOAmazon campaign and output from a hierarchy of numerical models, ranging from general circulation models of the coupled atmosphere-ocean system to cloud resolving models will be used in the proposed research.

In reference to approach (1), the effect of free tropospheric humidity and vertical shear on deep convective onset will be investigated. The intraseasonal variability in the characteristics of convection over the GOAmazon region will also be studied. Approach (2) will use the results from step (1) to stratify the data from the GOAmazon sites according to aerosol information (e.g., mass loading, size distribution and chemical composition). Then the regulating effects of aerosols on selected cases of deep convection will be assessed by running simulations using a cloud resolving model (CRM) coupled with detailed spectral bin microphysics for cases of pristine and polluted conditions. The results from this project will contribute to improving the parameterizations of cloud and aerosol effects by increasing the knowledge of the processes that drive tropical convection and the aerosol influences on these processes. An important collaboration is expected among participants. The GOAmazon proposal gives both groups the opportunity to exchange knowledge and experience, with the US team learning more about the Amazon climate and the Brazil team learning more about large-scale numerical models. There is a strong confidence that the proposed scientific collaboration will be mutually beneficial in many senses.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The hydroclimatic regime variability of the Amazon basin (AMZ) can be affected by local climate feedbacks as well as large scale climate patterns, for example associated with Sea Surface Temperature (SST) anomalies. For instance, the El-Niño Southern Oscillation (ENSO) influences the climate variability over this region. Climate change induced by increasing concentrations of greenhouse gases (GHG) affects the regional climate of the AMZ directly through modifications of the regional radiative budgets, as well as indirectly through changes in large-scale circulations patterns and changes in SST and potential for changes in ENSO events. Those changes may affect the hydroclimatology of the basin, resulting in high environmental and social impacts. According to global model projections, temperature may increase over South America (SA) by a wide range, up to ~1.0 °C to 7.0 °C, by the end of the 21st century, with the highest warming projected over the central Amazon region. The projected late 21st century precipitation changes are complex. Although ensemble average changes indicate a general drying of the Amazon, individual model projections range from a reduction of 20 to 40 % to even increase over tropical SA. Evidently, uncertainties in precipitation projections by General Circulation Models (GCMs) over SA remain high. Llopart et al (2014) analyze the local and remote impacts of climate change on the hydroclimate over the Amazon region (Fig.1) in an ensemble of four 21st century projections (1970-2100, RCP8.5 scenario) with a Regional Climate Model (RegCM4) driven by three global models from CMIP5 (Coupled Model Intercomparison Project Phase 5). First, they find considerable sensitivity of the precipitation change signal to both the driving global model and the RegCM4 land surface scheme, highlighting the pronounced uncertainty of regional projections over the region. However, some improvements in the simulation of the annual cycle of precipitation over the Amazon basin was found when using the RegCM4, and some consistent change signals across the experiments were simulated. Figure 2 shows the annual cycle and simulated precipitation averaged over the AMZ region (Fig.1) in the reference period (1976-2005) along with the corresponding late 21st century change. The seasonal precipitation cycle over the AMZ is emphasized (Fig.2a). Precipitation is somewhat underestimated by all models in January-March, i.e., during the peak monsoon phase. The regional model results show a much better agreement with observations. The precipitation change (Fig.2b) is predominantly negative throughout the year. However it shows a noticeable seasonal variation with maximum decrease during the monsoon onset phase (August-September-October). In general the results suggest two important points: one is a tendency towards the extension of the dry season over central SA deriving from a late onset and an early retreat of the SA monsoon. The second is a dipolar response consisting of reduced precipitation over the broad Amazon region and increased precipitation over the La Plata basin and central Argentina.

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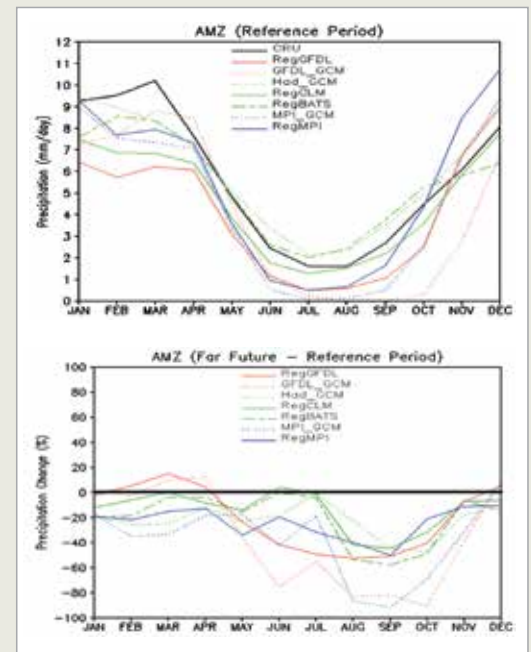


Figure 2. Annual cycle of observed and simulated precipitation averaged over the Amazon region (see Fig.1) for the reference period (1976-2005) (a) and the anomaly corresponding to the late 21st century change (2070-2099) (b). The colors correspond to the different model simulations analyzed. (Adapted from Llopart et al 2014)

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PETROLOGY AND GEOCHEMISTRY OF MAFIC-ULTRAMAFIC ROCKS FROM SELECTED AREAS: TECTONIC AND METALLOGENETIC IMPLICATIONS

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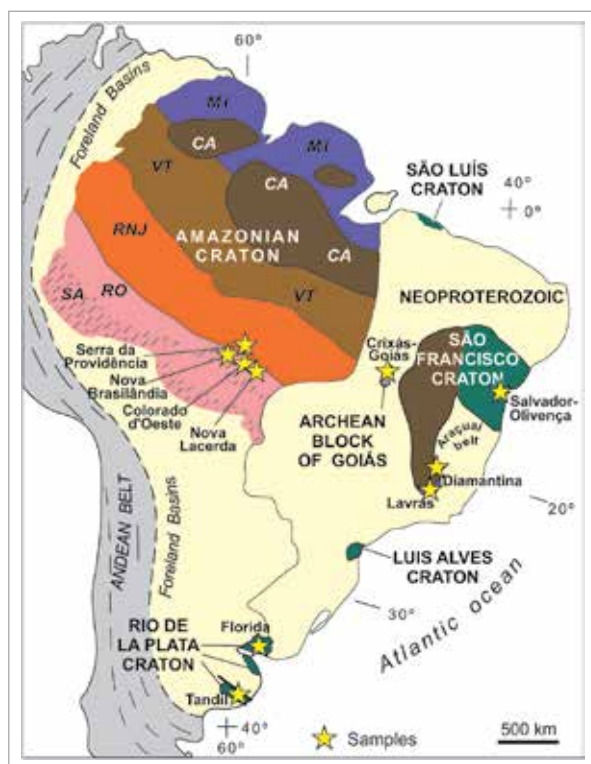


Figure 1.

The project is part of a research on mafic-ultramafic rocks which has been performed during the last four decades. The present study refers to four main types of mafic and ultramafic rock associations: the mafic dykes from the cratonic areas of the South American Platform, mainly those from the Amazonian Craton, the large mafic-ultramafic stratiform complexes of Niquelândia and Cana Brava, in Goiás State, the basalts and alkaline rocks form the Paraná-Etendeka system, in South America, Namibia and Angola, and the ultramafic-alkaline rocks of Planalto da Serra in the Amazonian Craton. Age determinations of mafic dykes can also generate important data on mantle composition and on the tectonic evolution of continental areas during the geological times. In several regions of the world, they are related to the breakdown of continents and supercontinents. Similar geochemical and tectonic importance is attributed to the study of the Mesozoic volcanism of the Paraná-Etendeka system, and its relationship with the opening of the South Atlantic Ocean. The studies on the age, stratigraphy and evolution of the stratiform complexes of Niquelândia and Cana Brava, important sources of nickel and asbestos respectively, are controversial with respect to their ages, stratigraphy and tectonic evolution. The alkaline ultramafic rocks from Planalto da Serra, in the Mato Grosso State, have been recently discovered, and their age, petrology and tectonic role are poorly known.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The study of selected mafic dykes from cratonic areas of the South American Platform shows considerable differences in their mantle sources and geodynamic features. Dykes from Nova Lacerda (1.38 Ga) and Colorado Complex (1.35 Ga) are related to arc settings formed during the 1.47-1.35 Ga closure of the oceanic domain separating the Amazonian Craton and the Paraguá Block, whereas those from the Serra da Providência Intrusive Suite (1.55 Ga) and the Nova Brasilândia Sequence (1.10 Ga) are considered intracratonic. In spite of the diversity of geological settings, all dyke swarms originated from a mantle source composed mainly of an E-MORB end-member, with a variable addition of slab fluids, which indicates the presence of episodic oceanic lithospheres subductions during the Mesoproterozoic in the SW Amazonian Craton. The dyke swarms from the São Francisco Craton are associated with intraplate events. The mantle source of the Lavras swarm (1.9 Ga) has a predominant E-MORB characteristic, whereas the younger dykes from the Diamantina (0.93 Ga) and the Salvador-Olivença swarms (0.92 Ga), have significant influence of slab derived and deep fluids (OIB type). These dykes could be related to the initial disrupting of the Rodinia Supercontinent. The heterogeneity of mantle source is also shown by the Florida (1.79 Ga) and Tandil (2.0 Ga) dykes, which are associated with extensional events of the Rio de la Plata Craton; and by the Crixás-Goiás (2.49 Ga) swarm in the Archean Block of Goiás, suggesting that crustal recycling occurred since Archean times. U–Pb zircon ages provide compelling evidence that the Upper and the Lower Niquelândia Complexes formed during the same igneous event at ca. 790 Ma. Similarly, to the Ivrea Complex (NW Italy) both complexes grew incrementally as large crystal mush bodies, which were continuously stretched while, fed by pulses of fresh magma. Syn-magmatic recrystallization during this deformation resulted in textures and structures, which, although appearing metamorphic, are not ascribable to post-magmatic metamorphic event(s), but are instead characteristic of the growth process in huge and deep mafic intrusions such as the Niquelândia and Ivrea. Data of the Cana Brava complex suggest similar age and significant crustal contamination. The genesis of Paraná-Etendeka magmatism, which includes tholeiitic and K and Na alkaline rocks, requires heterogeneous mantle sources, probably related to “metasomatic processes,” which would have occurred at ca. 0.5–1.0 Ga in Angola, Namibia, and Brazil; and 1.5–1.6 Ga in eastern Paraguay. The contribution of asthenospheric components, derived from mantle plumes to the genesis of the magmatism was not significant. Thermal anomalies in the deep mantle, mapped by geoid and seismic tomography, offer an alternative for a plume-unrelated heat source. The Planalto da Serra ultramafic alkaline rocks yielded an age of ca. 600 Ma. These age determination rules out geochronological and genetic relationship between the Planalto da Serra rocks and the Cretaceous bodies of the “Azimuth 125” Lineament. This age also indicates that the onset of the deformation of the Cuiaba Group may be older than 600 Ma, and is a strong argument against the existence of the Clymene Ocean, a controversial large Edicarian oceanic domain in South America.

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WORK SCHEDULES, LIGHT EXPOSURE AND THEIR EFFECTS ON SLEEP, BIOLOGICAL RHYTHMS AND WELLBEING OF WORKERS IN AN AMAZON EXTRACTIVE RESERVE

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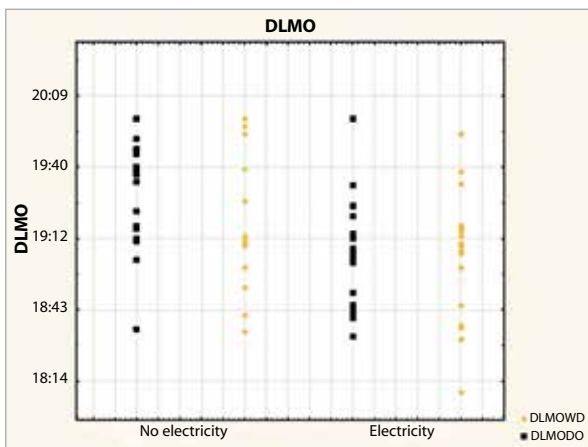


Figure 1. Dim light melatonin onset (DLMO) in rubber tappers with and without electric light at home

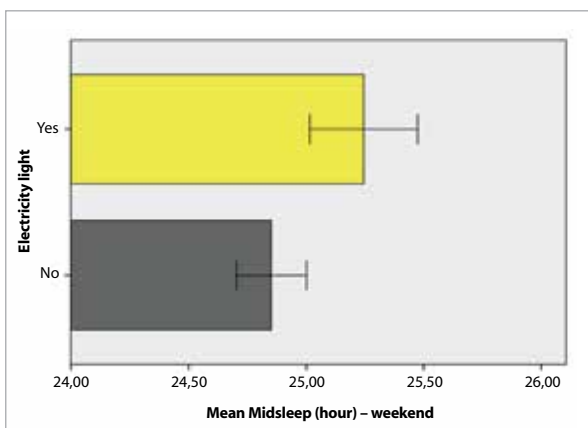


Figure 2. Mean midsleep in rubber tappers with and without electric light at home during the weekend

Environment light is the primary time cue affecting human circadian timing. Appropriate light exposure maintains synchrony of biological clocks and permits consolidated periods of sleep and wakefulness. Research has shown that light exposure is an important factor for aiding adaptation to working out of hours. Many of those who work irregularly show circadian rhythm problems or “social jet lag” that causes fatigue, mood deterioration, sleep problems, reduced work performance and ill health. In order to continue investigating the effects of the lighting environment on sleep and sleepiness during waking hours, it was designed a new project making use of unique access to a rural community living in an Amazon Reserve (latitude: 10°39’06”S; longitude: 68°30’16”W). This study aimed to understand the patterns of light exposure and work schedules, and their implications for sleep patterns/timing and the biological rhythms of 700 rubber tappers living at the Chico Mendes Extractive Reserve. The principal hypothesis was that there is a correlation between the extent of social jetlag and circadian misalignment and adverse health problems among this population. Rubber tappers work from 5:00 to 16:00 h, Mondays to Fridays, with 2 days-off at weekends. The study was conducted in two phases: in the first phase of the study data from 340 rubber tappers relating to sociodemographic characteristics, anthropometric measurements, diet, lifestyle, chronotype, working conditions and morbidities of the study population were collected. In the second phase the workers were selected according to the availability of electricity at home (n=42 in total; 17 with electric light and 25 without electric light at home). To obtain information on the workers’ activity/rest cycle, they wore a wrist actigraph for 10-14 consecutive days. Saliva was collected for assessment of the time of nocturnal melatonin onset and light exposure measurements will also be taken. These measurements allowed us to estimate how biological timing was affected by their work schedules and light exposure and what impact this might have on workers’ health and wellbeing.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The findings demonstrate a significant impact of availability of electric light at home on melatonin onset (*Figure 1*) and timing of sleep in workers (*Figure 2*) living in the Amazon. The results corroborate the idea of several factors affecting sleepiness besides working time. Light exposure might be related to sleep duration and sleepiness at work. Studying a person's internal biological timing and sleep patterns and how these are affected by different work shift schedules and the influence of light on this process may offer future treatment strategies and recommendations to reduce the health risk of work schedules.



Rubber tapper in the forest



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PLASMODIUM VIVAX: PATHOGENESIS AND INFECTIVITY

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FAPESP # 2012/16525-2 | Term: Aug 2013 to Jul 2017

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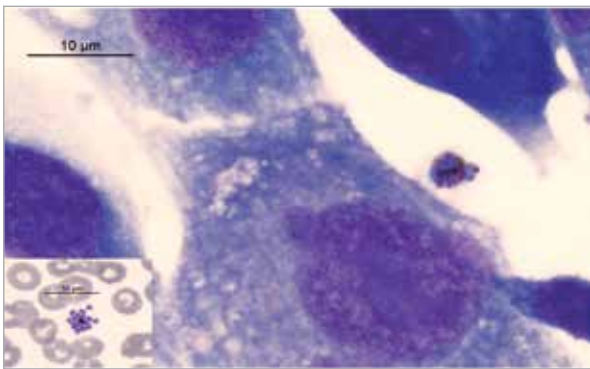


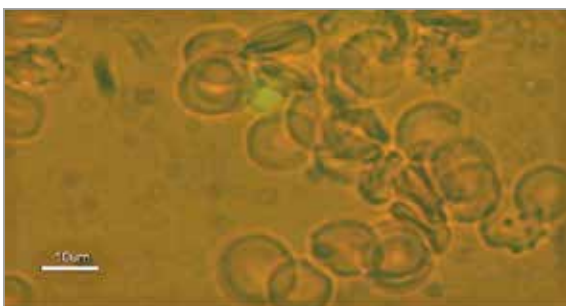
Figure 1. *Plasmodium vivax* cytoadhesion. Giemsa-stained light photomicrography revealing *P. vivax* schizont cytoadhered to human lung endothelial cell. Insert shows a schizont of *P. vivax* after maturation in a thin film blood smear Giemsa-stained

Malaria parasite infects more than 200 million individuals and lead to death of 600 thousand people annually. Fatalities are normally associate to *Plasmodium falciparum* infections as *P. falciparum*-infected erythrocytes (Pf-iEs) can sequester into the microvasculature of vital organs, playing a key role in the pathogenesis of life-threatening malaria complications, such as cerebral malaria (CM) and malaria in pregnancy (MiP). Moreover, despite the appropriate antimalarial treatment and the development of several adjunctive therapies, a significant proportion of individuals still succumb to CM and survivors develop neurological sequelae. Sequestration is marked by the cytoadhesion of Pf-iEs to host receptors on the surface of endothelial cells and on non-infected erythrocytes (rosettes). Although *P. falciparum* is the most lethal parasite and is responsible for the majority of malaria cases, *Plasmodium vivax* infects 22 million cases per year, with strong social impact in South-East Asia and the Americas. Moreover, it is estimated that 2.6 billion people are at risk of *P. vivax* infection worldwide. In Brazil, where transmission is almost exclusively restricted to the Amazon region (99.8%), 85% of malaria infections are caused by *P. vivax* accounting for 50-60% of all malaria cases reported in the Americas. Recently, it has been reported that in Brazil and Asia-Pacific region *P. vivax* infections may also lead to severe clinical complications. These observations challenge the concept that *P. vivax* is a “benign” species of parasite and open new avenues to study *P. vivax* pathogenesis and its mechanisms of infection. Thus, as long-term *in vitro* culture of *P. vivax* is still not feasible, the study of the biology of this parasite species remains restricted to endemic areas. Thus, as a result of a close collaboration with referral hospitals and research institutions in malaria endemic areas in the Amazon, the team was able to establish functional *ex vivo* assays allowing us to understand the mechanisms related to *P. vivax* cytoadhesion (including rosette formation) and to identify potential parasitic ligand(s) involved in this process. Moreover, it is also planned to determine the impact of *P. vivax* infections in pregnant women, the consequences to the placental tissue and the innate immune response involved in the adhesion to the placental. Finally, it is intended to verify the potential vaccine antigens of *P. vivax*.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Based on *P. vivax*-infected patient's clinical complications, it is hypothesized that these poor outcomes could be related to adhesion of *P. vivax*-infected erythrocytes (Pv-iEs) to the endothelium. Thus, Pv-iEs harvested from Brazilian patients were used in *ex vivo* cytoadhesion assays to brain and lung endothelial cell and to placenta cryosections. It is observed that Pv-iEs were able to adhere under static and flow conditions to both cell-lines and to placenta via ICAM-1 (mainly) and chondroitin sulfate A (CSA) cell receptors. In addition, the parasite surface ligand named VIR was implicated in this binding. Recently, it is confirmed cytoadhesion of *P. vivax* via ICAM-1 by performing adhesion assays to lung endothelial cells with Colombian isolates. Rosette formation has been investigated using Brazilian and Asia-Pacific isolates. It is revealed that the majority of isolates rosettes, however without an association between blood type and severity. Moreover, these rosettes were, mostly, formed by late stage-forms of Pv-iEs to normocytes via glycophorin C, rather than reticulocytes (*P. vivax* target cells). In addition, Pv-iEs when bound to non-infected erythrocytes were less likely to be phagocytosed. Assuming Pv-iEs display adhesiveness, therefore disappearing from the peripheral blood (sequestration), it is performed *ex vivo* adhesion assays with Pv-iEs, before and after maturation. It is observed a higher binding potential of schizonts compared to other asexual stages (young forms). These results were correlated with observations in vivax malaria patients in which schizonts were almost absent in the peripheral blood in a patient with negative peripheral parasitemia, Pv-iEs VIR-positive were observed bound to lung endothelium. Next, although MiP has been largely studied in falciparum infections, little is known regarding the consequences to the placental tissue and to the innate immune response in pregnant women bearing *P. vivax*. A recent study revealed more lesions in the placenta of *P. vivax*-exposed women in comparison to healthy volunteers. Moreover, by means of an experimental murine model representing MiP, it is demonstrated that MyD88 plays a major role in the severity of pregnant-infected mice. Collectively, the findings provide, so far, evidence that Pv-iEs cytoadhere and sequester, however it is not clear if this adhesiveness is directly related with *P. vivax* severity. Therefore, these observations prompt a paradigm shift in *P. vivax* biology and open new avenues to investigate the

Figure 2. Rosetting formation in *Plasmodium vivax*. Fluorescence photomicrography of a *P. vivax* mature-stage form stained with acridine orange surrounded by non-infected red blood cells (rosette)



role of sequestration in *P. vivax*, especially its involvement as a mechanism of immune evasion and its infectivity to the reticulocytes.

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EVALUATION OF THE BIOLOGICAL POTENTIAL OF AMAZONIA EXOTIC OILS BEFORE AND AFTER ENZYMATIC INTERESTERIFICATION PROCESS FOR THE PRODUCTION OF NEW OILS

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FAPESP # 2012/22829-4 | Term: Mar 2013 to Feb 2015

co-PIs: Andréa Falcão, Paula Speranza, Gabriela Alves Macedo

Samples	Tocopherol fractions ($\mu\text{g/g}$)				Total phenolics ($\mu\text{g/g}$ Eq galic acid)	Total carotenoids ($\mu\text{g/g}$)	DPPH (IC50)	ORAC ($\mu\text{mol Trolox/g}$ oil)	
	a	b	g	y					
Original oils	Patatuá	--	--	--	--	10.75 \pm 0.72	--	49.97	68.71
	Buriti	112.50 \pm 3.91	7.13 \pm 0.01	107.40 \pm 3.43	9.38 \pm 0.54	107.00 \pm 1.25	510.37 \pm 0.68	81.06	100.34
Mixed Oils	Patatuá: Palm estearin (7:3)	--	--	--	--	55.33 \pm 0.48	--	61.40	52.80
	Buriti: Murumuru (7:3)	74.64 \pm 0.73	1.90 \pm 0.16	50.11 \pm 0.34	8.26 \pm 0.24	52.42 \pm 0.64	405.98 \pm 1.35	80.50	70.71
Interesterified oils (TL-IM Novozyme)	Patatuá: Palm estearin (7:3)	--	--	--	--	10.75 \pm 5.05	--	58.30	57.71
	Buriti: Murumuru (7:3)	76.01 \pm 4.10	0.31 \pm 0.43	69.06 \pm 3.95	3.51 \pm 0.10	85.33 \pm 1.58	364.81 \pm 2.71	86.39	94.65
Interesterified oils (Rhizopus sp.)	Patatuá: Palm estearin (7:3)	--	--	--	--	25.33 \pm 1.34	--	47.15	102.42
	Buriti: Murumuru (7:3)	69.24 \pm 2.98	--	63.26 \pm 2.75	2.85 \pm 0.39	70.33 \pm 0.24	429.44 \pm 11.5	73.28	110.99

Table 1. Minor components characterization and antioxidant capacity (*in vitro*) of the oil samples: Patatuá (*Oenocarpus bataua* Mart.), Buriti (*Mauritia flexuosa* Mart.), Palm estearin (*Elaeis Guineensis* Jacq), Murumuru (*Astrocaryum murumuru* Mart.)

The Amazonian flora is extremely rich and diverse in oilseeds, being unique and incomparable. The Amazon oils have a great potential to apply in cosmetics, drugs and functional foods and has huge unexplored nutritional and biological potential. Apart from natural oils, the fatty bases production, with better physical-chemical properties to industrial application, high nutritional and biological potential, is an eminent need. Enzymatic interesterification, involving the rearrangement of fatty acids among glycerol backbones, is proving to be a good alternative. The change in the original triacylglycerol composition modified the physical and biological properties of restructured triacylglycerol, thus increasing the potential applications of these lipids. However, goal of this project was to evaluate the nutraceutical potential of these new generated oils, based on Amazon oils and biotechnological process. For that, the antioxidant capacity of selected

Amazon oils and the new oils generated by enzymatic interesterification were evaluated by *in vitro* e *ex vivo* methods. The interesterification reactions were carried out by two different lipases, first, the commercial NOVOZYME lipases (TL-IM), and, second, the lipases produced by wild fungus strain of *Rhizopus sp.*, isolated by the research group in previously projects. The Amazon fats chosen for this study were Buriti oil, known for its antioxidant capacity, and Murumuru fat. The results obtained of region specific distribution of fatty acids on triacylglycerol and its technological properties modifications are shown as results of another project financed by FAPESP (2012 22774-5), briefly, the analyzes indicate the production of an oil rich in unsaturated fatty acids at the positions sn-1,3. The production of lipids with high content of unsaturated fatty acids in the position sn-1,3 of triglyceride and free of trans fatty acids is of great interest for the development of lipids with high nutritional and biological potential.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

In addition to the potential healthy improvement of the fat acids composition on the new oils, our interest was also to evaluate if the high antioxidant potential of the Buriti oil, due to its minor components as tocopherols and phenolic compounds, was preserved. For that, this project evaluated these minor components composition on the original and new oils; tested the antioxidant capacity of the samples against the DPPH (2,2-diphenyl-1-picryl-hidrazyl-hidrate) and ORAC free radicals. At the present moment, the team is heading to the second half of the project development, testing the range of the samples



Figure 2. Illustrations of Murumuru, Buriti, Patauá and Palm fruits, from the higher to the lowest picture, respectively

concentrations adequate for the human hepatocytes antioxidant assays. The proposed cells assays mean to evaluate the capacity of the samples in modulate the endogenous antioxidant enzymes activity, for the detoxification of tissues highly metabolic active as the liver. The enzymatic activity of intracellular catalase, superoxide dismutase and glutathione peroxidase will be evaluated in human hepatocytes culture cells (Hep G2), before and after the treatment with the oils. The results obtained, so far, are shown on *Table 1*. These partial results indicate that the oils generated by enzymatic interesterification from the Buriti oil and Murumuru fat – highlighting the process catalysed by lipase from *Rhizopus sp.* – are promising with respect to their biological activity. The results of free radicals scavenging potential, assessed by DPPH and ORAC assays, are closely linked to minor components of the oils with high antioxidant potential, such as the tocopherols, phenolics, and carotenoids. Moreover, the tests involving modulation of endogenous antioxidant enzymes activity, may be influenced by both the minor compounds of oils and their triglycerides and fatty acids

composition. For this reason, the healthy potential of the new generated oils may be more evident after the following steps of this work.

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NETWORK RESEARCH GROUP OF MEDICINAL PLANT COMPOUNDS FOR MALARIA TREATMENT FROM ETHNOPHARMACOLOGY IN THE AMAZON AND ACRE STATES

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FAPESP # 2009/53638-7 | Term: Jun 2011 to May 2015

FAPESP/CNPq – Pronex Program



Figure 1. Elixir: medicinal formulas used to treat many diseases, Pastoral da Saúde. Barcelos AM, Tomchinsky B. 2014

Malaria remains one of the major neglected diseases worldwide, infecting more than three million people annually and causing the death of a million of them. Malaria results from the interaction of the protozoan parasite Plasmodium, its host, the humans, and its vector, Anopheles mosquitoes. Where it occurs, it causes of delay in human development. In the world, the Sub-Saharan Africa is the most affected area, while, in the Americas, the Amazon region is the main endemic area and accounts for 99% of the transmission in the country. Unfortunately the parasite has shown resistance to most of the available drugs and it is urgent the research of new effective compounds to combat it. The Research Network studies are based on the knowledge of traditional communities from the Amazon region to find medicinal plants used for the treatment of malaria and its associated

ills. Based on these indications, the most promising plants are studied and have their biochemical activities tested in laboratories for the identification of active phytochemical compounds. The research groups start from ethnobotanical studies in the communities, involved with the collection and identification of plants, the extraction of chemical compounds and realization of tests, such as:

- antiplasmodial activity *in vitro* with *P. falciparum*;
- schizont blood tests in mice with *P. berghei*;
- tests for acute toxicity *in vivo*; *in vitro* cytotoxicity assays;
- activity and toxicity of antimalarial substances obtained from plants;
- chromatographic screening, isolation and identification and structure elucidation of the isolated compounds;
- extraction and fractionation of pure substances;
- reaction tests with metalloporphyrin; and
- analysis by HPLC-UV and HPLC-MS/MS.

There are 55 traditional communities involved in this project distributed in eight municipalities around of the Purus and Negro rivers and their tributaries in the states of Acre and Amazonas: São Gabriel da Cachoeira (AM), Santa Isabel do Rio Negro (AM), Barcelos (AM), Novo Airão (AM) and Xapurí (AC), Lábrea (AM), Boca do Acre River (AM) and Pauini (AM). These communities are distributed in indigenous lands (IT), conservation units (FLONA and RESEX), settlements, private lands, lands of the Union, and some of them are characterized by the presence of indians from different ethnicity, gatherers, farmers, caboclos and ribeirinhos and there is also one religious community. The “Network research group of medicinal plant compounds for malaria treatment from ethnopharmacology in the Amazon and Acre States” was approved with the Call MCT / CNPq in 09/2009 - PRONEX - Malaria Network, process 555669/2009-2 with funding from FAPESP and CNPq from the end of 2009.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The ethnobotanical studies have been completed and from the 150 plant species listed for the specific treatment of malaria in visited communities, 30 are new and have never been published before, which shows the importance of this research. Twenty of these plants were selected for the laboratory tests, which should be completed by the end of 2015. For the agronomic tests, the same twenty plants were selected to propagation, fertilization, management and harvesting tests. All these steps are fundamental to know what are the most interesting species for the development of new drugs.



Figure 2. Searching for the indicated plants.
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EARLY WARNING SYSTEM FOR EMERGING INFECTIOUS DISEASES IN SOUTHWESTERN AMAZONIA: TECHNO-INNOVATION AS ADAPTATION TO THE NEGATIVE IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH

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MAGDALA Sustainability Science & Business – Franca/SP and Assis Brasil/AC

FAPESP # 2008/58156-8 | Term: Jan 2011 to Dec 2014 | FAPESP Research Program on Global Climate Change (RPGCC)

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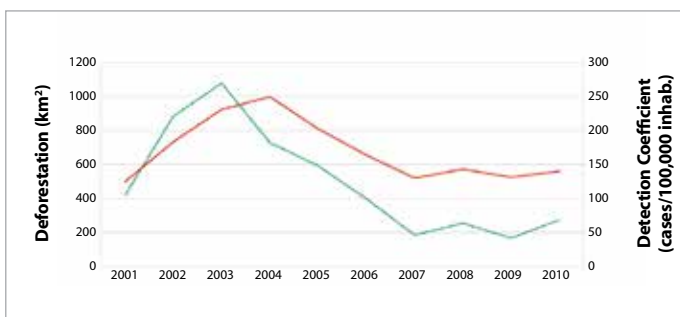


Figure 1. Pearson Correlation ($P=0,0030$; $r=0,8298$) between ATL Detection Coefficients and the Deforestation Rates, in Acre, from 2001 to 2010. Source: Ribeiro et al., 2011

The relationships between some determinants of Climate Change and their impacts on Ecosystems Services, especially on the capacity of Amazonian ecosystems to regulate the spreading of vector-borne infectious diseases is the focused problem. In Amazonia, forest burning is used to convert forested areas into pastures or plantations, emitting GHGs. Unprecedented regional changes due to the ongoing implementation of hydroelectric dams, hydro-ways and paved roads are expected to have great impacts on the epidemiology of human diseases, over the next years. LUCC and the associated biodiversity-loss favour the disruption of natural cycles that impinge on vectors' abundance,

jeopardizing an Ecosystem Service known as Infectious Diseases Regulation (the ability of ecosystems to act as buffer zones between zoonosis and human populations). Increased migration and urbanisation will affect the spread of transmission of vector-borne diseases, by increasing the density of both people and vectors and the transit of people. The most striking changes in the epidemiology of vector-borne diseases already observed in the Andes-Amazon region, so far, are the (re)emerging diseases transmitted by phlebotomine sand flies: American Cutaneous Leishmaniasis (ACL) and Bartonellosis (Carrion Disease). This project aims at developing adaptation strategies and tools to face the negative impacts of Global Climate Change on the health determinants of human communities living in the tri-national (Bolivia, Brazil, Peru) region known as Southwestern Amazonia. The Specific Objectives are:

1. to monitor changes in the eco-epidemiology of ACL and Bartonellosis at the tri-national frontier;
2. to monitor local/regional climatic (temperature, rainfall, humidity, wind, altitude), and land use/cover changes;
3. to identify the sand fly vectors (Diptera: Psychodidae: Phlebotominae) involved with the transmission of both diseases in the tri-national region;
4. to develop an Early Warning System for Emerging Infectious Diseases in Southwestern Amazonia, enabling health professionals to anticipate and face the negative impacts of climate change on the spreading of (re)emerging vector-borne infectious diseases.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

A 10-year (2001-2010) retrospective analysis of secondary data on the eco-epidemiology of ACL in the State of Acre was performed using bi- (Pearson Correlation) and multivariate statistics (Cluster Analysis, Analysis of Principal Components, Discriminate Analysis, Correspondence Analysis). It identified not only the main factors involved with the hyper-endemicity of ACL in Acre, but also found a strong correlation between the deforestation rates and ACL occurrence in Acre State. During 12 consecutive months, from April 2013 to March 2014, there have been conducted 5-night captures during the New Moons, in four sentinel sites (three of them at the Brazilian side and one at the Peruvian side of the tri-national Southwestern Amazonia borders). The sand flies collected by light traps (CDC-like) were separated by gender; males are being identified/classified according to references published by Prof. Dr. Eunice Galati (USP); females are being kept for DNA extraction, and Polymerase Chain Reactions (PCRs) to detect the existence of *Bartonella bacilliformis* and *Leishmania sp.* From the more than 23,000 phlebotomines (Diptera: Psychodidae: Phlebotominae) collected during this first-time ever vector surveillance in Acre State, our preliminary analysis of the sand flies found in the intra and peri-domicile areas, only during the months of April and May 2013, revealed a great richness of species. The further improvement of the hand-held computer-based interface for eco-epidemiological data- analysis and sharing called Nu-case has been tested for space-temporal mapping using the data resulting from fieldwork and was evaluated by students and lectures of a medical school for its usefulness.

Figure 2. Species of Phlebotomines collected (April - May 2013), in Assis Brasil-AC, by the intra and peri domicile traps, according to Eunice Galati's key. In: Rangel EF & Lainson R (org.). *Flebotomíneos do Brasil*, Rio de Janeiro, Fiocruz, 2003, 367 p.

Species	Period					
	April/2013			May/2013		
	n	Intra	Peri	n	Intra	Peri
<i>Nyssomyia antunesi</i>	3		3	11	5	6
<i>Nyssomyia anduzei</i>	0			1		1
<i>Nyssomyia whitmani</i>	0			8	3	5
<i>Nyssomyia sp</i>	0			1		1
<i>Migonemyia migonei</i>	0			1		1
<i>Pressatia choti</i>	1	1		4	2	2
<i>Pressatia calcarata</i>	0			24	7	17
<i>Psathyromyia dendrophyla</i>	1		1	1		1
<i>Psathyromyia aragoai</i>	1		1	2		2
<i>Psathyromyia digitata</i>	0			4		4
<i>Psychodopygus davisi</i>	0			4	4	
<i>Brumptomyia pentacantha</i>	0			12		12
<i>Brumptomyia sp</i>	0			1		1
<i>Brumptomyia avellari</i>	0			2		2
<i>Brumptomyia cunhai</i>	0			1	1	
<i>Brumptomyia brumpti</i>	0			2	1	1
<i>Evandromyia saulensis</i>	0			1		1
<i>Pintomyia pessoai</i>	0			1	1	
<i>Trichopharomyia auraensis</i>	14	1	13	57	10	47
<i>Trichopharomyia sp</i>	14	4	10	17	2	15
<i>Trichopharomyia octavioi</i>	0			3		3
<i>Trichopharomyia ubiquitousis</i>	0			3		3
<i>Trichopharomyia napaensis</i>	0			1		1
<i>Trichopharomyia sp n.</i>	1		1	0		
TOTAL	35	6	29	162	36	126

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MALARIA EPIDEMIOLOGY AND CONTROL IN RURAL AMAZONIA

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FAPESP # 2013/02764-8 | Term: Aug 2013 to Jul 2015



Figure 1. Study children in the Remansinho settlement, Amazonas State, Brazil. Photography by Alessandra Fratus

Malaria remains a major public health concern in Brazil. With 243,000 slide-confirmed infections, this country contributed 52% of the malaria burden in the Americas in 2012. Most transmission in Brazil occurs in open mining enclaves, logging camps and farming settlements across the Amazon Basin. Since the early 1970s, colonization projects have attracted migrant farmers from the malaria-free South and Southeast regions to frontier settlements in densely forested areas of Amazonia. Land clearing for agriculture and logging resulted in an increased abundance of the local malaria vector, the mosquito *Anopheles darlingi*. Not surprisingly, recent frontier settlements constitute malaria hotspots until these communities become more stable, with improved health infrastructure and reduced mobility of settlers. Although the two main human malaria parasites *Plasmodium falciparum* and *P. vivax* are widespread across Amazonia, the latter species accounts for 85% of the malaria cases in the region. The presence of dormant liver stages (hypnozoites) and the early circulation of infectious stages (gametocytes) in peripheral blood render *P. vivax* less responsive than *P. falciparum* to available control strategies based on early diagnosis and treatment of infections. With the long-term goal of providing scientific evidence that can be translated into effective public health interventions for malaria control, over the past 10 years we have carried out population-based prospective cohort studies in frontier settlements in rural Amazonia. We focused on the relative contribution of low-density and asymptomatic infections, which are missed by routine control measures, to ongoing *P. vivax* transmission. Furthermore, we used molecular genotyping to examine how community-level genetic diversity of malaria parasites varies across time and space and to track the spread of new parasite strains associated with outbreaks. The combined analyses of malaria morbidity data and individual and household-level risk factors provided the bases for new strategies for eliminating residual malaria in areas where most infections are asymptomatic and parasite densities are often below the detection.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Clinical and laboratory surveillance of malaria in the agricultural settlement of Granada, Acre State, revealed year-round transmission of both *P. falciparum* and *P. vivax*, mostly associated with logging and farming. Individuals with the Fya+b- phenotype in the Duffy blood group, a major red cell receptor for *P. vivax*, have a 30-80% reduced risk of clinical vivax in this prospective cohort. Molecular methods were 5.4-fold more sensitive than conventional microscopy for diagnosing infections, especially in asymptomatic parasite carriers. High rates of *P. vivax* recurs after malaria treatment, a finding with major implications for control. Nearly all recurrences involved parasite genotypes not found in the primary infection, revealing a high turnover rate of parasite strains. Since 2010, focusing on malaria transmission during the early stages of frontier settlements, population-based cohort study in Remansinho area, documented a major decline in the prevalence of *P. vivax* infection (from 23.8% to 3.0%) over three years, with vanishing *P. falciparum* transmission but a *P. vivax* outbreak in October 2012. Molecular genotyping of *P. vivax* isolates revealed a moderate to high genetic diversity, with a large proportion (78.5%) of infections comprising more than one strain. The lowest parasite diversity and the smallest proportion of mixed-strain infections were observed at the time of the outbreak. Risk of both infection and *P. vivax*-related disease in Remansinho decreased with increasing cumulative exposure to malaria, consistent with anti-parasite and anti-disease immunity being acquired. Up to 73.1% of the *P. vivax* infections were missed by microscopy as malaria transmission declined and most (56.6%) of these infections caused no clinical signs or symptoms. Few (17.0%) asymptomatic *P. vivax* infections that were left untreated eventually progressed to clinical disease, becoming detectable by routine malaria surveillance, over 6 weeks of follow-up. Moreover, nearly all *P. vivax* infections that were undetected by microscopy had gametocytes, the parasite's blood stages responsible for malaria transmission to mosquito vectors, detected by molecular methods. These findings indicate that apparently healthy carriers of low-density infections, who are often missed by conventional diagnosis, contribute significantly to ongoing *P. vivax* transmission and further complicate residual malaria elimination in rural Amazonia.

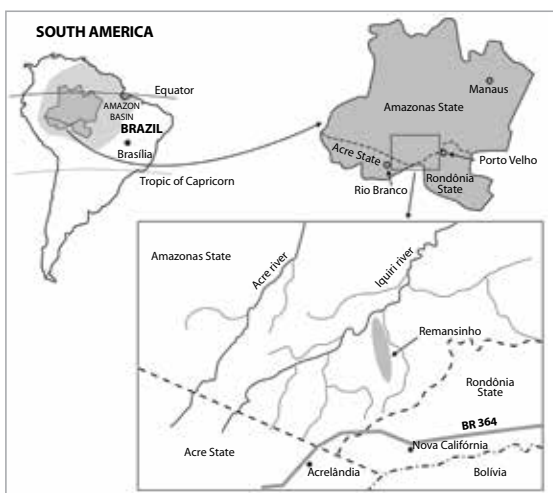


Figure 2. Location of the field site, Remansinho, southern Amazonas State

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NEGLECTED TROPICAL DISEASES' REGULATION AS AN ECOSYSTEM SERVICE, UNDER LAND-USE CHANGE AND HUMAN ADAPTABILITY SCENARIOS, IN ALTO XINGU-MT-BRAZIL COMMUNITIES

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FAPESP # 2014/01449-4 | Term: Mar 2014 to Feb 2015

co-PIs: Manuel Cesario, Silvia Maria Guerra Molina, Diones Antônio Borges (PhD Student)

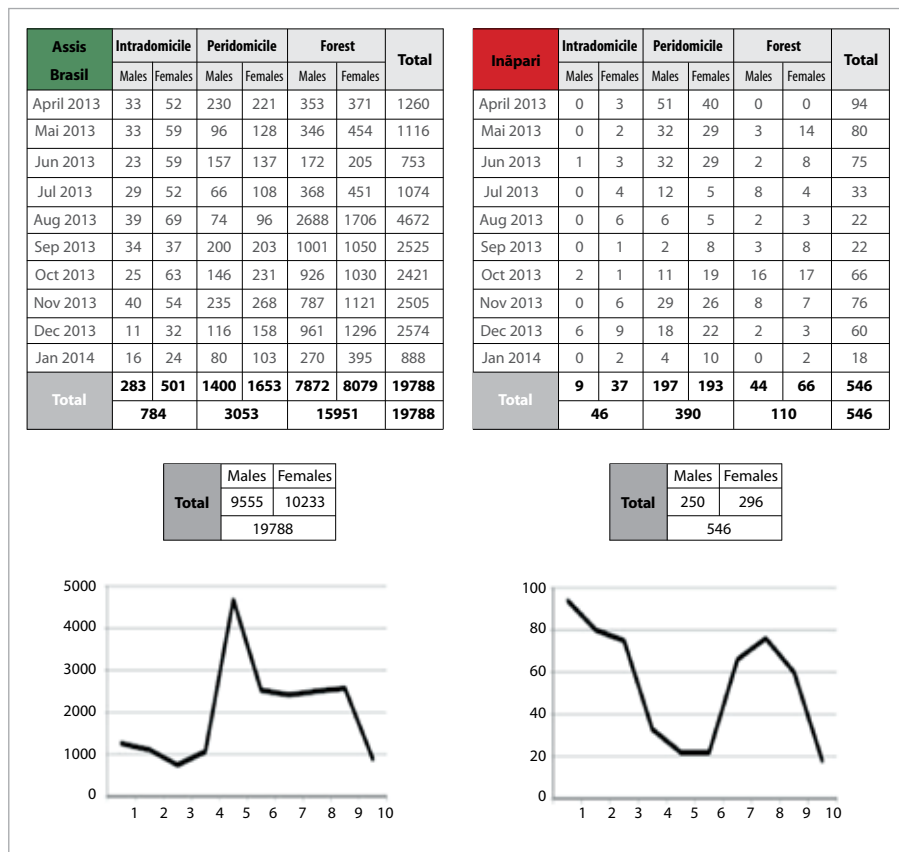


Figure 1. Phlebotomines collected during the first 10 months of an annual surveillance on the tri-national borders of Southwestern Amazonia, by gender and by month

This project is aimed at improving the competencies of the Genetics Department (LGN) at ESALQ/USP Piracicaba, with the inclusion of the 'One Health' (human, animal, vegetal and environmental health) dimension brought by the FAPESP Visiting Scientist Manuel Cesario, to the adaptive human strategies' approach developed by Professor Silvia Molina in her Ecogenetics and Evolutionary Human Ecology Laboratory. The research activities proposed include the pilot collection and identification of Leishmaniasis' vectors in sentinel sites among the municipalities of Canarana, Água Boa e Querência (MT), where these neglected diseases are endemic. On top of this, the acquisition of primary micro-climate data, as well as the retrospective survey of secondary data on land use/cover changes and human Leishmaniasis'

occurrence will allow extrapolating information on vector-borne diseases' regulation as an ecosystem service, under a scenario of land use/cover and human adaptability changes, in Alto Xingu, MT communities. Additionally, the identification of the protozoa species present in the phlebotomines (Diptera: Psychodidae: Phlebotominae) collected represents an opportunity to scientifically advance the most important link between climate change, neglected tropical diseases (American Cutaneous Leishmaniasis and Bartonellosis), and the human adaptive strategies in the tri-national frontier of South-western Amazonia. This identification will be made through molecular biology analysis (PCR) to be undertaken in the LGN/ESALQ/USP laboratories, which in turn will benefit from its competencies' improvement through the acquisition of the PCR technique for *Bartonella bacilliformis* identification, not yet available in Brazil. This technology transfer will be possible through the on-going partnership with the Humboldt Institute of the Peruvian University Cayetano Eredia, part of the Thematic Project 2008/58156-8, coordinated by Manuel Cesario.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

During 12 consecutive months, there have been conducted 5-night captures during the New Moons, in four sentinel sites, three of them were at the Brazilian side and one was at the Peruvian side of the tri-national South-western Amazonia borders, from April 2013 to March 2014. The sand flies collected by light traps (CDC-like) were separated by gender; males are being identified/classified according to references published by Prof. Dr. Eunice Galati (USP); females are being kept for DNA extraction, and Polymerase Chain Reactions (PCRs) will be performed during the present project to detect the existence of *Bartonella bacilliformis* and *Leishmania sp.* Figure 1 shows the impressive number of more than 20,000 phlebotomines (Diptera: Psychodidae: Phlebotominae) collected during the first 10 months of this vector surveillance. Our preliminary analysis of the species found inside the domiciles and in the peri-domicile areas of the four collection sites, only during the months of April and May 2013, revealed a great richness of species, as shown by Figure 2.

Figure 2. Species of Phlebotomines collected (April - May 2013), in Assis Brasil-AC, by the intra and peri domicile traps, according to Eunice Galati's key. In: Rangel EF & Lainson R (org.). *Flebotomíneos do Brasil*, Rio de Janeiro, Fiocruz, 2003, 367 p.

Species	Period					
	April/2013			May/2013		
	n	Intra	Peri	n	Intra	Peri
<i>Nyssomyia antunesi</i>	3		3	11	5	6
<i>Nyssomyia anduzei</i>	0			1		1
<i>Nyssomyia whitmani</i>	0			8	3	5
<i>Nyssomyia sp</i>	0			1		1
<i>Migonemyia migonei</i>	0			1		1
<i>Pressatia choti</i>	1	1		4	2	2
<i>Pressatia calcarata</i>	0			24	7	17
<i>Psathyromyia dendrophyla</i>	1		1	1		1
<i>Psathyromyia aragaoi</i>	1		1	2		2
<i>Psathyromyia digitata</i>	0			4		4
<i>Psychodopygus davisii</i>	0			4	4	
<i>Brumptomyia pentacantha</i>	0			12		12
<i>Brumptomyia sp</i>	0			1		1
<i>Brumptomyia avellari</i>	0			2		2
<i>Brumptomyia cunhai</i>	0			1	1	
<i>Brumptomyia brumpti</i>	0			2	1	1
<i>Evandromyia saulensis</i>	0			1		1
<i>Pintomyia pessoai</i>	0			1	1	
<i>Trichophoromyia auraensis</i>	14	1	13	57	10	47
<i>Trichophoromyia sp</i>	14	4	10	17	2	15
<i>Trichophoromyia octavioi</i>	0			3		3
<i>Trichophoromyia ubiquitalis</i>	0			3		3
<i>Trichophoromyia napoensis</i>	0			1		1
<i>Trichophoromyia sp n.</i>	1		1	0		
TOTAL	35	6	29	162	36	126

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EYE SURVEY OF THE CITY OF PARINTINS, AMAZONAS: PREVALENCE AND CAUSES OF NEAR AND DISTANCE VISUAL IMPAIRMENT AND BLINDNESS

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FAPESP # 2013/16397-7 | Term: May 2014 to Apr 2016

co-PIs: Solange Rios Salomão, Rubens Belfort Jr., Jacob Moysés Cohen



Figure 1. Near visual acuity measurement in a study participant

The World Health Organization (WHO) estimates that there are globally 39 million blind people and 246 million visually impaired at risk of blindness. Two thirds of these individuals live in developing countries, and more than half of the cases of blindness are avoidable or curable with the technology currently available. People ≥ 50 years of age represent 65% of the blind and 82% of the visually impaired. In Brazil, it is roughly estimated that there are 1.2 million blind people, 40% of them due to cataract. WHO also recognizes that near impaired vision is an important ocular condition that affects quality of life, but still has to be included in WHO estimates of burden of diseases, at least in part by the shortage of population based data scientifically validated. The most common cause of near vision impairment is presbyopia, a physiological, age-related, irreversible reduction in the eye's ability to change its focus to see objects that are near, resulting in the need for spectacle correction to assist in near vision-related tasks. The aim of this population-based study is to evaluate the prevalence and causes of near and distance vision impairment and blindness in the city of Parintins, Amazonas (AM). A population-based sample of adults ≥ 45 years of age residents of randomly selected urban and rural districts in the city of Parintins, AM, will be identified. In addition, in equatorial regions, with a high exposure to ultraviolet radiation, pterygium can be a prevalent cause of blindness/visual impairment, having currently only isolated reports of prevalence of this ocular disease in Brazilian equatorial territory. As a general proxy for the performance of the eye care system, the delivery and visual outcomes of cataract surgical services will also be evaluated. Because of the territorial extension and socioeconomic discrepancies, studies in underserved and/or rural areas with poor access to eye care services are needed to obtain more representative estimates of visual impairment and blindness in our country. The outcomes of this study will give health authorities information to improve ocular health services in that population.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Preliminary data from a pilot study were recently collected to provide an initial picture of the magnitude of visual impairment and blindness in that Amazonian town. An urban census sector from the city of Parintins was conveniently chosen for its proximity to the eye clinic for ophthalmic assessment. Subjects were enumerated through a door-to-door survey and those with ages 45 years and older were invited for measurement of visual acuity for distance and near followed by an ocular examination. In this small preliminary urban sample of Parintins population, the prevalence of blindness (visual acuity in the better-vision eye <20/200) was three times higher than that found in a study performed in the city of São Paulo (FAPESP 04/06670-9) with the same protocol in a low-income urban area of São Paulo city, the most industrialized region of the country. In Parintins sample, cataract followed by retinal disorders and



Figure 2. Slit-lamp exam for cataract detection and assessment of other anterior segment abnormalities of the eye

corneal scar/ opacities were the main causes of blindness. These results were distinct from those of the São Paulo Eye Study (SPES) in which retinal disorders were the main cause of blindness followed by cataract and glaucoma. Visual impairment (visual acuity in the better-

vision eye <20/63->20/200) prevalence in Parintins was higher than in the SPES, mainly due either to uncorrected refractive errors (myopia, hyperopia, astigmatism) or cataract. The prevalence of near vision impairment in middle-aged and older adults was almost 90% with most of it due to presbyopia. More than half of those in need of near glasses were not wearing them, reinforcing the need of access to refractive services in that region. The prevalence of cataract surgery was around 20%, higher compared with previous studies in Brazil. Cataract surgery campaigns implemented in the last 10 years in that area had provided access to this population in remote area of the Amazon. However, post-operative visual acuity was within WHO acceptable levels in less than two-thirds of operated eyes, reinforcing the need of improvement and monitoring of cataract surgery quality outcomes. Based on the preliminary experience the study is currently being performed in 15 urban randomly chosen clusters.

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FAMILY-BASED AGRICULTURE SYSTEM AND OIL PALM PLANTATION IN THE EASTERN AMAZON REGION

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FAPESP # 2012/51045-1 | Term: Dec 2012 to Nov 2014

co-PIs: Fábio de Castro, Ana Cláudia Rocha Braga

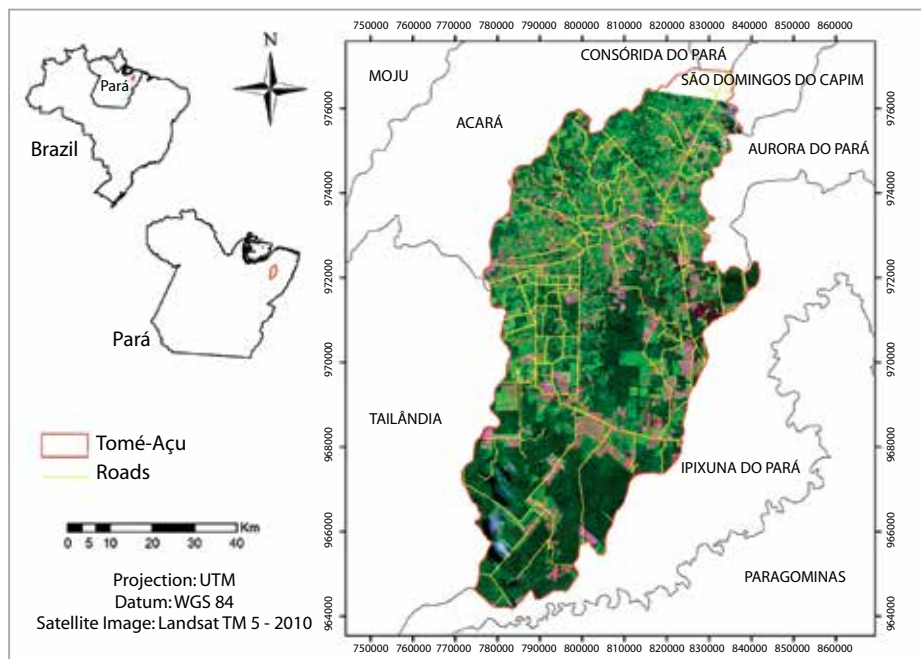


Figure 1. Location of the study area. On the right, map of the Tomé-Açu municipality. On the left, maps of Brazil and state of Pará

The National Program of Biodiesel Production and Use – PNPB (Federal Decree 11.097) was launched by the Brazilian government on January 13 2005 to create an incentive to an environmentally clean and socially sound production of energy, as opposed to Pro-Álcool Program. In addition, the federal government launched, on May 2010, another program towards specifically to palm oil production in the Amazon region – The National Program of Sustainable Palm Oil Production (PPSPO). The biodiesel public policy in Brazil seeks to enhance small-scale agriculture because one of its main missions is the social responsibility, through creation of Certification of Social Responsibility. This study search for analyzing the performance of the biodiesel program with regard to inclusion of family-based agriculture in the productive chain of palm oil – dendê *Elaeis guineensis* – in the Amazon region, Tomé-Açu, state of Pará. To do so, this research

project aims at contributing to three main goals:

- (1) to assess whether the PNPB and PPSPO do promote social justice with involvement of small-scale farmers into the productive chain of biodiesel by increasing family income, securing food and improving family welfare;
- (2) to analyze diversity of institutional arrangements and productive systems, as well the capacity of small-scale farmers to deal with socio-environmental changes, by taking into account social capital, human capital, and know-how capital among these local farmers, and thus, evaluate their resilience capabilities; and
- (3) to analyze environmental positive outcomes from biodiesel production by looking at landscape and property levels. Thus, this research proposal focuses mainly on social, institutional and environmental aspects of the productive chain of oil plants for biodiesel production, which involves family-based agriculture from regions considered marginal and poor in Brazil.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

This research has focused on two main issues: (1) the reconfiguration of rural territory, mainly for local farmers; and (2) the consequences of this program to regional rural production systems, mainly for food security. It addresses the reconfiguration of rural territory driven by the National Program of Production and Use of Biodiesel (PNPB) and the establishment of the Oil Palm Pole in the Eastern Amazon (SPOP). The complex social configuration in the region has led to different outcomes regarding the way the SPOP has impacted the landscape in the region. One clear outcome has been the fast pace of replacement of large cattle ranches by oil palm fields. The high acreage of plantations mainly refers to rented and purchased farms by oil companies. In regards to smallholders, the outcomes are much more nuanced and dotted with conflicts, hesitation, and innovative strategies. Smallholders have been divided into three groups:

- 1) a small group who considers the oil palm expansion project a threat to their autonomy and sustainability of the region;
- 2) a small group who has engaged in contract farming with oil companies;
- 3) a large group who remains at the margin of any innovative initiative.

The first peasant group is usually politically organized and is influenced by the agroforestry system developed by the Japanese farmers. According to some informants, farmers lose control over their production systems and are trapped in a dependency relation with oil companies. In contrast to the risks and fears described by the first group, those engaged in the contract farming have been positive about their decision to cultivate oil palm. According to them, their partnership with oil companies represents an upgrade in their status from peasants to 'entrepreneurs', and this new 'business' will provide them with continuous income for nearly two decades. Preliminary results also indicate two main models of oil palm productions: Monoculture and Diversified. Monoculture is mostly found among outsiders (e.g., private companies and large-scale ranchers), while diversified system is adopted by local farmers, who are mainly small and medium-scale farmers and hold strong background in agroforestry system. As it continues, this project seeks to study more in-depth reconfiguration of territories and their social, political, institutional, and environmental consequences.



Figure 2. From top and left, clockwise: (1) Oil Palm (*Elaeis guineensis*, dendê) plantation, smallholder farmer; (2) Oil palm plantation; (3) Meeting between smallholder farmers and researchers; (4) Agroforestry system, pepper, bananas and pineapple; (5) Manioc (*Manihot esculenta*) plantation; (6) Agroforestry system, açai palm (*Euterpe oleracea*) and wood trees; (7) Community meeting between local farmers and researchers

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INDIGENOUS SCHOOL EDUCATION: INNOVATION, TEACHERS' PARTICIPATION AND EVALUATION

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FAPESP # 2013/01617-1 | Term: Apr 2014 to Mar 2016

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UK co-PI: Tristan McCowan (University of London)



Figure 1. At São Pedro Community, Northern Amazonia, Tuyuka children make use of their traditional knowledge during their lessons, in July, 2012

This project proposes the following problem: in what aspects did indigenous school education overcome its colonialist character? This project supposes that, in pioneer experiences of indigenous school education at Alto Rio Negro's region, Amazonas state, that win occurred, although it presents significant limitations. The hypothesis with the research deals are:

- a) the communities know the schools' objectives and they are established through dialogue with them, including convergence between studied knowledge and communitarian aspirations;
- b) available offers of high education to indigenous peoples are little varied and most of those offers does not have participation in its formulation and evaluation;
- c) official ways of school evaluation impose barriers to innovative aspects (specific and differentiated ones) in indigenous schools and ignore communities' evaluation processes.

The hypotheses are examined through analysis of school processes (including teacher education among indigenous peoples) from the perspective of innovation and overcoming colonialist/civilizatory paradigm. The research will also check what kind of relationship exists between employed knowledge and communitarian aspirations of future. Offers of high education to indigenous peoples will be described in terms of participation level of formulation and evaluation. Finally, by identifying recommendations originated among many social categories that participate in the research, elements will be gathered to propose suitable evaluation indicators for a differentiated indigenous school education.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

This project is still in its initial phase. It focuses on indigenous peoples of Alto Rio Negro, in Amazônia, and responds to a double demand concerning many Brazilian indigenous communities: collecting information, which may serve as a basis for proper ways to evaluate indigenous school education. As a whole, these tasks are yet to be accomplished and require several research initiatives. This project is one of them, and may serve as encouragement.

There is still no answer to the following question: in which aspects has indigenous school education overcome the colonialist schooling model? Even if it is not possible to infer the exact range, the research has already gathered evidence that this overcoming has somehow occurred in that region, despite remarkable limitations. In three among four communities where research works are being developed, evidence adds up to the hypothesis that communities are aware of the goals of their schools, which have been set based on dialogues with the communities, so that their future aspirations and the school contents would converge.

It is also noticeable that official ways of school evaluation create obstacles for specific and innovative aspects of indigenous schools and disregard specific evaluation processes of the communities. The fact that schools prioritise the most spoken language of each people, reintroduce and make use of traditional knowledge, and also aim at learning through research practices, are some examples of essential contributions to proper elaboration of school evaluation indicators for specific indigenous schooling.

Figure 2. Tuyuka's school is a bilingual one and the students speak and write in their own language besides Portuguese, in July, 2012



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SOCIAL AND ENVIRONMENTAL PROCESSES THAT ACCOMPANY THE CONSTRUCTION OF THE BELO MONTE HYDROELECTRIC DAM, ALTAMIRA, PARA

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Michigan State University and University of Campinas (UNICAMP)

FAPESP # 2012/51465-0 | Term: Sep 2013 to Aug 2018 | São Paulo Excellence Chair (SPEC)

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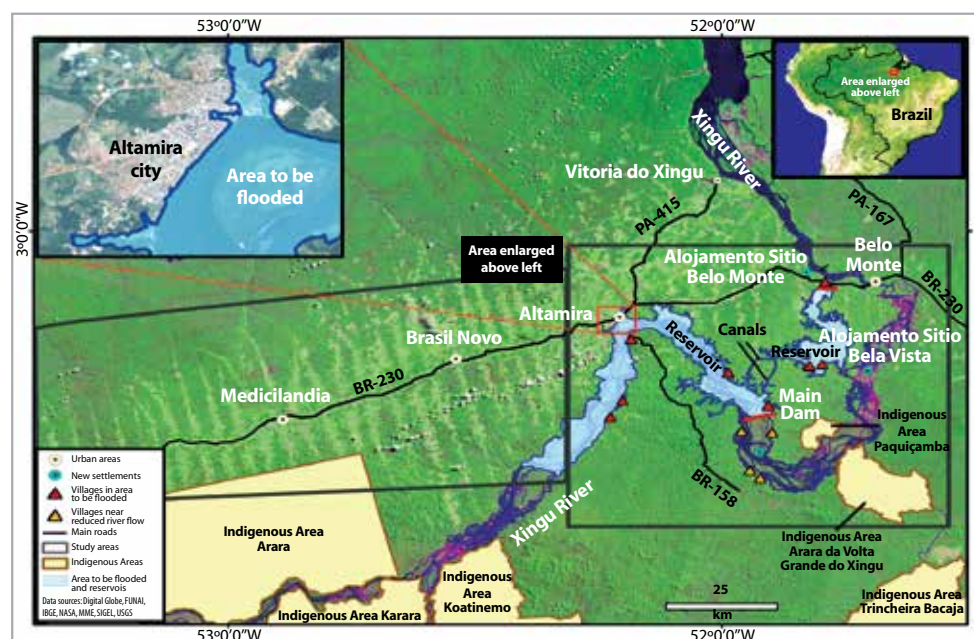


Figure 1. Map of the Belo Monte region, pre- and post-dam construction expected impacts (e.g. flooding of parts of urban Altamira in top left box), location of indigenous areas, and urban and rural areas likely to be affected by flooding (RIMA 2009). Villages to be relocated (red triangles), and those likely impacted by lower levels of river flow (yellow triangles) are indicated. Phase I of the study will examine the boxed area on the right, while phase II will examine the agropastoral area on the left box to understand the impacts of the agropastoral sector

The broad objective of this project is to examine the social and environmental consequences of the construction of the Belo Monte Hydroelectric Dam. This study will not be the study of an isolated case, since there are many dams being built in Brazil and elsewhere by countries seeking energy independence. 147 dams are planned in Amazonia, 69 of them in Brazil. The themes to be investigated represent important scientific and policy challenges:

- how to respond to the rapid increase in infectious water- and vector-borne diseases, to the rapid but temporary increase in the human population and the resulting difficulties in health, food, and residential provisioning;
- how to respond adequately to the changing labor market, changes in land use, and the flow of investments; and last but not least, how to ensure lasting regional economic development.

The project will make use of innovative methods such as annual cellphone re-interviews, after initial

face to face interviews with over 2,000 households selected by stratified random sampling procedures; the use of satellite data to assess land use and land cover and environmental changes; and examination of processes rarely studied before, such as how temporary migrants invest in the agricultural sector or in urban-industrial firms. The results will have immediate value to the agencies responsible for providing social and health services in the region. The objectives are:

- 1) What are the social and economic consequences of this doubling of population over the next three to five years that the construction is expected to last?;
- 2) What are the urban economic impacts of the capital flows, expected to exceed 10 billion dollars over five years, on the local economy? Are there lasting effects on urban infrastructure and employment?;
- 3) What is the impact of Belo Monte on the agricultural and pastoral economy?;
- 4) Determine the effects on the risk of transmission of malaria, dengue, and other infectious water- and vector-borne diseases.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The Project began with preliminary field research in January 2014, with a survey of old Altamira household residents in May 2014, and with ethnographic research among riverine people undergoing resettlement during both of these field campaigns. While it is too early to have published results from the data collection, it would be illustrative to show the study area (see map), which include not only Altamira the city, but also other urban area such as Vitoria do Xingu, Medicilandia, and Brasil Novo, numerous riverine settlements, such as Ilha da Fazenda and the farms along the Transamazon Highway.

It was already found that the people of Altamira think that the hydroelectric will benefit Brazil, but that, besides current employment opportunities, the benefits to the people in the community have been few, with declining health, sanitation, public order, and growing violence. There was a complete lack of preparation for the doubling of population that has taken place in the two years since construction began, and thus the public health sector has been unable to meet the needs of the old and new populations. There has not been a proportional increase in police and urban services to meet the increased demand. In other words, while the engineering at the dam has proceeded on schedule (despite numerous efforts to stop it by a variety of groups), the counties have been unable to meet the new demands from rapid population growth. The social situation can only be described as chaotic. Even more surprising has been the lack of response from the agropastoral sector to the growing demand for food. Ninety percent of the land cleared of forest is in pasture, and none of this land use has been reallocated to the production of staple crops to meet the food demand of a doubling of population, despite the area having some of the best soils in the Amazon region. Instead, the food is imported from far away. The research is trying to understand this lack of response to the demand for food in the area. The next stage of research will involve a study of producers along the Transamazon Highway to try to understand this counterintuitive and non-economic response by area farmers.

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REPRESENTATION OF THE AMAZON BY NOVELISTS AND TRAVELERS

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FAPESP # 2013/50499-1 | Term: Oct 2013 to Sep 2015

University of California Davis Agreement

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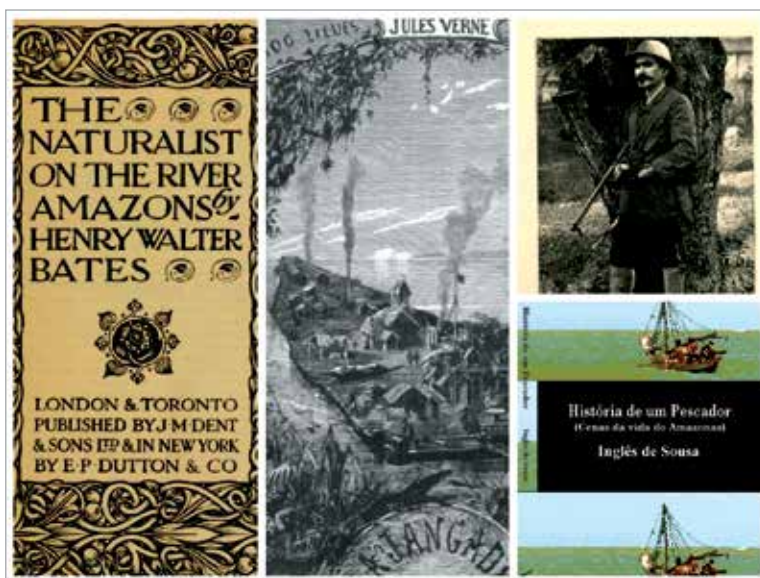


Figure 1. From top and left, clockwise: 1) Henry Walter Bates. *The Naturalist on the River Amazons*, 1863; 2) Jules Verne. *La Jangada*, 1881; 3) French explorer Henri Coudreau on one of his Amazon expeditions; 4) Inglês de Souza. *História de um pescador*, 1876

The project “Representation of the Amazon by novelists and travelers” is related to a Thematic Project called “The Transatlantic Circulation of Printed Matter – The Globalization of Culture in the 19th Century”, also financed by FAPESP (2011/07342-9), which in turn is part of a larger international project developed under the same title. It aims to produce better knowledge about printed matter and ideas circulating among England, France, Portugal, and Brazil during the “long nineteenth century” (1789-1914). Its main objectives are two-fold: (1) to identify and analyze the cultural, political, and economical processes set in motion by the movement of ideas and printed matter on a transnational scale, and (2) to examine the appropriation of these ideas in those four countries.

More specifically, its goal is to clarify the multiple circuits made by books and periodicals from Europe to Brazil (and vice versa) and the paths that printed matter traveled inside Brazil. It also aims to measure the speed and intensity in which works, people, and ideas moved back and forth between England, Portugal, France, and Brazil, evaluating the synchronicity of the interest aroused by the same books in different places. Finally, it hopes to identify the public for these works and to examine the critical reception received by them throughout the nineteenth century. The project “Representation of the Amazon by novelists and travelers” examines the circulation of books about the Amazon written by novelists and naturalists, their reception in journals and magazines published in Brazil and abroad, and read by a Brazilian audience. It also aims to compare the literary Amazonian fiction (especially that produced by the Brazilian novelist Herculano Inglês de Souza) to the written accounts by a group of French travelers who visited the Brazilian Amazon between 1860 and 1910. Instead of considering the unilateral flow of ideas and goods from Europe to Brazil only, emphasis shall be placed on the notion of circulation and its relevance as a movement between Europe and Brazil. In other words, this research privileges connection rather than *dependence*.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

In the nineteenth-century Europe, the fascination for the Amazon region was felt among literate people, but more importantly among travelers and writers. Notions such as exotic beings, haunting memories, and utopian landscapes became part of a European invention, often times applied to the Amazon region as well. In France, well-known writers such as Jules Verne, just to mention one of the most read in France and Brazil, find the relevance of the role that travelogues on remote and exotic places play in general in novels. Brazilian novelists also dealt with the Amazon region as part of the effort to build a national literature. Herculano Inglês de Souza, a pioneer in fictional and Naturalist representation of the Amazon, is credited as the first major Latin American novelist and short-story writer ever to depict scenes of commercial and labor practices, customs, missionary work, legends, and spiritual manifestations among

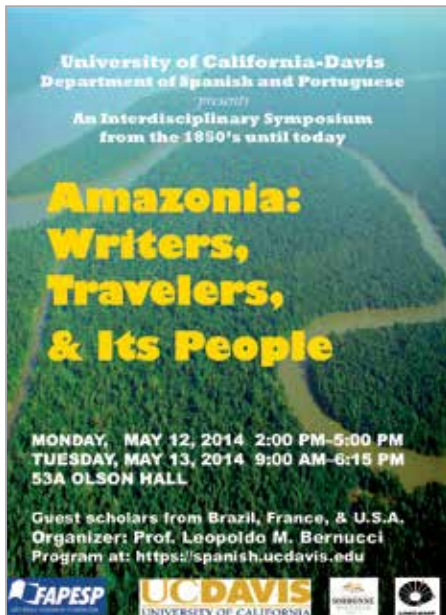


Figure 2. Poster of the Symposium "Amazonia: Travelers, Writers, and its People", 2014

have, of Amazonia as an "exotic" place. These issues were debated in the first colloquium held by the project in Davis, California, on May 2014, called "Amazonia: Travelers, Writers, and its People." At this interdisciplinary symposium, we discussed the relation between accounts by foreign travelers, novels, theatrical plays, newspapers, and magazines about the Amazon.

natives and immigrants living in the Amazon region, particularly in his home state Pará. Likewise, the scientifically oriented impressions French travelers have recorded of the Brazilian people in the Amazon region captured the imagination of thousands of readers, both in Brazil and France. In each case, these accounts further shaped the images and stereotypes that the French and coastal Brazilians had, and in fact continue to

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DETERMINANTS OF HUNTING AND BUSHMEAT CONSUMPTION IN AN AGRICULTURAL FRONTIER OF EASTERN AMAZON

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FAPESP # 2011/19108-0 | Term: Jun 2012 to Nov 2014

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Figure 1. Vista Alegre do Moju, at the margin of Rio Moju, one of the communities studied in the project

The extraction of forest products is an important livelihood strategy that in average accounts for more than 1/5 of total income for rural households in developing countries. One widely used forest product is bushmeat, an important source of both animal protein and cash income. Despite its livelihood importance, hunting can threaten game species, particularly large-bodied mammals and birds, driving local and regional extinctions. Since these animals play key roles in ecological processes, overhunting not only can compromise people's livelihoods but can also affect the persistence of non-hunted biodiversity in the long term. Understanding which factors drive hunting and bushmeat consumption could guide us in identifying which actors are contributing the most to hunting, which are most dependent on bushmeat for nutrition and therefore more vulnerable to law-enforcement policies on hunting and how this dependence relates to the values people attribute to forests and thus their propensity to engage in conservation programs. Beyond the well-studied cultural and socioeconomic characteristics at the household level, two often-neglected large-scale factors should determine decisions on hunting and bushmeat consumption: forest cover that defines game availability, and distance to urban centers, a proxy to the access to alternative sources of animal protein. Thus, game availability together with the access to alternatives should interact with cultural/ socioeconomic factors to drive decisions on hunting and bushmeat consumption, which in turn should influence perceptions on the values of forest and its conservation. As part of an international research network (Rede Amazônia Sustentável – RAS), we aim at testing these hypotheses by focusing on a highly heterogeneous ~1 million ha post-frontier landscape south of Santarém, state of Pará, eastern Amazonia. By interviewing people living in areas with varying forest cover and distance to urban centers, we investigated (i) the importance of socioeconomic, cultural and large-scale factors in driving hunting and bushmeat consumption; and (ii) the influence of hunting and bushmeat consumption on people's perception on the values of forests.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Our findings demonstrate that large-scale factors are important determinants of bushmeat consumption and especially hunting, even in regions with high socioeconomic and cultural diversity as post-frontier tropical landscapes. Bushmeat consumption was widespread (nearly 80% of all households) and slightly more likely in remote and less deforested landscapes, as expected. In contrast, hunting (nearly 40% of all households), although more likely in more forested landscapes, was unexpectedly more common near urban centers. Bushmeat consumption is thus high even in altered areas, playing an important role in food security in post-frontier tropical landscapes. Populations near urban centers seem to impose a pressure on game resources, suggesting that hunting pressure may not decrease with urbanization. While



Figure 2. Research team conducting interviews with local inhabitants

people from remote, forested areas, are the most dependent on bushmeat for subsistence and thus the most vulnerable to law-enforcement policies on hunting, people living near urban centers are the actors contributing the most to hunting. The supply of ecosystem services (including bushmeat) to people may influence their perceptions of forest value and therefore people's incentive to conserve forests. Because deforestation eventually leads to fewer forest experiences, it should erode perceptions

of non-utilitarian forest value (emotional affection to forests). On the other hand, the associated decrease in bushmeat use should mainly weaken perceptions of forest utility (i.e. utilitarian value). We found that, as expected, bushmeat consumption was associated with a positive utilitarian forest value. Conversely, living in a more forested area, instead of bushmeat consumption, was associated with positive non-utilitarian forest value. The fact that bushmeat consumption is important for positive perceptions about forests suggests that rural people particularly value this forest product. By losing the contact with forests, people tend to ignore its non-utilitarian value. Our results indicate that incentives to conserve forests could decrease with deforestation and the subsequent decrease in resources use, which could further complicate forest conservation in highly altered landscapes.

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SMALL CITIES OF THE ESTUARINE REGION OF AMAZON RIVER AND THEIR IMPORTANCE ECONOMIC FLOWS AND SOCIAL NETWORK

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FAPESP # 2013/50176-8 | Term: Nov 2013 to Oct 2014

Belmont Forum Agreement

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co-PIs: Sandra M.F. Costa, Eduardo S. Brondizio, Artur Rosa Filho, Valéria Zanetti, Viviana Mendes Lima,

Gustavo Rodrigo Milaré Montoia, Jobair Assis Rangel, Monique Bruna Silva do Carmo, Ed Carlos dos Santos Valota

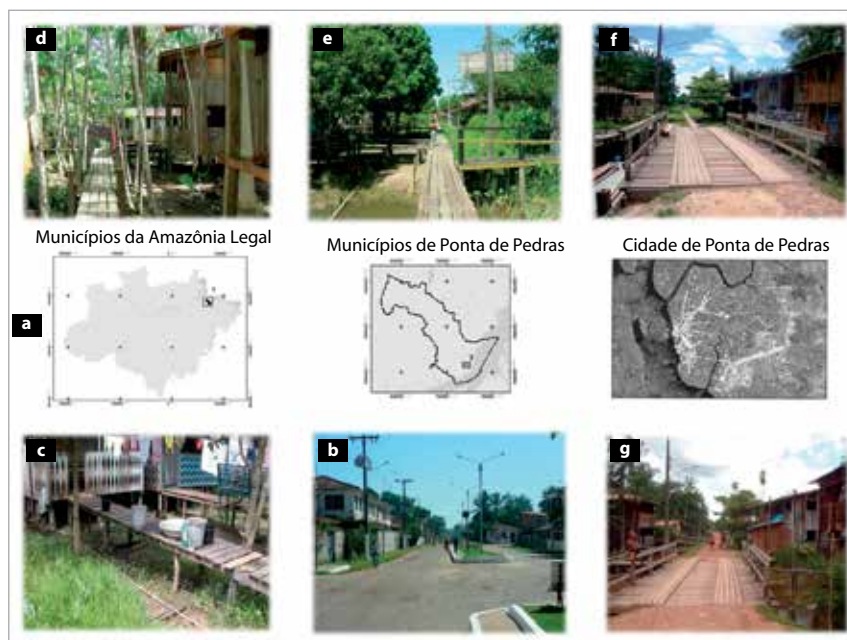


Figure 1. Location of the city of Ponta de Pedras, Brazilian Amazon (a), and some images of the city: (b) downtown; (c) an usual timber-frame house, showing the precariousness of infrastructure; (d) and (e) wood streets, known as “pontes,” on flooded areas; (f) and (g) show a street in different periods, that was filled with land. Source: Project (2013)

In the Brazilian Amazon, towns with less than 20,000 inhabitants are predominant (84%). Those small cities have modest or no infrastructure, are also strongly dependent on public resources and do not have economic activities characterized as urban. Despite of these characteristics, these cities can offer job opportunities, even in the informal sector, and more access to basic health and education services, attracting population from rural areas and surrounding cities. Considering these aspects, this research intends to analyze the city of Ponta de Pedras, located on the island of Marajo, in the estuarine region of Amazon River. This city had a total population of 25.999 inhabitants in 2010, and 47.8% of this total live in the urban area.

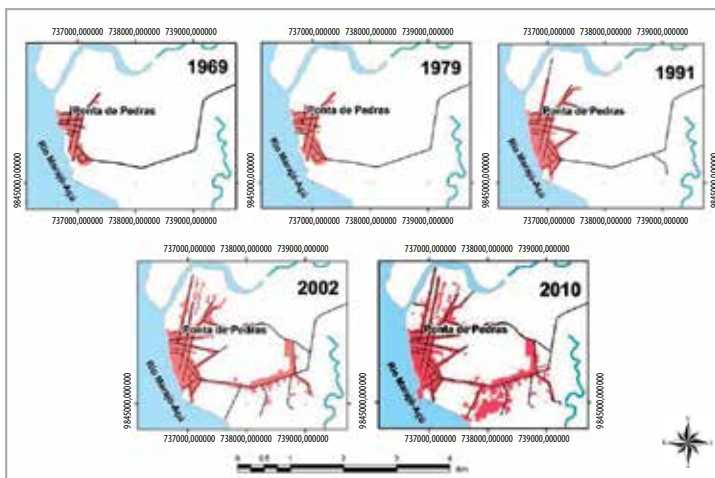
According to the IBGE (2013), this

municipality is the second largest producer of açai fruit (*Euterpe oleracea*) in Brazil. This production has greatly influenced the changes that have occurred in the city, both in terms of growth of the urban area and in economic transactions. This study has monitored the growth of urban area, social situation and the existing infrastructure in order to promote an understanding in terms of socio-economic development and social networks that are established among urban residents and their local of origin. The methodology followed, basically, the urban growth mapping, using remote sensing data, survey of data at local government agencies, and application of questionnaire mainly related to socio-economic status of residents, household conditions, social networks, flows that are established on the basis of activities economic, among others, which was applied to 350 urban households (more than 11% of the total urban household). The preliminary results have revealed that urban residents perform activities related to extraction of açai fruit, the main product of the municipality or in formal sector. Many, if not most, formal employment in urban areas is offered by State and municipal public administrations. While maintaining strong social ties with relatives who live in rural areas of Ponta de Pedras, or in others (69% have relatives residing in rural areas), only 40% of urban residents provide some support for family members, mostly maintained to support the resident as family than giving financial maintain.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Part of this research project began in 2010. Since then, it was focused on three perspectives: analyze the urban growth of Ponta de Pedras, along 1969 and 2010; relate this growth with the development of the açaí economy and evaluate the effect of this economy in the urban life, in defining the importance of the city in the urban network of the estuarine region of Amazon River and in the social networks established between urban residents and riverside communities. Between 1969 and 2010, Ponta de Pedras experienced a growth of almost 900% compared to the urban area in 1969. This expansion was particularly significant between 1991 and 2010, when urban population increased more than 111%, also the açaí fruit economy. Despite offering precarious services and conditions for its residents, Ponta de Pedras continues to attract individuals and families in search of a better life, secure housing, access to water and electricity, access to education, and, perhaps most important to many, to share a part of modernity represented by an active and rather festive urban social life. As a local pun goes “in the middle of nothing, anything is something” particularly in relation to even more precarious in rural areas. In order to cope with such economic disadvantages, these families are increasingly articulating their lives by expanding their social networks to multiple cities and areas to compensate for local deficiencies through access of resources and services from this expanded social network. Rural areas have also become an increasingly important part of this network of movement, representing a point of departure and return and a safety net of resources and economic opportunities. The açaí economy narrows these networks and guarantees some extra income to urban population. Rural families also benefit economically and socially from urban connections. They access particularly health and education, and informal employment, even more precarious in rural areas. To many, cities emerge as an “Eldorado” of modernity, a prospect to a larger connection to the globalized world, and eventually a chance to improve lives. Any attempt to understand and contribute to the future of the Amazon region requests close attention to these processes.

Figure 2. Spatial growth of the city of Ponta de Pedras, during 1969 and 2010. Source: Project (2013)



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IMAGES OF RESOURCE EXTRACTION: NEW TERRITORIAL LOGICS IN THE AMAZONIAN AND ANDEAN REGIONS

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FAPESP # 2013/50313-5 | Term: Oct 2013 to Sep 2015

University of California Davis Agreement

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co-PIs: Salvador Schavelzon, Maíra Bühler



Figure 1. Malku Khota, Bolivia



Figure 2. Field Research in Malku Khota, Bolivia

In this project we discuss from an anthropological angle how the landscape of the Amazon and Andean region of South America is understood in a moment of economical growth and extractivist projects. Following the indigenous and other more recently established communities or small cities, the aim of this research is to collect images, testimonies and knowledge about this moment of mobilization, new experiences and social change. In order to develop the project we are visiting critical places related with development and extractivist economies, conducting short fieldworks. As we visit these places, we combine traditional ethnographic method and visual anthropology techniques, together with documentation and bibliographical work. In Andes and Amazonia the mining frontier is aggressively expanding throughout the national territories. We have chosen to work in these four different contexts: In Bolivia, we research the community of Malku Khota, silver mining located in Potosi, where the Bolivian government nationalized a Canadian mine, responding to pressure from local indigenous communities. In Peru, Minas Yanacocha, the second largest gold mine in the world (located in Cajamarca, Northern Andes) where the Conga communities have been opposing to the mining project and rising up against the project that will destroy the environment on which their existence depends, by poisoning the water, lagoons and lands. In Colombia, we've been working in Santa Marta, where we observe the impact of Drummon, a North American coal mining company that is being accused of environmental disaster in 2013. In Ecuador, where we still have not been, we will work in El Mirador, a recent concession for an open-pit gold mine in Shuar territories. In Brazil, we will work in Carajás, where the mining corporation Vale do Rio Doce produces most of the Brazilian iron. The aim of this research is to understand how these sites, in some degree, overlap with other geographies. They overlap with community and territorial claims, as well as with water resources.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

In all four sites, political conflict around mining is almost permanent; in most cases, although not always, protest has been spearheaded by local populations, some of them indigenous others non-indigenous. Yet what is important here is that ‘ethnicity’ – the political condition through which indigenous groups organize their relationship vis-à-vis the state—has been differently deployed in each country. In Peru, where anti-mining conflicts represent more than 70% of the political confrontations between the state and grassroots populations, so far, ethnicity has not been the main catalyst of the protests. These instead demand the respect of international treaties (mainly ILO 169) as well as environmental demands linked to agricultural possibilities and peasant economies. In Bolivia, the indigenous population is divided according to their support of or opposition to Evo Morales; rather than ‘ethnicity,’ or the environment, the anti-extractivist sentiment has been articulated by complex movements to decolonize the state itself. In Brazil, a latent alliance between the MST and indigenous population in Carajás has intermittently opposed the expansion of the iron network extraction which consists of a railroad, and deforestation for the production of charcoal for the production of steel in nearby plants. Finally, in Colombia, political struggles are less organized in a context of violence still coming from the period of war, which makes harder to understand what is really going on from the perspective of people that are afraid to talk. The research is an initial contribution to debates in anthropology, environmental science, science and technology studies, bringing from multisited ethnography voices, mobilizations and modes of existence that compose a map from the Amazon to the Andean region that is usually hidden by non-local perspectives that hide the ethnographic encounter in which we are focused.



Figure 3. Communitarian Leadership in Bolivia

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