AMAPhD

7 Novembre 2024

Organisateurs :

Marc Hétier, Chloé Mouillac, Lucie Bivaud & Witold Podlejski

Planning AMAPHD 2024

Café 08h30-9h00					
Accueil	9h00	20	Comité	Welcome	
			Raphaël PELISSIER	Mot d'ouverture	
Session 1	9h20	20	Gian Luca SPADONI	Fires in socio-ecological systems: tropical and subtropical environments	
	9h40	20	Oriane BRAUD	Multiscale hybrid modelling framework for intercrops: the best of plant and crop models	
	10h00	20	Marc HETIER	Impact of anthropization on vector community dynamics : modelling, analysis and simulation. Control of epidemiological risk in peri-forest context in Cameroon	
	10h20	15	Yannick BROHARD	Point : Gestion des données	
Pause café 10h35-10h50					

Session 2	10h50	20	Guillaume PAPUGA + Eric MARCON	MCE (Mission Complémentaire d'Enseignement)	
	11h10	20	Margaux ROJAT	Are JSDMs useful to reveal biotic interactions?	visio (+3)
	11h30	20	Chloé MOUILLAC	An overview of wild-harvested plants in metropolitan France	
Déjeuner 11h50-13h20					

Session 3	13h20	20	Junliu YANG	The use of multitemporal lidar to monitor the impact of climate change on tropical forest C sink	
	13h40	10	Witold PODLEJSKI	Mechanistic modelling of an alternative stable state of the Congo tropical forest : the Marantaceae forests	
	14h00	20	Houssem TRIKI	Interaction between pest attacks and plant growth using a model approach applied to robusta coffee in Uganda. Effects on the production.	
	14h20	20	Lucie BIVAUD	Is global warming blowing hot or cold on high mountain plants? Reduced snow cover, nursery plants and adaptations to cold in temperate and tropical latitudes.	
	14h40	20	Maria Daniela DIAZ	Successional dynamics in post-glacial environments of the Andes: Dark Diversity and plant-microbiome interactions	
	15h00	10	Médie COLLET	Dynamiques spatiotemporelles des communautés de moustiques et de culicoïdes en mangroves guyanaises & liens avec des facteurs environnementaux	visio (-4)
	15h10	10	Ninon BESSON	Leaf demography and the phenology of primary and secondary growth in semi-deciduous forests of Cameroon: From leafy shoot to tree crown	
	15h20	20	Paul CATHELINEAU	Inter and intra-specific diversity of biomechanicals properties of Amazonian's palm fibers in wood landscape of french Guiana	visio (-4)
	15h40	10		AMAParole	
Pause café 15h50-16h05					

Session 4	16h05	10	Mathieu VALDEYRON	Computational methods for hidden semi-Markov models with mixed effects - applications to plant branching models	
	16h15	10	Valentine ANSTETT	Temporary Mediterranean lagoons: potential sentinels of climate change and biodiversity conservation	
	16h25	10	Hugo TEROL	Microbial diversity of forest soils: ecological importance and impact of forest management	
	16h35	10	Jiaxi YAO	Holistic modelling of ecosystem services in social-ecological systems	
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Mot de la direction

AMAPhD, la journée des doctorants et post-doctorants de l'UMR AMAP, est toujours un moment important de la vie de l'unité. Elle permet de faire un peu mieux connaissance avec les nouvelles têtes arrivées dans l'unité à l'occasion de la rentrée universitaire et d'avoir un panorama complet de l'avancement des projets qui sont, par définition, à la pointe des recherches menées dans les trois axes thématiques de l'unité : Biodiversité (Systématique, biogéo-graphie, écologie), Biomasse (dynamique et production des plantes et des peuplements) et Plantes Numériques (Modèles, analyses et données de l'organe aux écosystèmes). C'est aussi un moment de convivialité entre doctorants, post-doctorants et chercheurs en poste, qui prennent pour l'occasion le temps de relever le nez du guidon pour découvrir les travaux de leurs jeunes collègues. Merci à l'équipe qui a cette année contribué à perpétuer la tradition des AMAPhD, en particulier Colin, Vincyane et Alexandre.

La Direction d'Unité
Raphaël PELISSIER

Using high penetration airborne LiDAR and dense UAV scanning to characterise the light levels in dense tropical forest.

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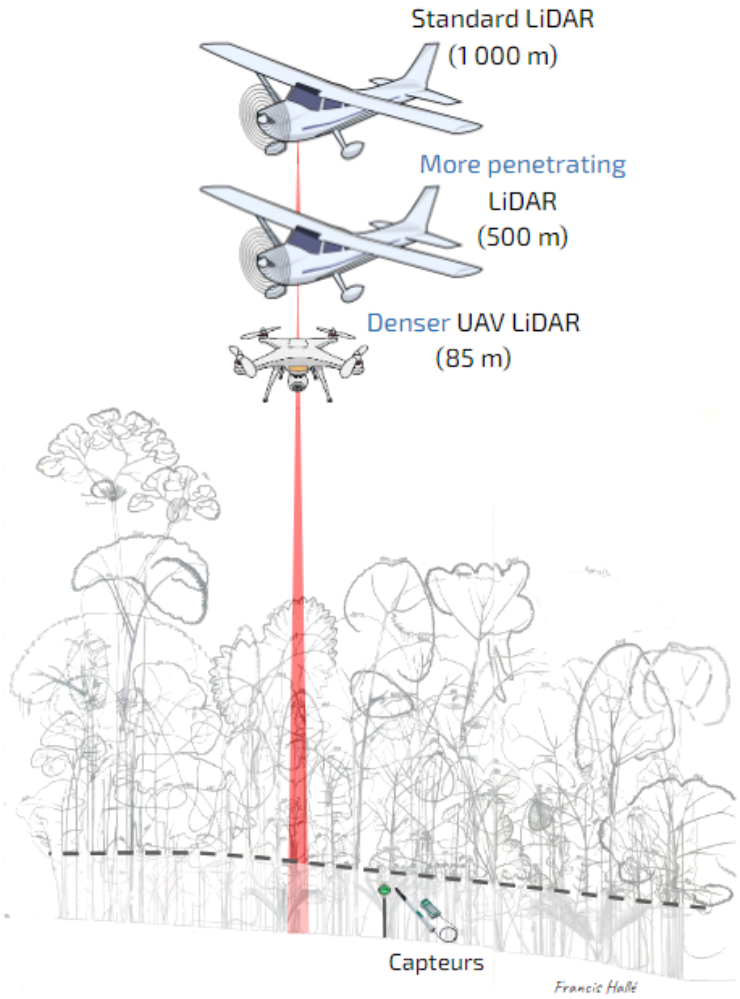
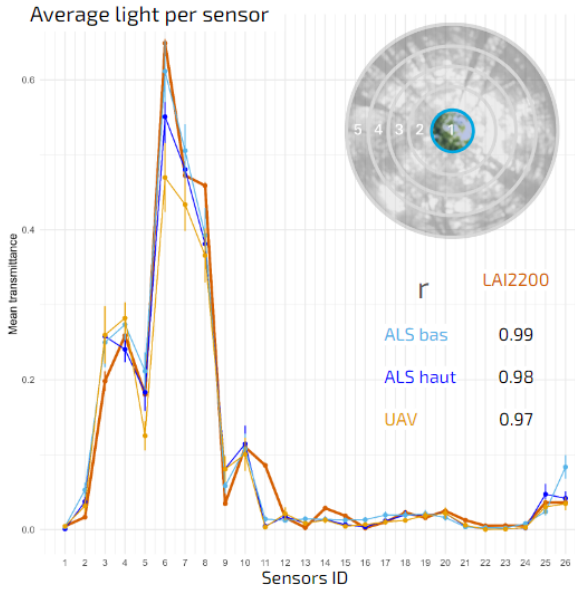
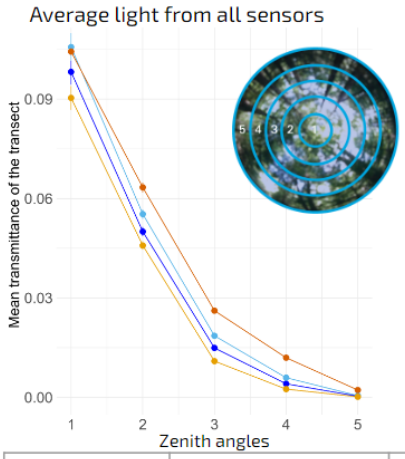
Funding	Ademe (Agence de l'environnement et de la maîtrise de l'énergie) - Cirad
	Labex CEBA - AIBSI project (Amazonian Institute of Biodiversity and Sustainable Innovation)

Keywords : LiDAR, understory light, 3D raytrace model, ALS, UAV, Forest structure, Dense tropical Forest.

LiDAR makes it possible to characterise the 3D structure of the forest, from which species habitats can be faithfully estimated, over large areas at fine resolution. The LiDAR acquisition methods currently used have some limitations. Standard airborne laser scanning fails to describe the lower canopy in sufficient detail due to occlusion by the upper canopy. The understory is important to characterise as it harbours the majority of the forest stand and is the place where regeneration takes place. Here we explore the potential of low altitude high power ALS with enhanced penetration, and a denser UAV to describe the structure of the forest understory. We use the recorded laser pulse extinction to build a 3D model of light transmission through the canopy. We evaluate the capacity of the light transmission model to estimate the spatial and angular variation of light in tropical understory which was monitored by two different field sensors. We found that (i) a low altitude ALS can better describe the understory canopy structure and thus the understory microenvironment, thanks to its higher penetration and smaller footprint ; (ii) UAV LiDAR underestimates light levels in the understory but provides a very accurate spatial characterisation of understory light and has the advantage of allowing transmittance anisotropy to be taken into account thanks to the larger scan angles. We highlight that high point cloud density does not guarantee an accurate characterization of the forest structure. Penetration rate and footprint size are important characteristics to accurately describe the forest structure, including the understorey.







Acquisitions
- Standard ALS
- Low altitude ALS
- UAV
- *LAI2200 sensor*
- Standard error

	High altitude ALS (standard)	Low altitude ALS	UAV
Sampling	++	+	+++
Penetration	++	+++	+
Ground precision	+	+++	++

Fires in socio-ecological systems : tropical and subtropical ecosystems

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Funding	FISSA, ANR project

Keywords : Fires, Deforestation, Cerrado, Land Governance, GIS

The aim of my research is to understand how interacting social and ecological variables can affect fires at the landscape scale and which virtuous governance approaches can deal with these drivers, mitigating fire impacts. Within this frame, I focus on the specific process of deforestation in tropical and subtropical environments, looking at how it is altering natural fire regimes. I also seek to identify land governance strategies that can hamper these unfavorable alterations, with a consequent reduction of fire impacts. My study areas cover regions of South America, mainly included in the biome of the Brazilian Cerrado. The methods I use to deal with these issues are mainly based on geospatial analyses and statistics, with recurrent use of machine learning algorithms. Results of my research are expected to clarify how complex processes, such as deforestation, are affecting fire regimes in different regions and which are the best governance practices to counteract these strong anthropogenic pressures. These findings will support the conception of guidelines for an integrated land management aimed at creating a fire-resistant and resilient landscape.

Figure 1 – The Brazilian Cerrado biome. Source : GLS

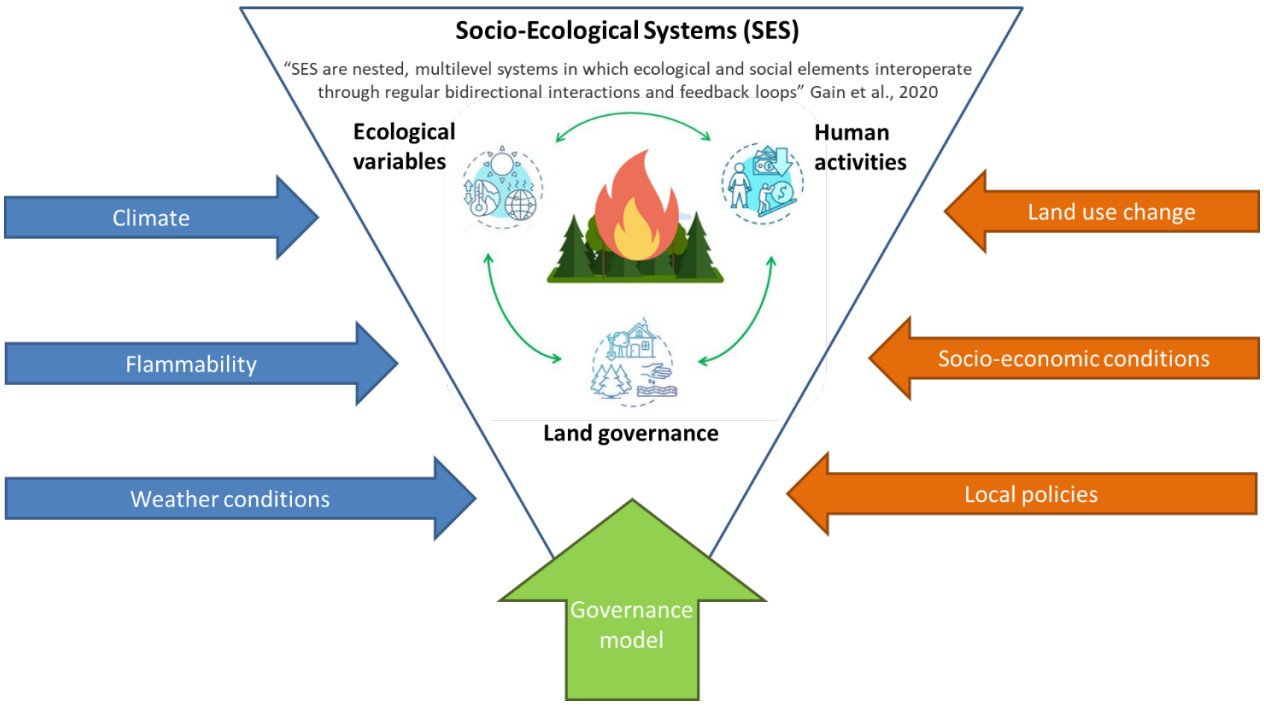

FIGURE 2 – Conceptual framework of my PhD research project. Source : GLS

Spatiotemporal dynamics of mosquito and culicoides communities in French Guiana mangroves & links with environmental factors

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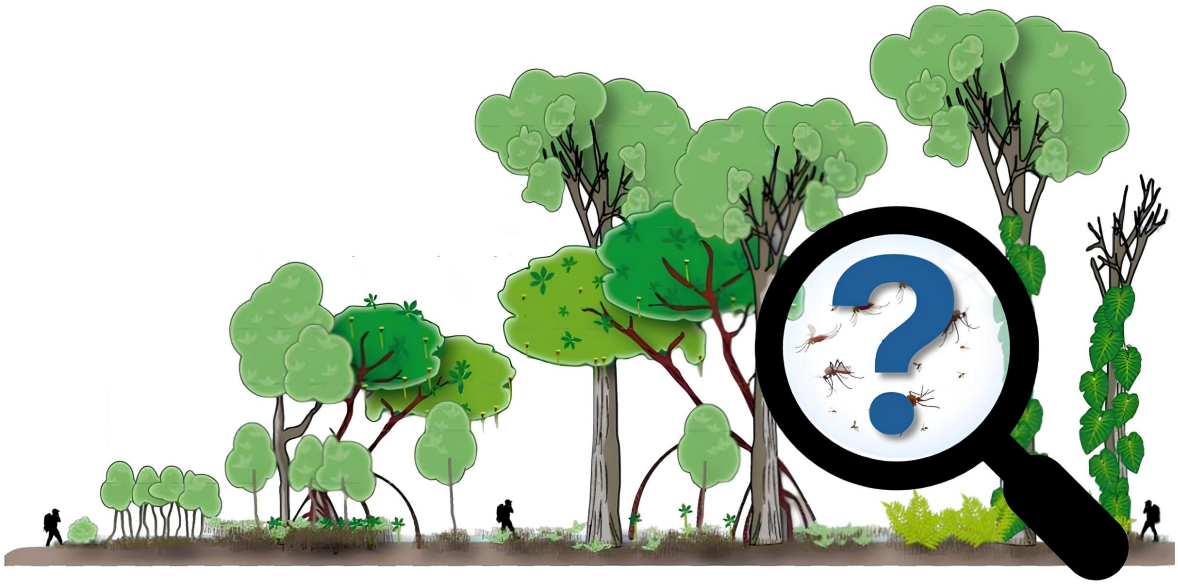
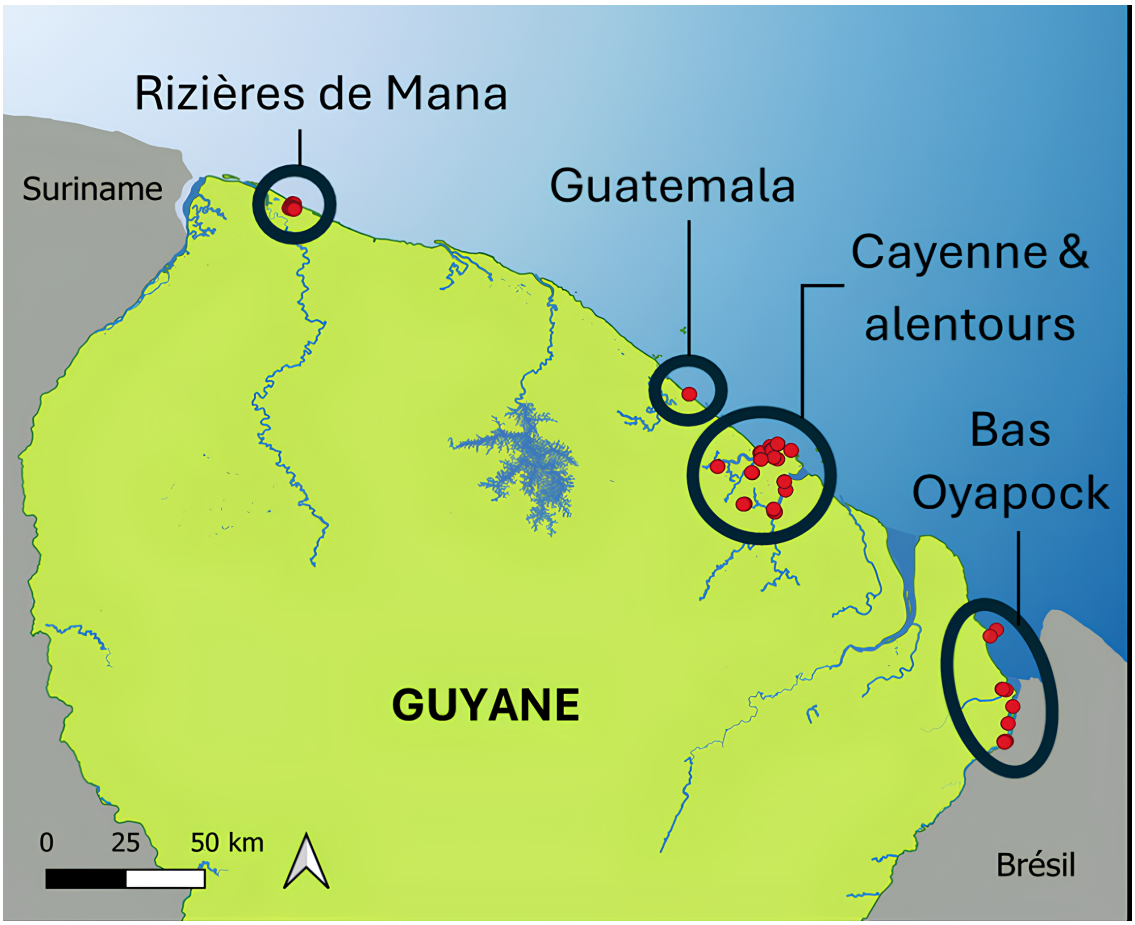
Mangroves are natural, dynamic forest ecosystems located in the intertidal area of intertropical regions. These natural habitats, which are subject to a wide range of environmental fluctuations (oceanographic, sedimentary and geomorphological), provide numerous ecosystem services and harbor potential insect vectors such as mosquitoes and culicoides. Mosquitoes are one of the main arthropod vectors of human diseases (malaria, dengue fever, chikungunya, Zika, etc.) with high morbidity and mortality rates worldwide. As for Culicoides, they can transmit numerous diseases such as Ovine Catarrhal Fever and Oropouche Fever. The proximity of these habitats to human populations can directly or indirectly increase the ecological interactions of potential vector species, as well as the emergence of pathogens, representing a risk to public health. This is particularly the case in French Guiana (84,000 km2) located in South America, where mosquito-borne diseases are common. Up to the present day, around 250 species of mosquitoes and 25 species of Culicoides have been recorded in French Guiana, including vectors of bacterial, viral and parasitic pathogens. Although this knowledge may give cause for concern, the species of mosquitoes and culicoides that are associated with mangroves are poorly inventoried.



The first objective of my thesis is to inventory mosquito communities in a variety of French Guiana mangrove areas located around Cayenne & its surroundings, and in other coastal sites. Secondly, their temporal dynamics will be studied at a number of sites chosen for their representativity, and linked to environmental factors (tide, rainfall, vegetation, surface area of forest cover, anthropization, etc.). The microbiome (microbes, arboviroses, parasites, etc.) of the specimens collected will then be studied to establish the presence of pathogens within these communities. Finally, cross-analysis of the results will enable us to develop models of the spatio-temporal dynamics of French Guiana's mangrove mosquito and culicoides communities, as well as their microbiome, according to environmental parameters.



Interactions Between Soil and Roots and Impacts on Soil Carbon Pools

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Funding	Kurdish Institute of Paris and Campusfrance

Keywords : Root exudation, Soil organic carbon, Non-structural carbohydrate, Microbial Community, Plant-soil interaction, Fine root morphology, Carbon Allocation

Understanding forest ecosystem responses to environmental stressors such as nutrient limitation, water stress, and temperature fluctuations is critical for predicting their resilience to climate change. Forest trees, including species like Pinus, Quercus, and Betula, allocate surplus photosynthates towards secondary metabolite production under these stress conditions. However, the mechanisms underlying this allocation and its ecological consequences are not fully understood. Previous studies suggest that nutrient, water, and temperature limitations lead to surplus carbon being directed toward secondary metabolites and root exudates, which in turn affect belowground soil processes. Despite this, significant gaps persist in comprehending how trees specifically allocate surplus carbon and the composition of root exudates in response to varying environmental conditions. A key area of uncertainty lies in the role of whole tree functional traits, including root traits, stem characteristics, and non-structural carbohydrate (NSC) forms, in shaping these responses. Literature indicates that variations in root morphology and fungal activity influence root exudation rates across nutrient gradients. Additionally, root exudation varies with growing season and latitude, indicating complex interactions between root traits and environmental conditions. The carbon surplus hypothesis posits that tree growth is often constrained by the abiotic factors (Nitrogen and Phosphorus, water and temperature) other than carbon fixation. Under these limiting conditions, surplus carbon is directed toward secondary metabolites and root exudates, with implications for both aboveground and belowground ecosystem dynamics.

Our study aims to broaden the carbon surplus hypothesis by considering the role of tree wood structure in influencing carbon allocation. For instance, a larger parenchyma fraction in the stem may increase NSC storage capacity, potentially reducing the amount of NSC reaching the roots and influencing root exudation. Additionally, seasonality is expected to affect the quantity of carbon in root exudates, with implications for microbial communities in the rhizosphere. Understanding these seasonal patterns across different tree species could offer new insights into the complex interactions between tree functional traits, carbon allocation strategies, and ecosystem processes.

In the context of the Eco2Adapt project, which examines forest ecosystems under varying nutrient, water, and temperature regimes to maintain the forests healthy and resilient in the face of challenges of climate change, therefore, it is essential to investigate how trees adjust their carbon allocation strategies in response to environmental stress. By focusing on the production of secondary metabolites and root exudates, our research aims to address key knowledge gaps and improve our understanding of how forest trees mediate their responses to environmental stressors through carbon allocation. The insights gained will have important implications for predicting ecosystem resilience and managing forest responses to future climate challenges.

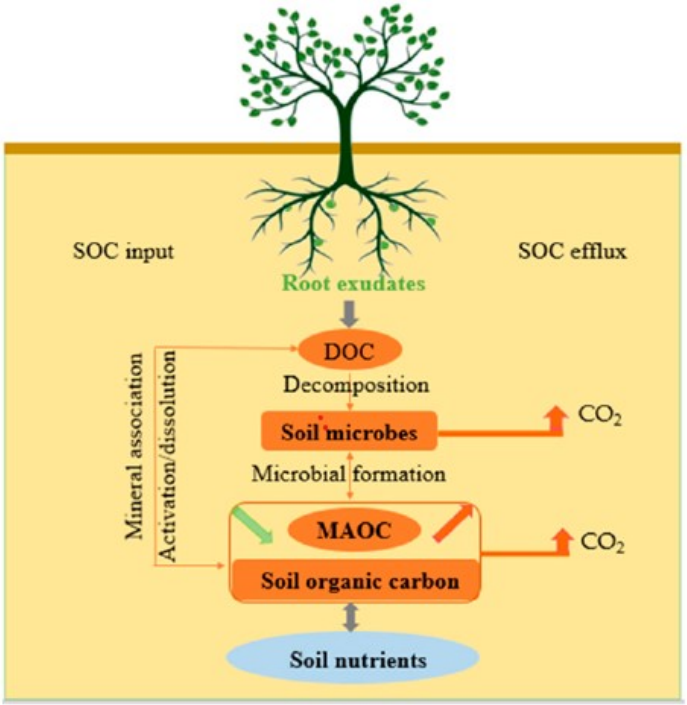

FIGURE 1 – Main process of soil organic carbon input and efflux mediated by root exudate

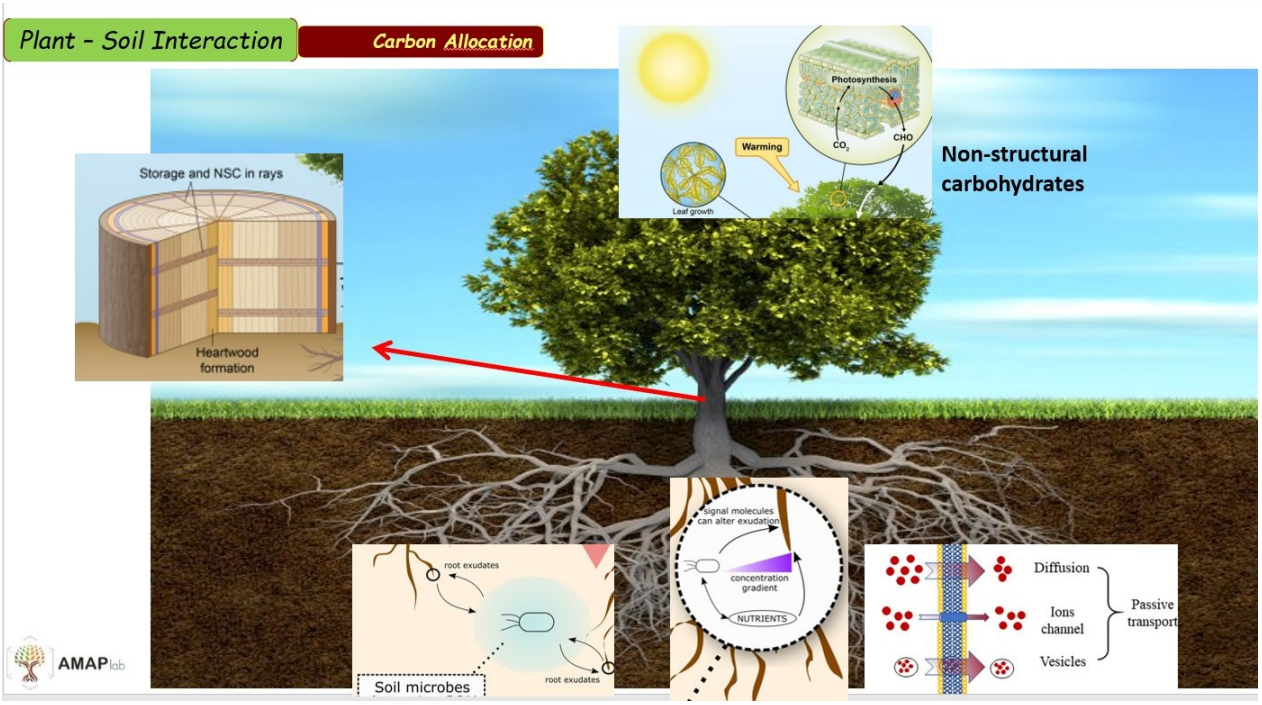

FIGURE 2 – Surplus carbon allocation and plant-soil interaction

Successional dynamics in post-glacial environments of the Andes : Dark Diversity and plant- microbiome interactions

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	Fabien Anthelme (UMR AMAP)
Funding	ARTS IRD

Keywords : primary succession, post-glacial environments, climate change, plant-microbiome interactions

Tropical glaciers are key systems for understanding the effects of climate change on the dynamics of new ecosystem formation. Due to their geographical location and high altitude, these systems are experiencing very high rates of temperature increase and, consequently, accelerated glacial retreat, with still poorly understood consequences for post-glacial colonization patterns of plants and microorganisms. Although the accelerated loss of ice mass in the tropics represents a major environmental and social challenge, glacier retreat also offers a rare opportunity for organisms to colonize newly available areas on mountaintops. In this successional process, the responses of each species, determined by their dispersal capacity, physiological tolerance ranges, and genetic ability to adapt, along with key interspecific interactions promoted in these environments, will determine their future path. Understanding these mechanisms becomes crucial for comprehending the assembly of novel plant communities and their associated microbiomes, as well as the potential cascading effects of these changes across the various stages of primary succession on the functioning and structure of post-glacial ecosystems in the Andes.

To understand the ecological mechanisms that support the processes of primary succession, this study aims to evaluate the dynamics of plant communities and plant-microbiome interactions across three post-glacial chronosequences of the Andes, in Colombia and Bolivia. This project is structured into three chapters, focusing on understanding the links between the aerial and soil compartments through : i) The exploration of Dark Diversity to know what are the dynamics for the not observed plant species that can potentially inhabit those particular ecological conditions ; ii) The role of Plant-Mycorrhiza and Plant-Plant interactions on the success of primary succession along a short time window caused by rapid warming ; and iii) the link between aboveground and belowground diversity across the chronosequences.

Mechanistic modelling of an alternative stable state of the Congo tropical forest : the Marantaceae forests

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Funding	ANR DESSFOR

Keywords : Alternative stable states, mechanistic modeling, tropical forests, Marantaceae, central Africa

Marantaceae forests are a forest ecosystem frequently found in central Africa in place of the usual tropical forests. They are distinguished by their low tree cover, interspersed with an abundance of giant herbaceous plants from the Zingiberales group. These herbaceous and treed strata, competing for light and nutrients, have formed an apparently alternative stable state of the forest over the last century. These Marantaceae forest provide a number of ecosystem services, such as sheltering megafauna and supplying local populations. However, they produce much less wood than tropical forests, and store and fix less carbon. Given their ability to thrive in the face of recent climate change, it is important to assess the future of central Africa's tropical forests and their potential role in mitigating climate change.

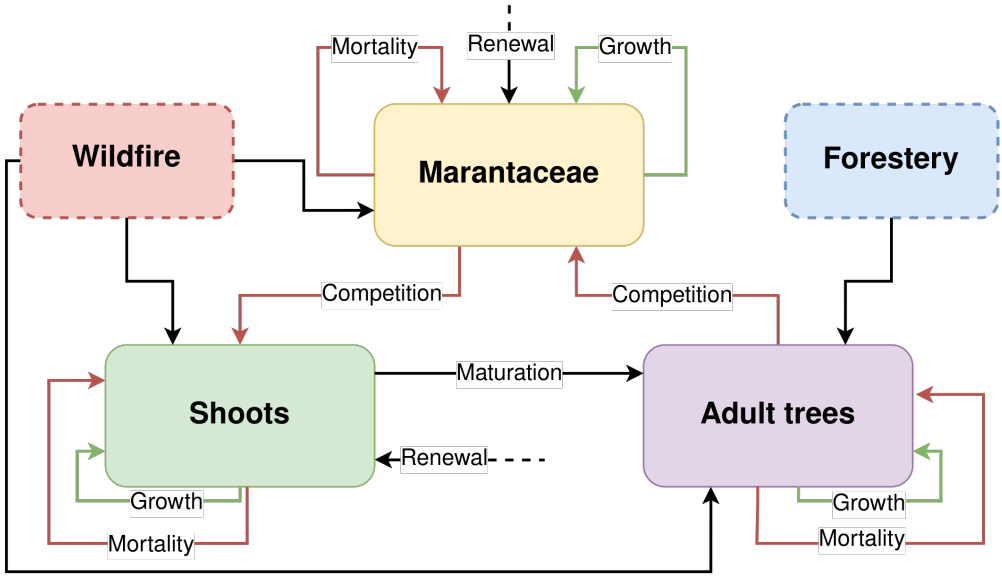

FIGURE 1 – Diagram of the model used to represent the biomass of three components : the Marantaceae biomass, the biomass of adult trees and the biomass of saplings.

The aim of my post-doc is firstly to determine whether the Marantaceae forest is a true alternative stable state, then to isolate the drivers of their prosperity, focusing on the role of fire and forestry. Finally, the aim is to outline the possible future of these ecosystems in the context of ongoing global change. To do this, the main ecological processes in these forests are represented in a mechanistic model that monitors the compartmentalized biomass of the forest (see Fig 1). In particular, the growth, renewal, mortality, and

competition of trees and herbaceous plants are represented by a system of ordinary differential equations. These processes are calibrated using parameter estimates obtained from field measurements and numerical tests in order to reproduce long-term forest transitions (see Fig. 2). On this basis, fire and forestry will be included in the model as regular episodic events. The frequency and intensity of these phenomena will make it possible to represent different climate scenarios and forest management plans and to draw conclusions about the future of tropical forests.

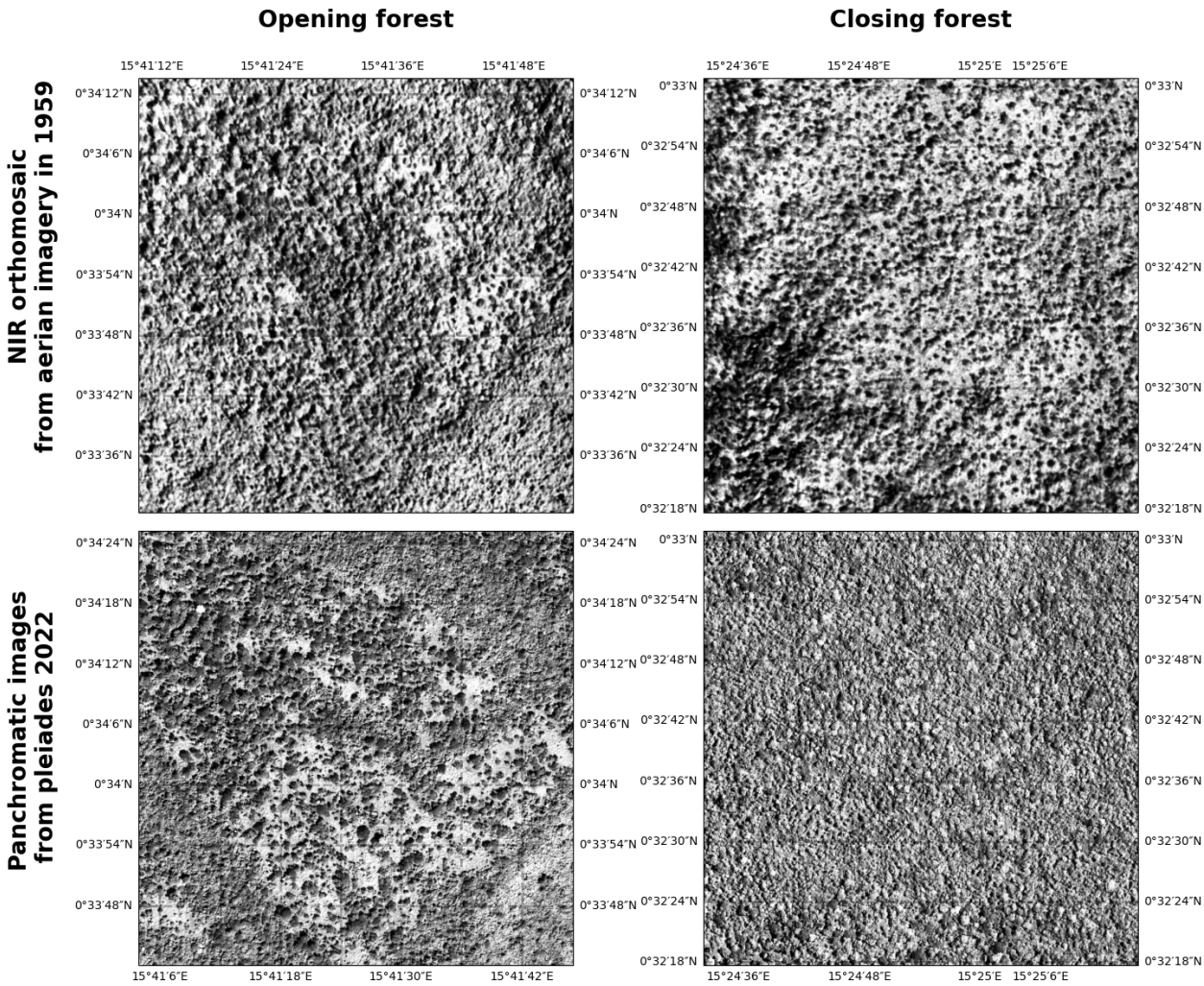

FIGURE 2 – Forest states transitions between 1959 and 2022.

Microbial diversity of forest soils : ecological importance and impact of forest management

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Funding	Biodiversa+ (UE) ; ANR

Keywords : Soil, Microbial communities, Roots, Forest, Carbon storage, Ecosystem services

Soil is a biodiversity reservoir, with a large proportion of soil biomass represented by microorganisms (bacteria, fungi, protists, viruses, etc.). Soil microbial abundance figures are often quoted, with up to 10 9 bacterial cells and 10 6 different species per gram of soil, reflecting the ubiquity and high taxonomic diversity of soil microorganisms. The result is great genetic and functional diversity, and microorganisms are central players in the functioning of the soil ecosystem. They are involved in the decomposition of organic matter and thus in the carbon cycle, in several other major biogeochemical cycles (nitrogen and phosphorus), form mutualistic associations with plants and promote their growth and resistance to various stresses, enable the formation of soil aggregates, among other things, and are therefore essential for maintaining certain ecosystem services provided by the soil.

The MicroEco project (European Biodiversa+ and French ANR funding) aims to study the bacterial and fungal diversity of forest soils located in biomes ranging from boreal to subtropical climates, and along a disturbance gradient (i.e. old-growth forests vs. planted/cut trees ; fires ; anthropogenic activities etc.). The project will assess the impact of forest management on soil microbial diversity, in relation to certain ecosystem services such as the maintenance of soil structural stability and carbon storage. Particular attention will also be paid to mycorrhizal fungi and rare and key microbial species, with a view to identifying taxa for protection.

Taxonomic and functional diversity will be assessed by "molecular" approaches (i.e. metabarcoding) using state-of-the-art genomic sequencing tools. Ecological data on microbial diversity will be related to physico-chemical parameters and root biological traits in the soils studied, certain characteristics of the plant cover on the land studied, etc.

Exploring sources of instability in the spectral reflectance of a tropical canopy in French Guiana.

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Funding	CNRS - Institute of Mathematics for Planet Earth

Keywords : Remote sensing, Hyperspectral, Lidar, Machine Learning

This thesis aims to develop a methodological reflection and mathematical / statistical processing of the hyperspectral signal to improve the genericity of the spectral characterization of forest canopies from hyperspectral imagery (atmospheric correction and BRDF effects), which would be organized in three parts :

— A first investigation of the variation of a tropical canopy reflectance given different identified and notable sources of variability. Here is an illustration of the phenomenon of spectral variability in fig. 1.

— A study on the influence of various data encoding methods capable of producing a representation of an hyperspectral reflectance, resilient to previously explored sources of variability using various subspace encoding techniques, here is the illustration of the self-supervised learning framework I use in fig. 2.

My current work is now focused on the second objective of my PhD, using repeated overflights of different tropical forest sites in French Guiana to encode with self-supervised contrastive techniques, stable and relevant spectral features for tropical species classification.

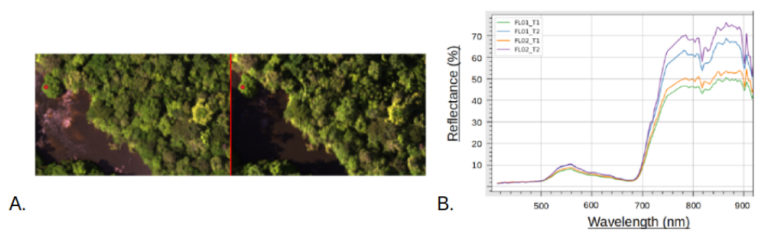

FIGURE 1 – Different reflectances for different acquisitions (B) for a single pixel (red point in A)

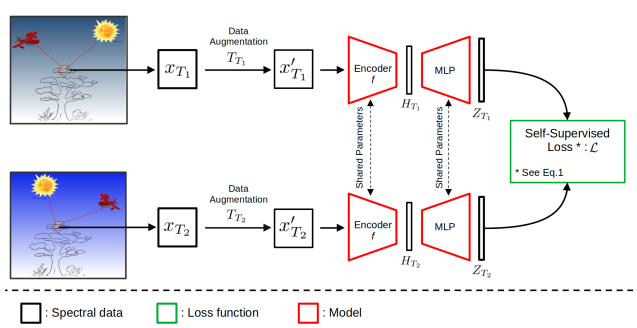

FIGURE 2 – Cool Barlow-Twin self-supervised framework to encode resilient spectral representation across overflights and different acquisitions

Assessing leaf area index in evergreen forests through UAV Laser Scanning

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Funding	Université Grenoble Alpes

Tropical forests, covering only 7% of the Earth's land surface, play a disproportionately vital role in biosphere, storing 25% of the terrestrial carbon and contribute to over a third of the global terrestrial productivity. However, the seasonal variability in fluxes between tropical rainforests and atmosphere is still poorly understood. Better understanding the processes underlying flux seasonality in tropical forests is thus critical to improve our predictive ability on global biogeochemical cycles. Leaf area index (LAI), a key parameter governing water and carbon fluxes, is inadequately characterised, necessitating advancements in monitoring technologies such as aerial and terrestrial laser scanning (LiDAR). This study addresses key challenges in quantifying leaf area in tropical forests using LiDAR technology. The first part focuses on the development of a novel end-to-end Deep Learning approach named SOUL (Semantic Segmentation On UAV laser scanning data) for semantic segmentation of UAV Laser Scanning (ULS) data in tropical forest environments. It is based on PointNet++ with an additional sampling scheme, a novel spatial split schema and an innovative training loss function to handle the high imbalance between the classes. The SOUL method relies on the coordinates of the points to increase its range of application to other forests and other sensors. SOUL has reached the best results on 3 over 6 evaluation metrics, particularly those metrics adapted to unbalanced datasets. After overcoming the challenge of semantic segmentation, the second part focuses on analysing various sources of uncertainty and biases that affect LAI estimation from LiDAR surveys. These biases include limitations in sensor sensitivity, clumping, weighting of multiple LiDAR returns, leaf angle distribution, leaf size, and the presence of woody components within the canopy. As there is currently no efficient and comprehensive method to obtain the true LAI of a forest plot, the study uses simulated ULS data generated by the DART software based on two forest mock-ups : Wytham Woods and RAMI-V Järvselja Birch Stand. The simulated data mimics the characteristics of real ULS data while providing full access to details about the forest. The presence of woody components poses unique challenges to LAI estimation, as their unique structural characteristics lead to biases that are distinctly different from those of leaves. Therefore, the second paper priorities addressing this bias to isolate and understand the individual contributions of other factors to LAI estimation. To eliminate the impact of woody components, the paper proposes a robust protocol that combines the SOUL method with AMAPVox, a software for LiDAR data analysis. Once the woody component bias is removed, the paper conducts a quantitative analysis of the remaining biases, laying the foundation for future work in this area.

Leaf Demography and the Phenology of primary and secondary growth in semi-deciduous forests of Cameroon : From leafy shoot to tree crown

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Funding	One Forest Vision

In 2019, atmospheric CO2 concentration will reach 410 ppm, an increase of 12%between 2010 and 2019. In the face of this increase, tropical rainforests play an essential role in the assimilation of CO2 via the photosynthetic activity of their leaves, and in the massive storage of carbon in the woody biomass of trees. While they account for 30% of the world's forest cover, they store nearly 54% of the carbon stored in above-ground forest biomass worldwide. What's more, they contribute half of the global forest carbon sink, giving them a major role in climate regulation. These ecosystems are also home to incredible biodiversity, with 50% of the 64,000 known tree species found in the tropics, in forests with up to >200 tree species per hectare (dbh>5cm) in Amazonia, Southeast Asia or Melanesia. The forests of Cameroon, part of the Congo Basin (the second largest tropical forest after Amazonia), are no less diverse, with 600 tree species and up to a hundred species per hectare. Despite the major role played by forests in carbon assimilation and storage, studies on the foliar dynamics of tropical rainforests, particularly those of Central Africa, remain incomplete.

Over time, the leaf demography of trees, which results from the events of organogenesis, maturation and leaf senescence, evolves within the crown. As leaves are the seat of photosynthesis, leaf demography is closely linked to a tree's carbon storage capacity and to the temporal organization of secondary growth and axis thickening. In turn, the properties of the wood formed directly influence the photosynthetic capacity of the crown. Understanding the functional and temporal coordination between leaf demography and secondary growth is essential for understanding the global dynamics of carbon storage in trees.

The aim of this project is to (i) characterize the diversity and coordination of vegetative phenology patterns (primary and secondary growth) within tree communities in the tropical rainforest of Cameroon, and to examine their plasticity in the face of environmental conditions at different scales. In addition, this thesis aims to (ii) precisely describe leaf demography through the study of leaf organogenesis, maturation and senescence processes at different scales, from axis and branch structure to crown structure. The data collected will also be used (iii) to analyze how leaf structure, optical properties and physiology evolve during aging, and how these factors influence productivity and carbon sequestration.

The permanent systems at Mbalmayo and Bouamir in Cameroon, supported by the One Forest Vision initiative, provide an ideal setting for examining these issues. The student's work will be based on (i) the analysis of observation time series obtained through regular overflights by drones equipped with RGB sensors, carried out on the two study sites for almost two years ; (ii) growth monitoring carried out directly in the canopy by tree-climbing ; (iii) morpho-anatomical descriptions of branches (counting the number of leaf organs present or abscised) ; (iv) measurement of the spectral and functional properties of leaves as a function of their age.

Climatic, oceanic and sedimentary conditions of natural renewal of mangroves in French Guiana for an adaptive coastal protection strategy

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Funding	PPR Océan & Climat

Keywords : mangrove, coastal biodiversity, erosion, hydro-sedimentary dynamics, mud bank, ecological restoration, nature-based solution, French Guiana

Are there key indicators of the natural functioning of mangroves that would allow us to better understand and anticipate how ocean and climate processes impact the coastal interface ? The question arises with regard to the persistence of mangroves for more than 60 million years during which climatic and tectonic upheavals have followed one another. To address this issue, the mangroves of French Guiana have a unique story to tell as the renewal of coastal mangroves is rapid and seems to compensate, according to the phases of silting, the losses by erosion. However, as everywhere in the world, the oceanic and climatic processes are changing, in particular the swell regimes that arrive at the coast : the maintenance of the ecosystem could be thwarted by an accentuated remobilization of the muddy substrate on which the young mangrove develops.

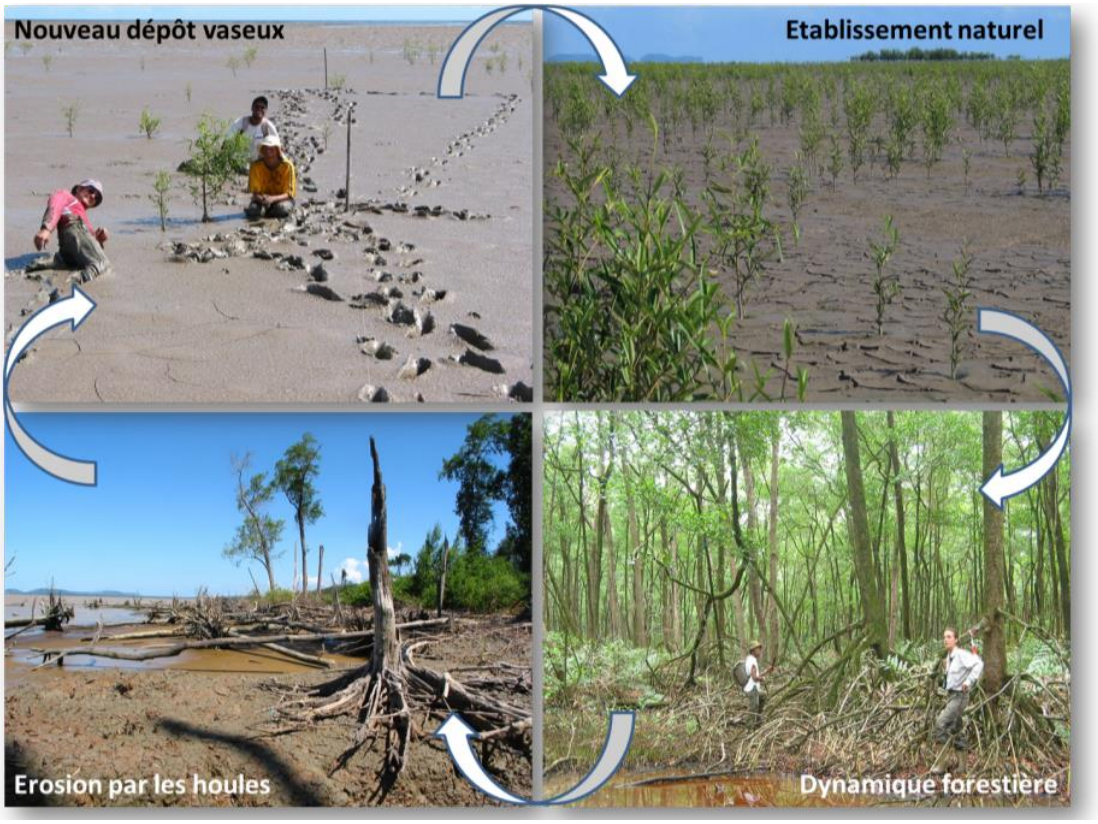

FIGURE 1 – Different 'faces' of Guianese mangroves. Colonization phases can be particularly rapid and involve several tens of hectares in a few months (Proisy et al., 2009. https ://doi.org/10.1016/j.csr.2008.09.017).

Thanks to a better understanding of the natural settlement patterns of local mangroves, we will try to reveal the vulnerabilities that affect mangrove coasts. In practice, the aim is to characterize the spatial expansion and growth patterns of mangrove seedlings according to hydro-sedimentary and ecological factors considered as determinants of mangrove establishment, using field surveys and repeated fine-scale spatial observations on several sites in French Guiana.

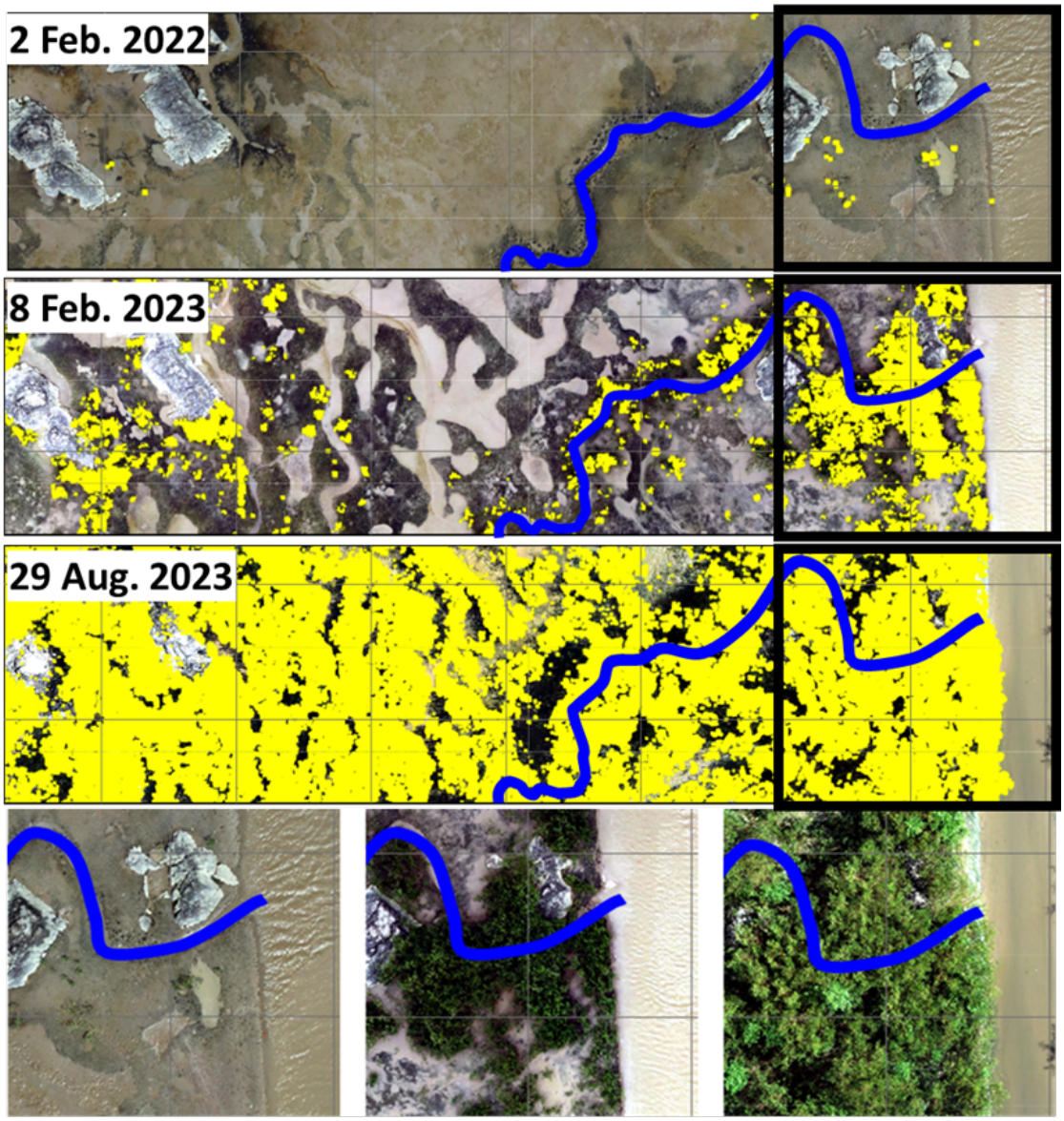

FIGURE 2 – A top-down sequence of three 75 m x 20 m orthomosaic sections taken in February 2022, February 2023 and August 2023, with mangrove highlighted in yellow. At the bottom, a left-right sequence of 20 m x 20 m image snippets 'as they come' from the right corners of the orthomosaic section. The grid spacing in each orthomosaic is set to 10 m. Blue line is a dewatering channel.

Is global warming blowing hot or cold on high mountain plants ? Reduced snow cover, nursery plants and adaptations to cold in temperate and tropical latitudes.

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Funding	GAIA funding

Keywords : community ecology, global change, plant-plant interactions, chronosequence, functional traits, nurse plants, proglacial margins

Climate change is leading to a global retreat of glaciers, revealing land that can be colonised by vegetation, the proglacial margins. The global rise in temperatures, by modifying the abiotic and biotic factors determining the ecological niche of alpine species in proglacial margin ecosystems, forces them to either migrate, adapt or become extinct. Nurse plants, or facilitators, have a positive effect on the fitness of other plants, the beneficiaries. Present in the ecosystems of high mountain proglacial margins in temperate and tropical latitudes, nurse plants, by buffering local microclimatic conditions, encourage the establishment of plant species and accelerate succession. While temperate alpine species are constrained by snow cover and the short duration of the growing season, this is not the case for tropical alpine species. However, a delay in facilitation has been observed on the proglacial margins, expressed by the absence of nurse species or by the immaturity of the nurse species present. As a major process in the construction of proglacial ecosystems, it is interesting to (1) quantify the nurse effect, to (2) understand what characterises a nurse plant and (3) the effects of nurse plants on the assembly of species and the construction of proglacial margins ecosystems in tropical and temperate latitudes.

Root-stem interactions in trees under climate change. Applications for ornamental tree nursery production.

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	Claire Atger (Consulting firm 'Pousse conseil')
Funding	ANRT (CIFRE), BRL Espaces Naturels, CIRAD

Keywords : root – shoot interactions ; root system ; root pruning ; tree growth ; growing conditions ; architecture ; urban tree ; nursery ; climate change.

Planting trees in urban areas often results in a poor establishment, leading to many failures. This is explained by the harsh growing conditions in urban areas, but also by the production systems in the tree nursery industry. Indeed, the growing conditions of trees in nurseries are far from those that will be encountered in urban areas. In addition, trees are damaged by repeated high-intensity pruning of roots and shoots and the aerial part of the tree is oversized compared to the root system.

This thesis investigates whether urban tree establishment can be improved by producing young trees under conditions closer to urban environments and by managing root system deployment to restore root/stem balance. We hypothesize that growing trees in stonier soil with limited irrigation will enhance the root/-shoot ratio, improving establishment. Additionally, early root pruning may encourage root system division, mitigating uprooting impacts.

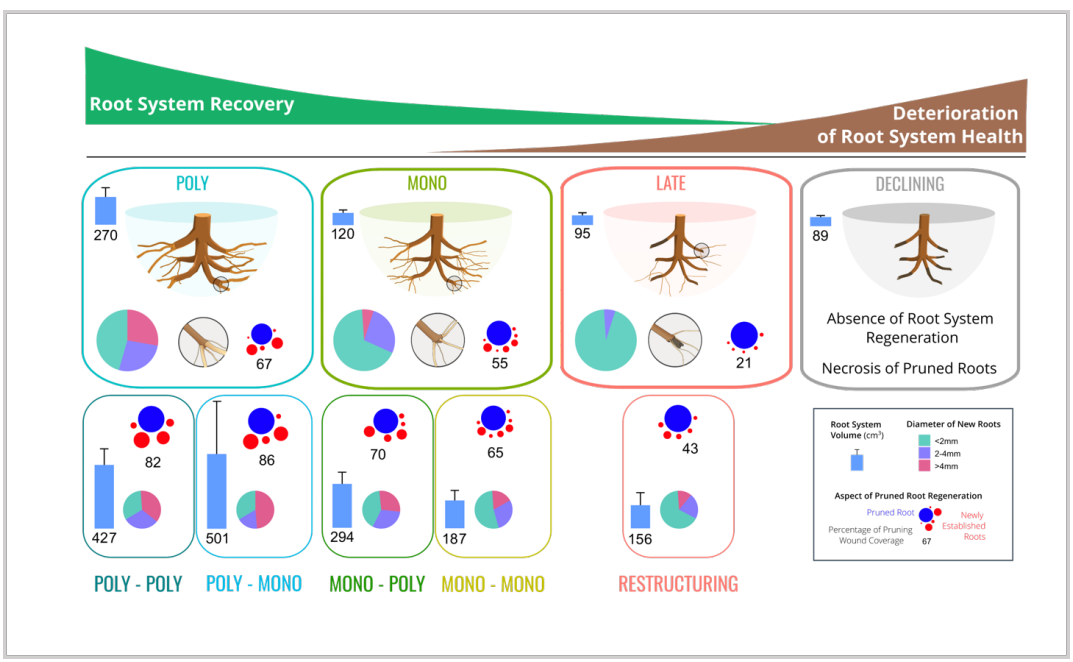

FIGURE 1 – Root systems contained within excavated root balls at the end of the first and second years after transplantation, categorized by aboveground growth dynamics.

Conducted at the BRL Espaces Naturels nursery in Gard, France, this study involves planting hackberry trees (Celtis australis L.) using alternative methods (restrictive soil, no fertilization, reduced irrigation, varied root pruning) versus conventional methods. Tree growth is monitored under each treatment.

The research is divided into three areas :

1. **Links between Shoot and Root Establishment :** After two growing seasons, we identified different aboveground growth dynamics categories based on the time between planting and budburst and the annual shoots growth dynamics (Fig. 2). Excavation of 125 trees revealed that root regeneration and health were linked to aboveground growth categories (Fig. 1) and different root-to-shoot investment strategies.
2. **Spatial Heterogeneity of Regrowth :** By mapping growth variables within plots, we identified high and low growth areas suggesting that soil conditions (compaction, water/nutrient availability) limit growth. Soil pits were opened in these areas to characterize soil profiles and parameters.
3. **Impact of Root Pruning :** At the end of the first growing season, roots were pruned using mechanized equipment with varying intensities. In the second season, fully pruned trees showed reduced shoot production, leaf area, and trunk growth compared to partially pruned or unpruned trees.

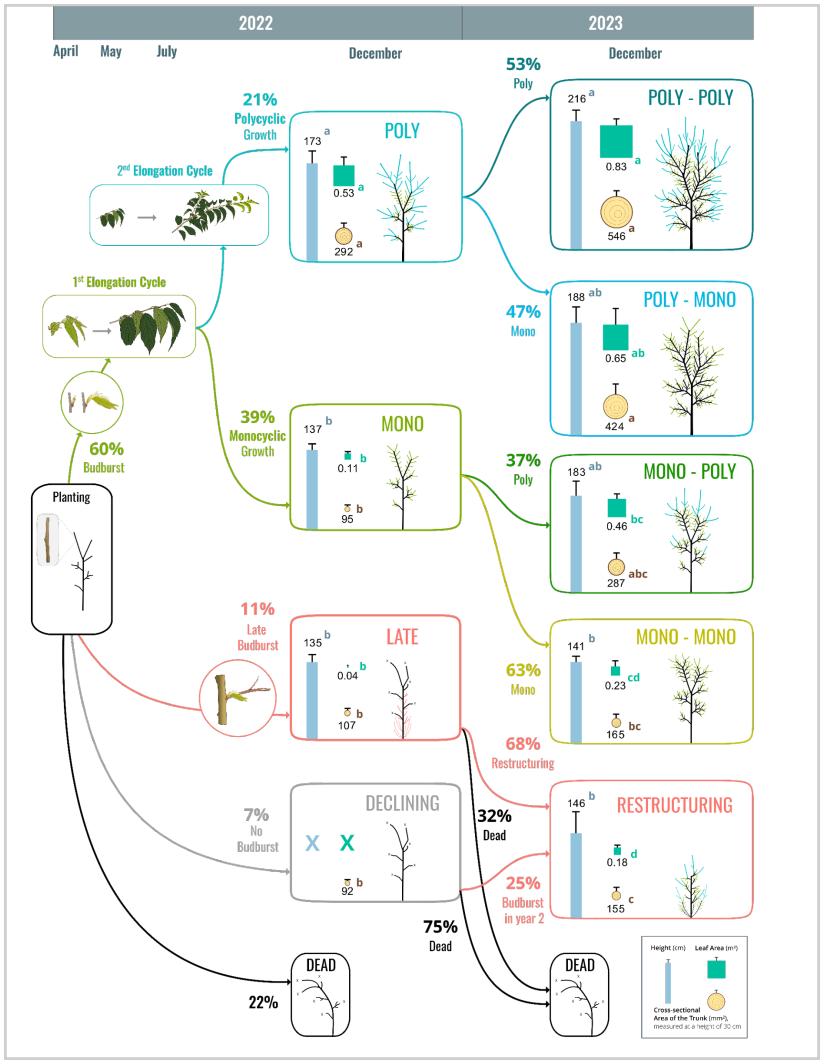

FIGURE 2 – Aboveground growth dynamics categories and resulting structures over the two years following transplantation. Growth dynamics were categorized based on two traits : time to budburst and annual shoot growth type (monocyclic or polycyclic).

The use of multitemporal lidar to monitor the impact of climate change on tropical forest C sink

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Funding	Université de Montpellier

Keywords : Multitemporal LiDAR, Tropical forest carbon, Aboveground biomass estimation, Canopy Constructor model, French Guiana

The intact tropical forest carbon sink appears to have peaked and its saturation and continued decline have implications for policies aimed at stabilising the Earth's climate. Although they remain a major carbon sink tropical forests' capacity to absorb additional carbon seem to be diminishing. While tropical forests may be more directly threatened by deforestation and degradation, the future carbon balance will also be affected by climate change and forest restoration initiatives. To better understand drivers of current forest dynamics, we propose to leverage an exceptional dataset of coincident ground-based forest inventories and ALS scans covering a range of tropical forests physiognomy and spanning over a decade. In this study, we will use repeat LiDAR to characterize not just the structure of forests, but also the aboveground carbon dynamics in relation to forest composition and environmental context. This should help produce guidelines to better manage and safeguard these vital ecosystems by gaining insight into how vast, inaccessible forests are faring in the face of accelerating global climate change. The scientific objectives and research strategy are as follows :

1. Develop robust methods for estimating above-ground biomass (AGB) using LiDAR-derived metrics (based on vertical profile metrics derived from AMAPVox) at different spatial resolutions. Estimation of AGB using the latest ALS data (2023) at three sites (Paracou, Nouragues and Montagne Tortue) to produce high precision carbon stock maps with a resolution of 1 hectare. Assess and reduce uncertainty in landscape-scale biomass estimates using techniques such as cross-validation and convex hull analysis. This step will establish a baseline methodology for AGB modeling.
2. Assess and validate the Canopy Constructor (CC) model. Explore whether integrating vertical vegetation profiles (from AMAPVox) improves CC extrapolation step performance. The CC model will be tested in extrapolation mode in Paracou on a test set (subset of plots) not use for training and compared with standard methods of AGB prediction (as defined during the first point).
3. If the improved CC model (in point 2) performs well, the model will be applied to multiple sites and time points across the Guyafor network to evaluate its robustness and transferability. Integrate with the GEO-TREES network for larger scale validation.
4. Analyze the drivers of changes in carbon stocks at the landscape scale and regional scale to better understand carbon dynamics in tropical forests.

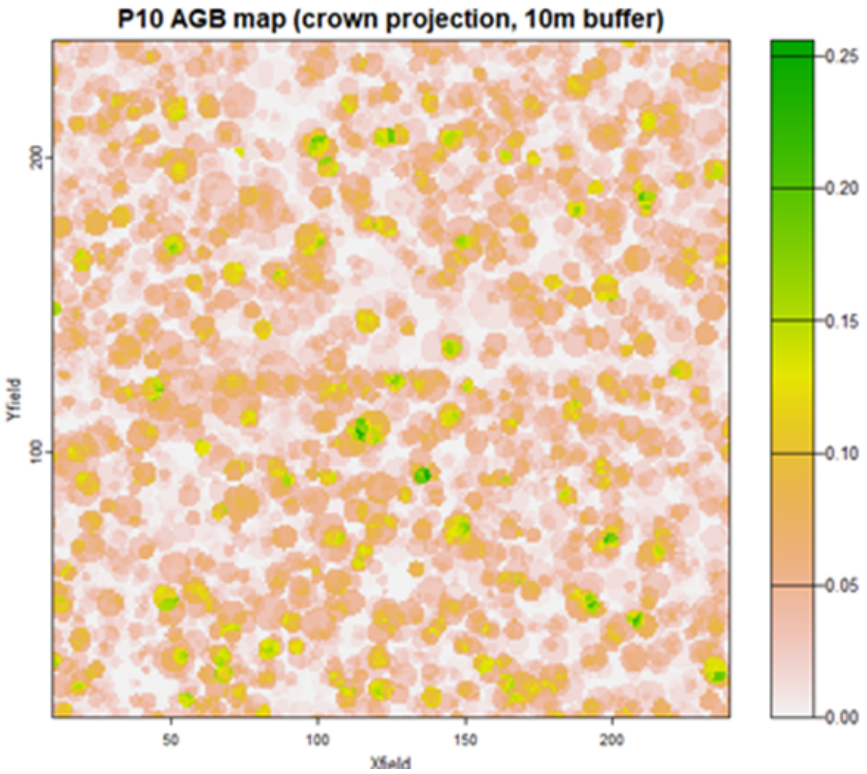
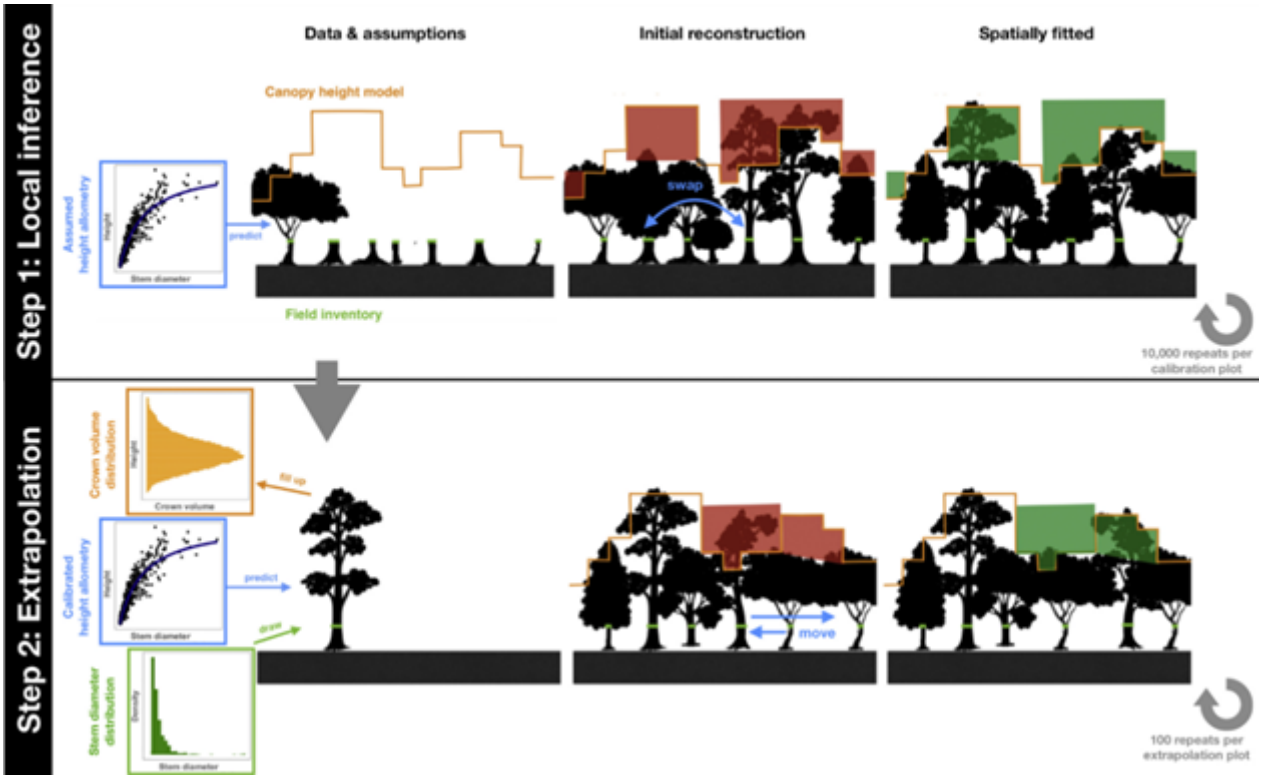


FIGURE 1 – AGB map (tons/m2) of Paracou Plot 10 using crown projection.



Early woody plant diversity and biology : An integrative evolutionary and paleoenvironmental study

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Funding	TCD Provost Ph.D. Award

Keywords : Paleobotany, Wood, Fungi, Evolution, Paleozoic

The Devonian (419–359 millions years ago (Ma)) is a period that witnessed an explosion of plant diversity and the evolution of numerous innovations such as leaves, roots, seeds, trees, and wood. The first woody plants (i.e., plants possessing secondary xylem) appear at the beginning of the Devonian (about 407 Ma, Gerrienne et al., 2011). This period and the following one, the Carboniferous (359–299 Ma), exhibit woody plant species belonging to groups such as the lycophyte and ferns that do not possess wood in today's flora. The aim of my Ph.D thesis is then to work on the Devonian-Carboniferous woody plant to study the early evolution of wood. For this purpose, I have worked on three different genera of anatomically preserved woody plants from Devonian-Carboniferous deposits of France and Ireland (paleogeographical location : Fig 1).

The first genus is Callixylon, with the description of a new species (Fig. 2A) found during our fieldwork in an Upper Devonian locality of Ireland (Fig. 1). Callixylon is a form-genus used for anatomically preserved fossils of the Devonian tree Archaeopteris, famous for being the first tree in Earth's history with a large amount of wood and a deep-rooting system. The discovery of a new species showing a specific combination of wood characters expands the known diversity of this genus. In addition, the new species possess a unique root anatomy, increasing our knowledge about a part of this plant that remains less understood. The second studied genus is Cladoxylon (Fig. 2B), with 50 specimens of Cladoxylon taeniatum from the early Carboniferous of France (Fig. 1). Their study allows the reconstruction of the plant architecture and shows that this plant possessed an asymmetrical growth of its wood around its numerous primary xylem bundles. This shows how the same wood components can create different growth patterns.

The third genus is Stauroxylon, with the species S. beckii (Fig. 2C), from the same formation as the Cladoxylon specimens. This plant was initially described in 1970, but never included in recent analyses. We redescribed this plant with an additional specimen and included it in a phylogenetic analysis that places it inside the group of aneurophytales. This expands the stratigraphic distribution of this group, previously known only in the Devonian.

This work provides 1) an increase in our knowledge of the diversity of Devonian- Carboniferous woody plants, 2) a reconstruction of the architecture of an atypical extinct woody plant, and 3) a better understanding of the transition between Devonian and Carboniferous floras. In addition, the ongoing study of a new plant with fungal remains inside its wood is increasing our knowledge about this type of interaction in the fossil record.

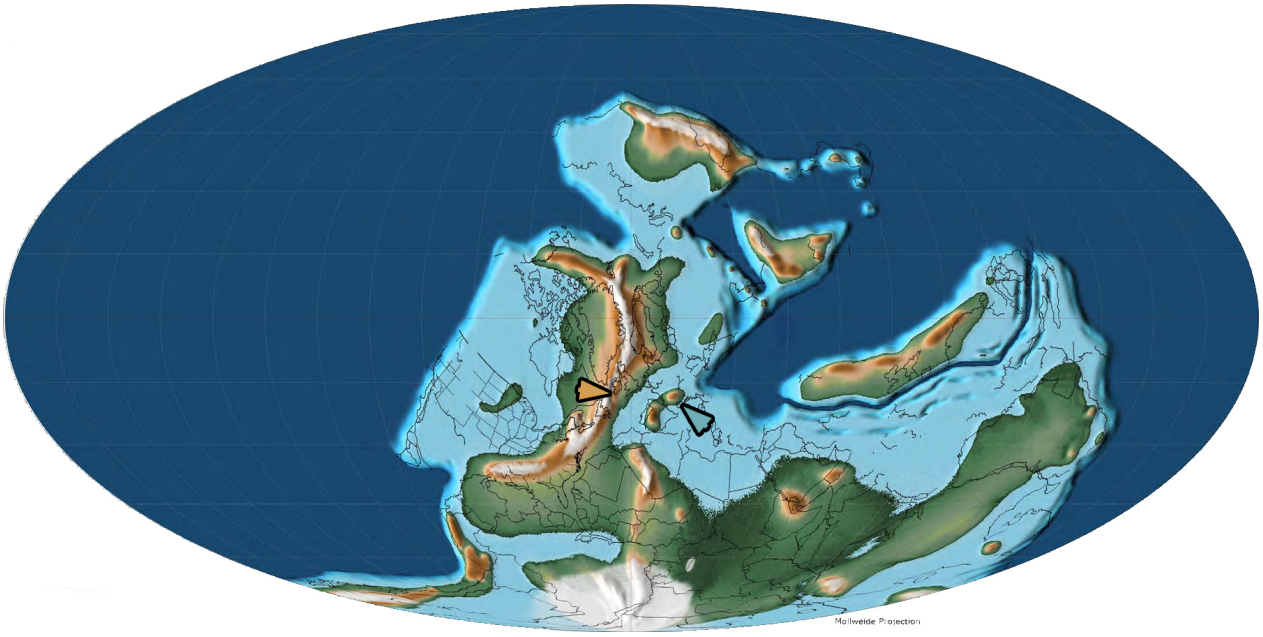

FIGURE 1 – Paleogeography of the earth at the Devonian Carboniferous boundary (359 Ma). Arrows indicate the location of Ireland (orange arrow) and France (blue arrow). Modified from C.R. Scotese, Paleomap Project 2014 (Atlas of Devonian Paleogeographic Maps).

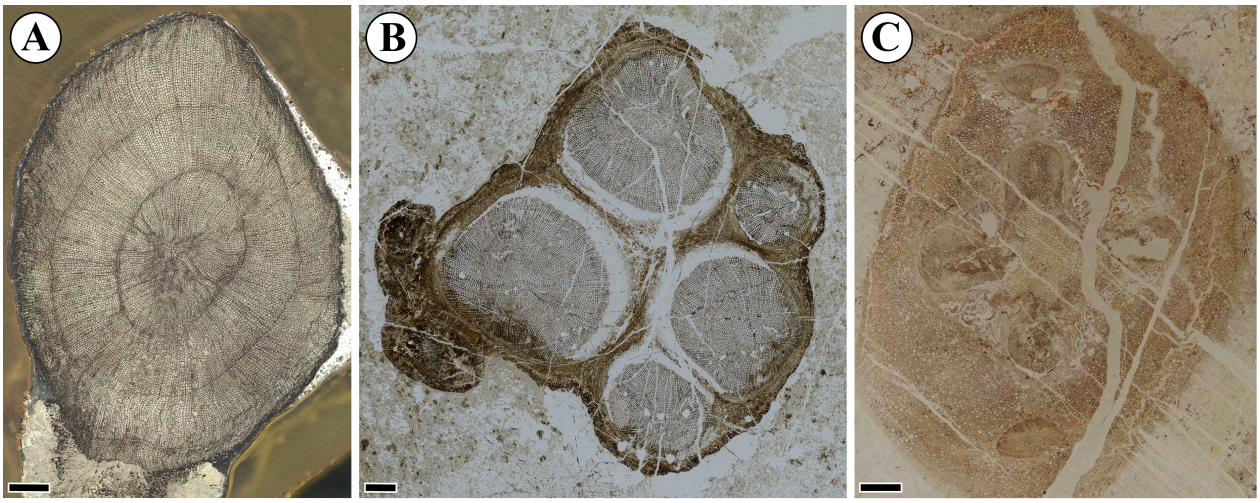

FIGURE 2 – Cross section of (A) the root of the new Callixylon species, (B) Cladoxylon taeniatum, and (C) Stauroxylon beckii. Scale bars = 1 mm.

Analysis of sea-mangrove coastline fluctuations for coastal vulnerability and carbon sequestration assessments. Multi-scale and multi-decadal modeling approach of the influence of hydro-sedimentary and climatic processes in French Guiana.

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Funding	ADEME / DGTM (French Guiana)

Keywords : landscape evolution modelling, coastal mangrove, coastal vulnerability, carbon sequestration, French Guiana, Marine Copernicus, remote sensing

The Guianese mangroves occupy 68% of the total area of mangroves in the French overseas territories. On a particularly unstable Guianese coastline, they can develop extensively and with a great dynamic of forest biomass. In a rapidly growing department where 80% of the population lives on the coast, it is urgent to assess the future and potential of these coastal forests in a context of climate change. This thesis project will examine the influence of hydro-sedimentary and climatic processes on mangrove extension using a modeling approach that simulates sea-mangrove coastline fluctuations and compares them to observations from a unique spatial database (70 years of monitoring). The influence of waves ocean on the Guianese mangroves can thus be evaluated in various sedimentary contexts and over several decades. The maintenance capacity of mangroves will be tested, locally and regionally, through simulations that involve realistic scenarios of oceanic and climatic forcing (e.g. winter storms in the North Atlantic Ocean). This better understood capacity to maintain and renew Guianese mangroves will be used (notion of nature-based solutions), on the one hand, to help predict the vulnerability of the Guianese coastline to erosion and siltation and, on the other hand, to propose a framework for analyzing and monitoring carbon sequestration by mangroves.

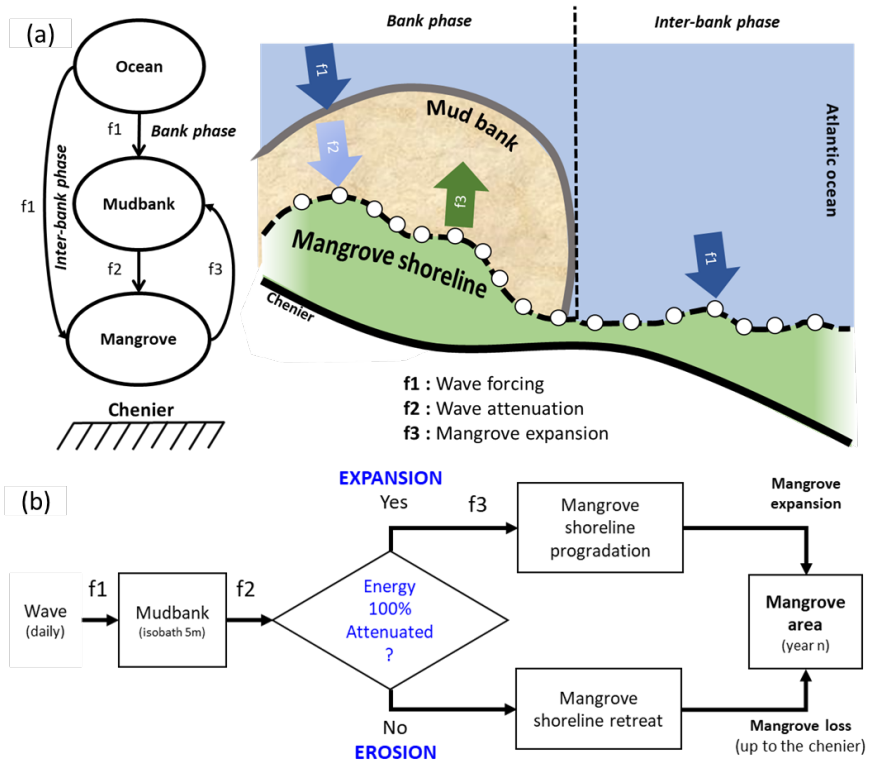

FIGURE 1 – Mangacoast model conceptualisation and implementation. (a) Conceptual diagram of the MANG@COAST modelling framework based on entities and relationships. (b) Iterative flowchart diagram of the model for any point on the mangrove shoreline.

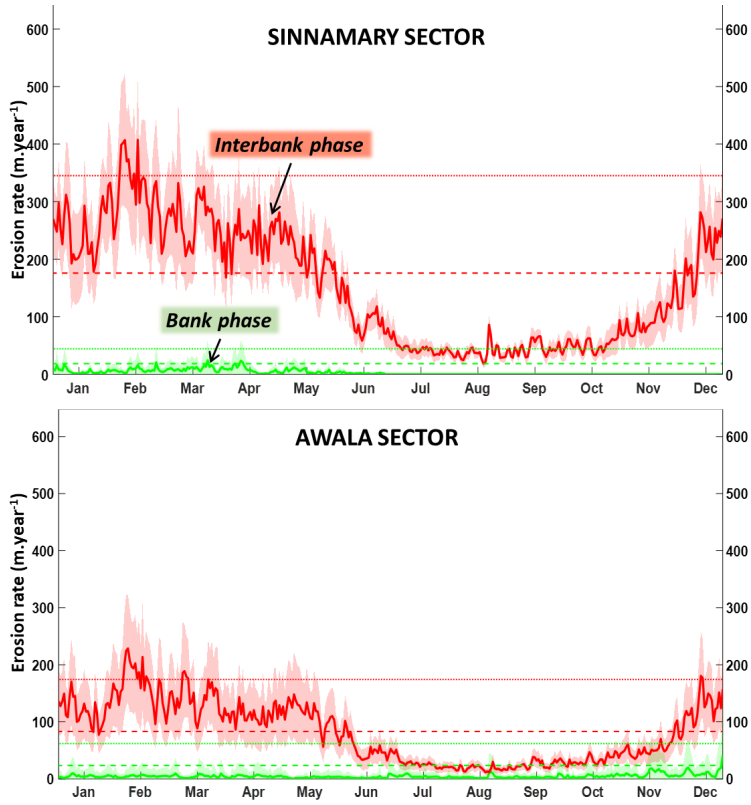

FIGURE 2 – Simulated seasonal erosion rates (i.e., mangrove retreat) for bank and interbank phases in the SINNAMARY and AWALA areas. The dotted and dashed horizontal lines correspond to the maximum and average values observed in remote sensing images for the bank and interbank phases.

Impact of anthropization on vector community dynamics : modeling, analysis and simulation. Control of epidemiological risk in peri-forest context in Cameroon.

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Funding	Institut ExposUM

Keywords : One Health – Vector-borne diseases - Mathematical Modeling - Population dynamics - Qualitative Analysis - Numerical Simulations

In Central Africa, population growth is driving an increasing demand for resources, resulting in significant changes to forest and agricultural landscapes. This human pressure is manifested not only through the degradation of vegetation and the loss of biodiversity but also in shifts in the populations of disease-carrying animals, which can facilitate the emergence of zoonotic arboviruses, particularly those transmitted by mosquitoes. It is therefore essential to better understand the interactions between vectors, the environment (their habitat), and hosts (humans and fauna) in order to assess the positive or negative effects of human activities on epidemiological risk. Establishing a framework for coordinated actions is crucial to limiting negative impacts and ensuring the long-term sustainability of positive outcomes.

In order to embrace all those aspects, an interdisciplinary project has been funded by the institute ExposUM. This project, named I-CARE (for ImpaCt de l'Anthropisation sur le Risque d'Emergence d'arboviroses zoonotiques en Afrique Centrale, see also figure 1), involves 3 research units (MIVEGEC, INNOVATION, and AMAP) and it is structured around 3 PhD thesis in Entomology, in Economy and in Applied Mathematics. Mathematical modeling is a useful tool to integrate the processes involved, to check or refute scientific hypotheses, and to evaluate, through mathematical analysis and simulations, the evolution scenarios of these systems to aid decision-making. The results obtained throughout the theoretical studies and numerical simulations will be discussed with the I-CARE experts and PhD students. Moreover, field studies will be done in the South-Cameroon (region of Kribi) to obtain entomological and epidemiological data and knowledge on the ongoing control strategies.

A first step to model the interactions between human population, environment and epidemiological risk is to focus on the dynamics between the human population and the environment. Our modeling is based on bibliographic knowledge and exchanges with our partners. This model is described by the compartmental diagram given in figure 2, where we distinguish two areas : the urban or domestic area and the wild area. In the domestic area, humans breed domestic animals and plants. In addition, humans may enter the forest for hunting or foraging activities. These resources influence their living conditions and, consequently, the population size in the domestic area.

Studying this model helps identify, among other things, the conditions under which wild fauna and humans can coexist, as well as the point at which agricultural practices may begin to affect these conditions.

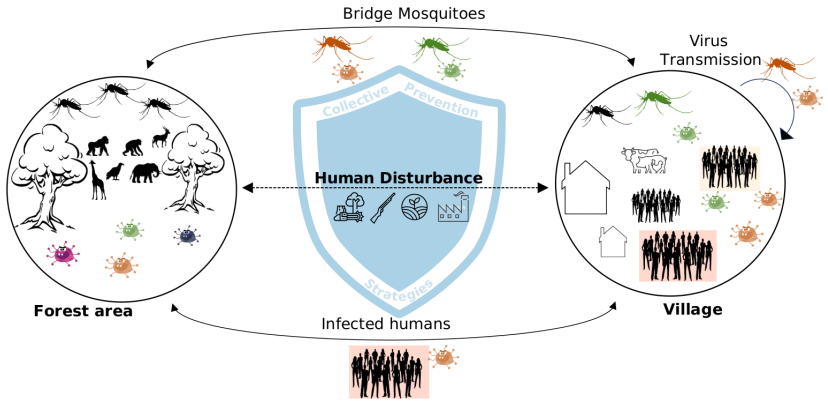

FIGURE 1 – Schematic representations of the interactions between humans, environment and vectors.

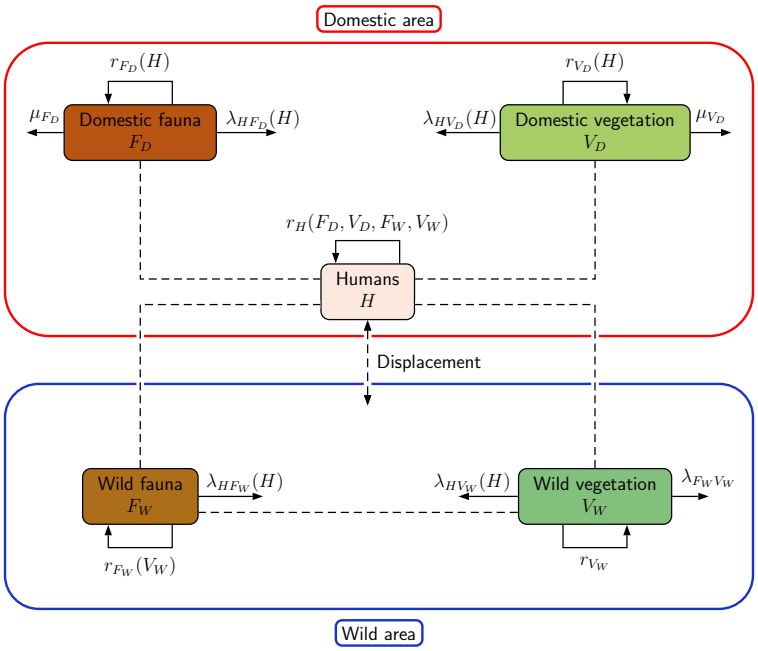

FIGURE 2 – Dynamic model compartmental diagram.

An overview of wild-harvested plants in metropolitan France

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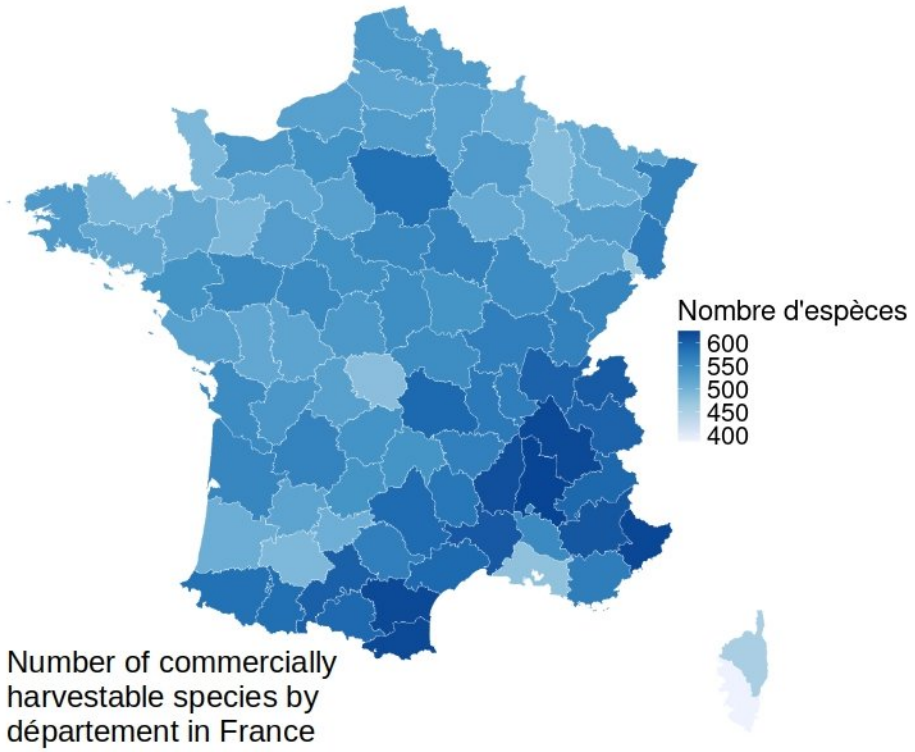
Funding	Organisme Français de la Biodiversité (OFB) et Université de Montpellier

Keywords : wild plants, harvesting, plant uses, biogeography, Grime's CSR, phylogeny, conservation

Wild plant harvesting, a practice dating back to prehistoric times, continues to be a significant yet often overlooked activity in modern society. It plays a vital role in industries such as medicine and cosmetics, with 60 to 90% of globally traded medicinal and aromatic plants sourced from wild habitats. The demand for these plants has surged, driven by a global interest in natural products, leading to concerns over unsustainable harvesting practices. Plants like American ginseng and yew trees have already faced overharvesting threats, raising alarms about the sustainability of these practices.

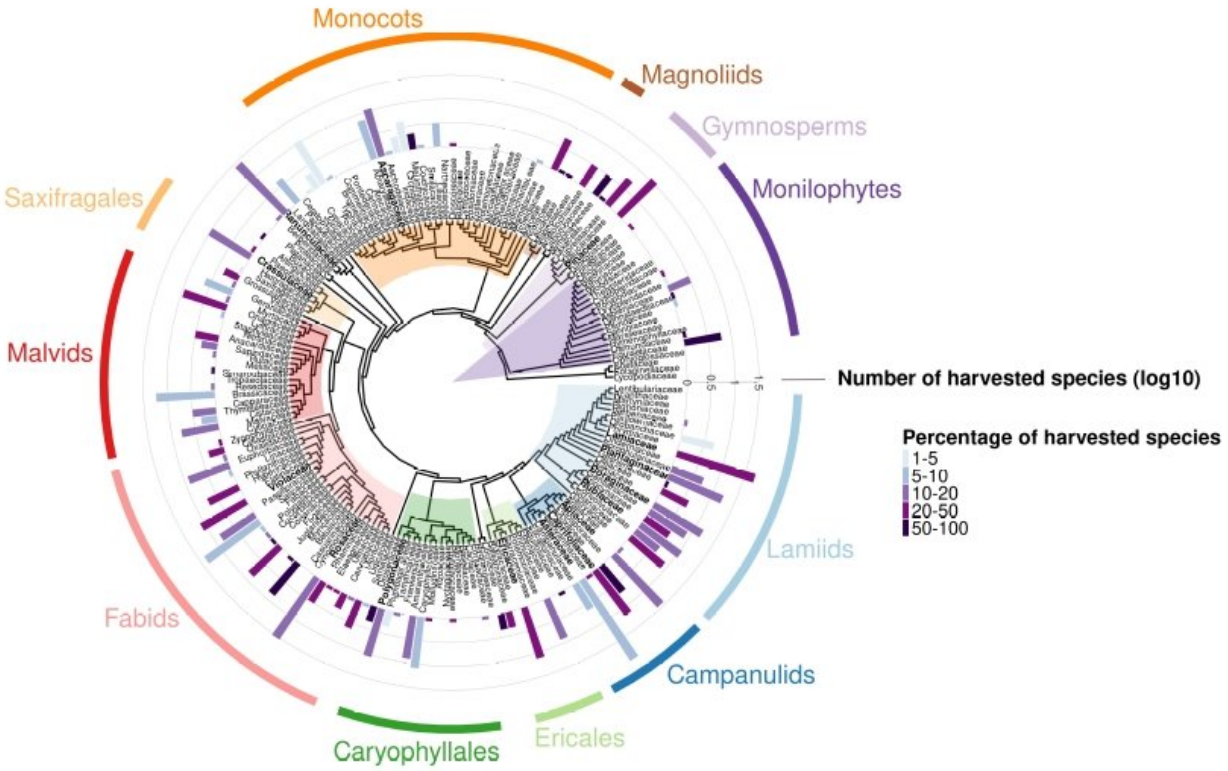


Despite this, understanding the ecological impacts of wild harvesting remains limited. Only 7% of approximately 30,000 plants documented for their medicinal and aromatic properties have undergone global conservation assessments, in stark contrast to the near-complete evaluations of bird and mammal species. Of those assessed, one in five wild medicinal and aromatic plants are at risk of extinction. Overharvesting is a significant threat, but the lack of comprehensive assessments hinders the development of effective management strategies.

France, with its diverse climates and rich flora, is particularly well-suited for wild plant harvesting. Approximately 7,000 plant taxa exist in the country, with at least 10% being harvested. However, the absence of a detailed overview of the industry hampers efforts to understand the full scope and impact of these practices. Most research focuses on a few emblematic species, leaving much of France's wild plant diversity underreported. This study aims to fill that gap by providing a broader overview of wild-harvested plants across metropolitan France, including Corsica.

The research explores five key areas : the taxonomic and phylogenetic diversity of wild-harvested plants, their uses, geographic distribution, life-history strategies, and conservation status. By identifying the core plant families subject to harvesting and understanding which parts are most frequently collected, the study sheds light on the pressures faced by these species. Mapping hotspots of plant diversity across France also helps identify regions where human activities pose significant risks to plant populations. Furthermore, by examining the life-history strategies of harvested species, the study provides insights into how certain plants respond to disturbances like harvesting.

The research also evaluates the conservation status of these plants, comparing IUCN Red List assessments with existing protections and regulations in France. By addressing these gaps, the study aims to inform conservation efforts and guide policy decisions for the sustainable management of wild-harvested plants. The construction of a comprehensive database on plant distribution, biology, uses, and legal status marks a crucial step toward better understanding the vulnerability of wild-harvested species in metropolitan France.



Distribution of commercially harvested plants within the phylogeny of the french vascular flora

Temporary Mediterranean lagoons : potential sentinels of climate change and biodiversity conservation

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Funding	Région Occitanie (50%) et Conservatoire Botanique National Meditérannéen (50%)

Keywords : biodiversity, flora, coastline, hydroperiod, sentinel

Mediterranean aquatic ecosystems represent a crucial challenge for the conservation of biodiversity. The LTM-Flora project focuses on Temporary Mediterranean Lagoons (TMLs), ecosystems that are both fragile and important in terms of natural heritage. These environments, which are subject to seasonal hydrological variations, provide a refuge for a specific biodiversity adapted to their unique environmental conditions. However, human pressures and climate change projections are threatening their persistence and ecological functioning.

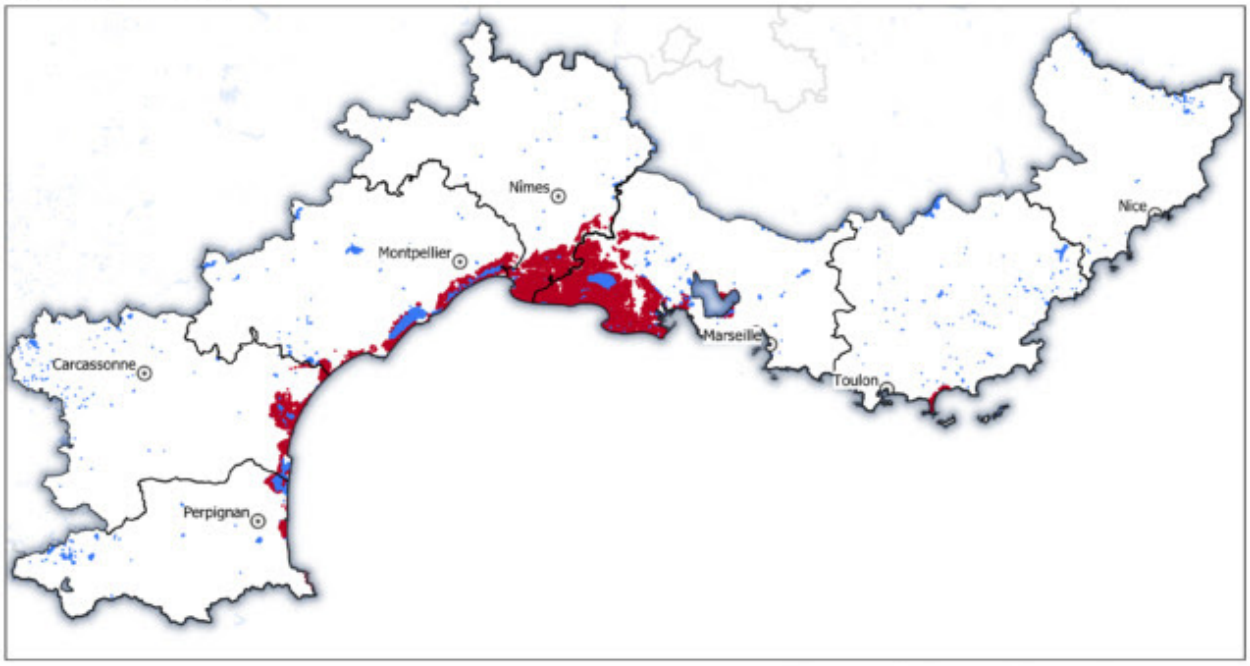
These TMLs cover 8,870 ha in Natura 2000 areas, and the Conservatoire du Littoral owns a majority of these lands. A Regional Action Plan for the TMLs has been drawn up to strengthen the conservation and ecological restoration of these areas.

TMLs, little studied until recently, play a crucial role in Mediterranean coastal ecosystems. The LTM-Flora project aims to analyse the interactions between these ecosystems and environmental pressures, particularly those linked to climate change. Using a multidisciplinary approach combining ecology, botany and spatial modelling, the project aims to assess the potential of TMLs as sentinels of climate change and to develop appropriate conservation strategies.

Several research questions will be addressed :

1. Predicting the impact of climate change : How do climate variations influence TMLs in the French Mediterranean ? Using a large-scale spatial analysis, this study will examine the effect of climate variables on the distribution of key TML species, providing clues as to their response to environmental change.
2. Response of plant communities to abiotic factors : How do plant species associated with TMLs respond to changes in environmental conditions ? An approach based on in-depth field studies will enable us to understand the impact of abiotic factors such as trophy, salinity and hydroperiod on the plant diversity of TMLs.
3. Ecological restoration : How can degraded TMLs be restored ? An in situ experiment will be carried out to assess the effectiveness of different management methods, such as detaching and stripping, in the ecological restoration of these fragile ecosystems.

Répartition des zones de présence potentielle de lagunes temporaires le long de la côte méditerranéenne de France continentale



Départements
Chefs-lieux départementaux
Hydrographie de surface
Zones de présence potentielle de lagunes temporaires

Sources : modèle de cartographie des zones de lagunes temporaires V1 (© Cbnmed)
BD CarTHAgE (© IGN)
Réalisation : CBNMed (M. Latron)
Logiciel : QGIS V 3.1
Date : août 2021
Projection : Lambert 93

Interaction between pest attacks and plant growth using a model approach applied to robusta coffee in Uganda. Effects on the production

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Funding	$\frac{1}{2}$ CIRAD $\frac{1}{2}$ EU DESIRA ROBUST project

Keywords : modelling, agronomy, applied mathematics, pest and disease, crop production, simulation, integrated model, FSPM, statistics

Agroecological transition is a rapidly developing field of research and development that aspires to enhance the efficacy of agronomic systems through the employment of intricate systems modelling. This process entails a comprehensive analysis of production processes to identify potential interactions within the system [0]. The aim of this thesis is to assess how pests and diseases (P&D) impact crop production, including the mechanisms at the plant and crop scales, as well as the effect of crop practices on production.

The estimated effects of P&D on plants are considered to result from interactions between dynamic models : the plant growth model (considered at least at the organ scale), the P&D model, and the possible addition of a human intervention model (treatment, harvesting...).

To determine more precisely the thresholds at which P&Ds are likely to have a significant economic impact on production [0], and to make an appropriate treatment decision, a coupled model operating over the long term is necessary.

Such a model could provide a more accurate estimation of the effects of climate change on plant phenology/biotic development. One interesting field where we can apply this coupled model is Uganda. It has experienced a great resurgence of pests and diseases in coffee tree fields [0], [0] despite the important efforts of national institutes to create resistant clones, especially for coffee wilt disease (Fusarium xylarioides). In addition, climate change induces new environmental conditions impacting plant growth dynamics as well as the dynamics of pathogens and insects [0, 0, 0]. Consequently, the coffee berry borer (CBB) (Hypothenemus hampei) and coffee leaf rust (CLR) (Hemileia vastatrix) ; are present in Uganda, although at moderate levels. However, severe cases of red blister (RB) (Cercospora coffeicola) which affects berries, of black twig borer (BTB) (Xylosandrus compactus) [0] and of coffee wilt disease [0, 0, 0] are now reported.

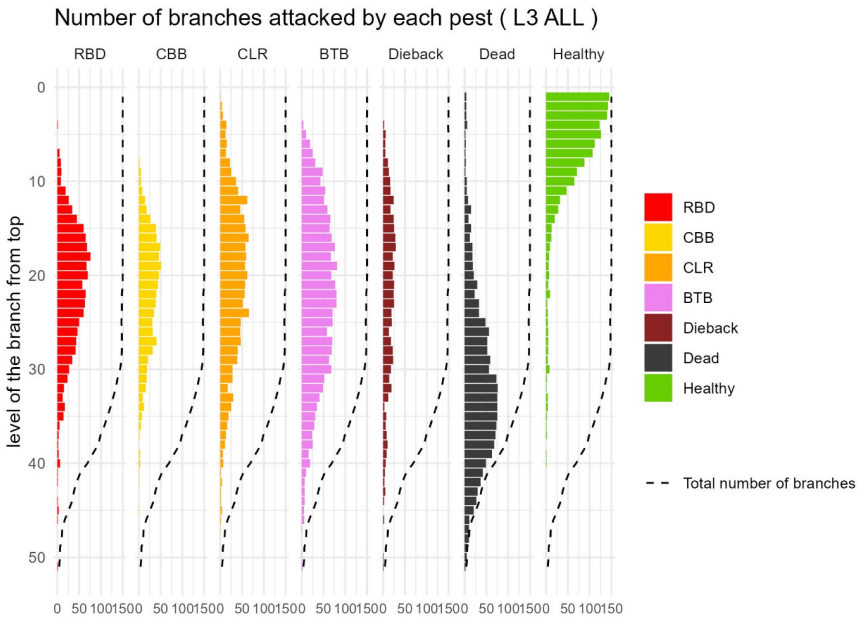

FIGURE 1 – Number of branches attacked by different pests (RBD, CBB and BTB) disease (CLR) and their state on a set of 75 coffee trees (L3 Clone from Uganda)

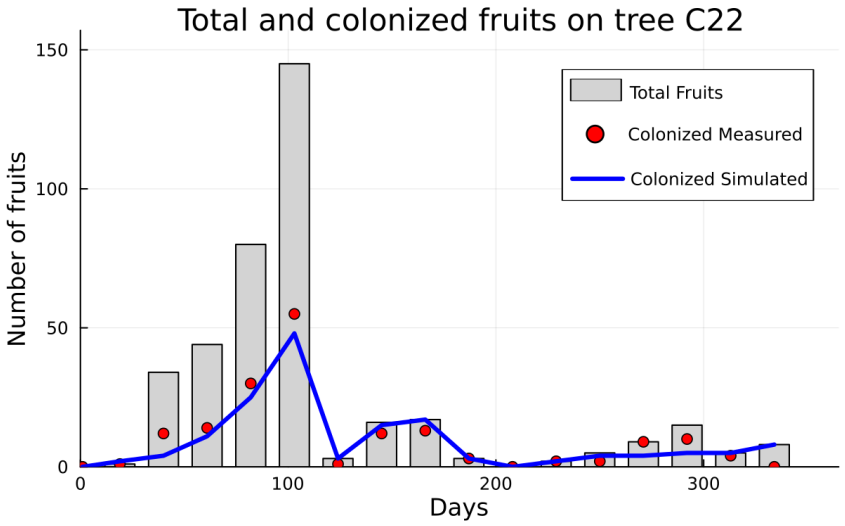

FIGURE 2 – Simulation results compared to field data on a coffee trees in Indonesia. Points represents the recorded number of harvested fruits colonized by CBB on 6 fruiting branches of the tree. Lines represents the results of the simulation by MIMIC at the same date as the observation. Bars represent the total recorded harvested fruits (healthy and colonized) [0]

The spatio-temporal dynamics of Marantaceae forests in Central Africa

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Funding	ANR DESSFOR

Keywords : tropical forests, Marantaceae, Central Africa, arrested succession, fire, logging

My doctoral thesis focuses on the spatio-temporal dynamics of a little-known yet widespread forest type in Central Africa : the Marantaceae forests. These forests, characterized by an open canopy and an understory dominated by giant herbs from the Zingiberales order, appear degraded with a striking lack of tree regeneration. Marantaceae forests have been suggested to be very stable over thousands of years and to thrive under current global changes, making them a potential case of alternative stable state to dense mature forests and of primary concern for the future of central African forests.

The general objective of my research is to understand the external drivers and ecological mechanisms that explain the maintenance and expansion of Marantaceae forests in the North of Congo, a hotspot of Marantaceae forests. My thesis will most likely be structured into four chapters :

In the first chapter, we combine remote sensing (Planet, Pléiade and Sentinel-2 satellite images) and extensive field data to map the large-scale distribution of Marantaceae forests and characterize their structure, composition, function and environmental drivers. We specifically show that open Marantaceae forests are significantly associated with drier areas and share a common flora with previously burned secondary forests, supporting the hypothesis of a specific link between Marantaceae forests and fire.

The second chapter focuses on the impact of fire on Marantaceae forest dynamics at the stand level. By comparing paired plots that burned or did not burn in a 2016 fire event, along with older burned areas (2009 and 1970), where we inventoried trees >1 cm dbh and giant herbs and sampled soil and Marantaceae leaves, we aimed to determine if fire maintains Marantaceae forests or reinitiates succession. The results suggest a positive short term impact of fire on tree regeneration but which does not persist over time, leading to the long-term maintenance of open Marantaceae forests.

In the third chapter, we investigate the impact of logging disturbances on giant herb dynamics, specifically on their abundance and reproductive strategies. To do so, we used drone measurements, field inventories, germination monitoring and genetic analyses. We found that low-intensity logging slightly increases giant herb abundance, but significantly alters reproduction strategies, with a higher proportion of clones in disturbed areas.

The fourth chapter examines the individual interactions between giant herbs and tree saplings. We conducted a 11-months nursery experiment to study competitive and potential allelopathic interactions between a Marantaceae species and four tree species. We applied four different treatments (control, competition, allelopathy from decomposing Marantaceae leaves and allelopathy from living Marantaceae) to 500 tree plants. We regularly monitored their growth and measured various leaf and root traits at the end of the experiment. Our results indicate no allelopathic effects but significant competition, particularly affecting pioneer species.

Multiscale hybrid modelling framework for intercrops : the best of plant and crop models

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Funding	Projet EU INTERCROPVALUES

Keywords : Multiscale modelling, FSPM, Crop models, Intercropping, Agroecology

Agroecology is a promising way to achieve sustainability in agriculture through crop diversification. Among these practices, intercropping involves growing at least two crop species together a significant portion of their growth cycle. The challenge in modelling intercrops lies in the consideration of interspecific interactions for resource acquisition. Among the process-based models available for simulating the growth of intercrops, there are two main types : crop models and Functional-Structural Plant Models (FSPMs). Crop models are good at predicting crop yield over several years, consider many plant and soil processes, but do not explicitly consider heterogeneous canopies. FSPMs consider 3D plant structure and compute some processes at organ scale, which can provide a better understanding of the processes underlying plant interactions, but imply a high computational complexity. However, both approaches have limitations and difficulties in answering key questions : a) how to model intercrops with crop models that consider a homogeneous distribution of plant canopy and root systems without spatial and temporal heterogeneity ? b) how to simulate an intercrop over several seasons while being limited by the complexity of plant-plant and plant-environment interactions ? Hybrid approaches exploiting both models' complementarity could enable to better account for interspecific interactions in crop models, representing them as emergent properties of the system, simulated through the processes rather than parameters being forced into the crop model.

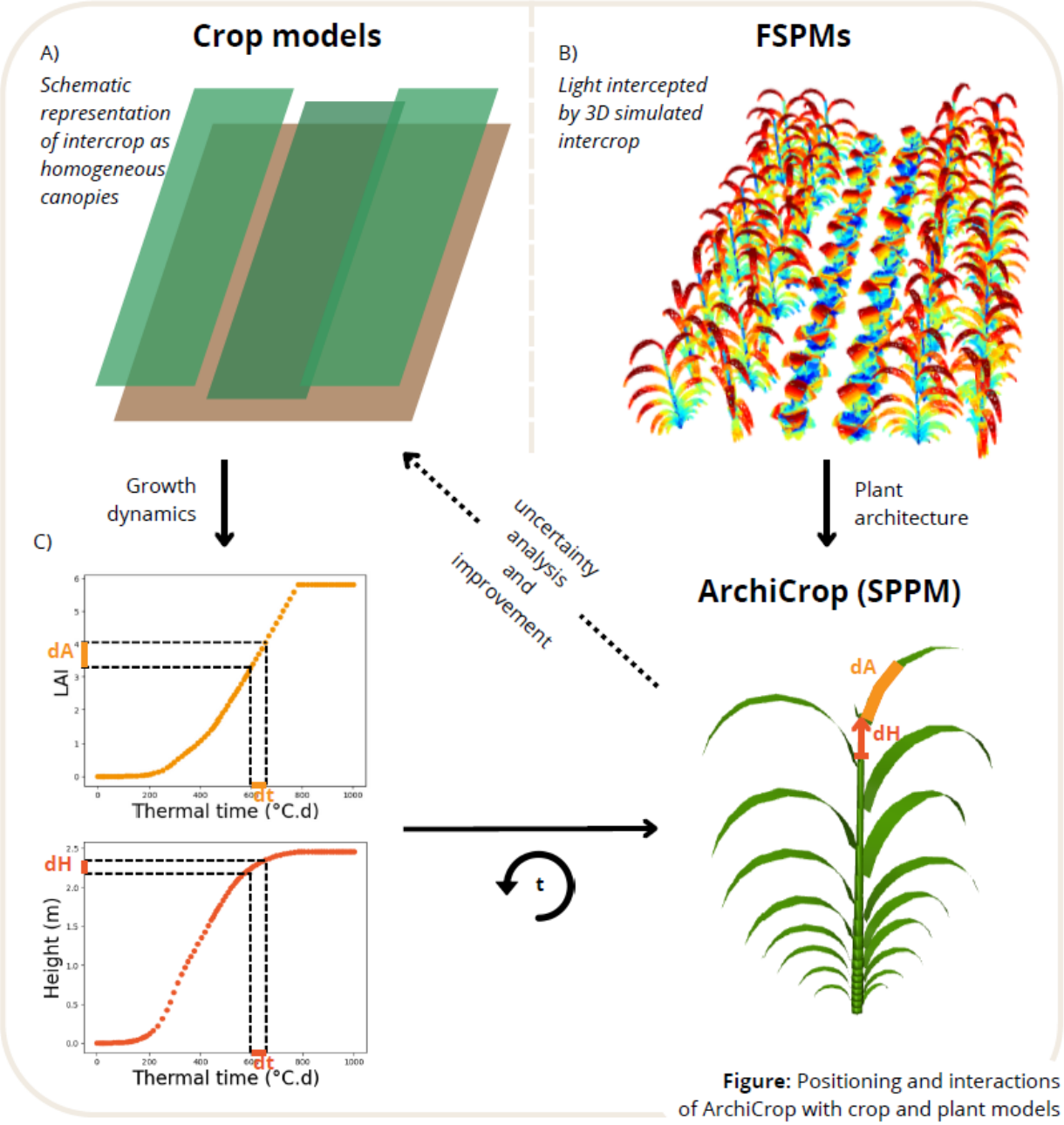

Figure: Positioning and interactions of ArchiCrop with crop and plant models

Using a top-down approach, we developed ArchiCrop, a 3D dynamic parametric model where crop growth is globally constrained, by crop model outputs for example. The explicit consideration of individual plants and organs in ArchiCrop provides degrees of freedom linked to plant architecture (i.e. topology, geometry, development) as well as spatial configuration for intercrops, introducing heterogeneity between plants and organs. The aim is then to simulate ecophysiological processes at this finer scale, and to use this simulation as a reference for evaluating the formalism of the crop model. Our method consists in analyzing the uncertainty of key variables related to the processes (e.g. intercepted radiation for light interception), with respect to architectural traits and spatial configuration. This hybrid multiscale approach could enable to focus on the architectural traits and spatial configurations that could be relevant to explicitly consider in order to improve crop models' accuracy, robustness and genericity, while not increasing the number of parameters. We will apply this approach to STICS crop model, running simulations for sorghum-cowpea intercrop.

Computational methods for hidden semi-Markov models with mixed effects - applications to plant branching models

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Funding	1/2 INRAE (MATHNUM department) + 1/2 Occitanie region

Keywords : Plant growth modelling, Hidden semi Markov Models, GLM(M), Approximated inference, Computational statistic

In the framework of plant development modelling, statistical models can be divided into two categories. The first one, referred to as 'genotype x environment', is based on mixed models, which do not account for time dependencies existing in the considered processes. The second category is based on sequence analysis models that are funded on biological models, but currently do not account for genotype or environmental effects.

More specifically, we are here focused on hidden semi-Markov models, introduced about 20 years ago (Guédon et al., 2001) to model dynamical aspects of plant structure development. These models allow modellers to account for different development phases of either plants or their components (branches, roots, etc) through hidden states. The PhD proposal aims at including fixed and random effects within this category of models, the former aiming at characterising the effects of targeted covariates (genotype and environment) ant the latter, to account for constraints related to experimental design. The work to be accomplished, beyond model specification, is to develop inference algorithms suited to the specific complexity of these models .

Beyond plant developement modelling, the methodological advances obtained in the hidden semi-Markov framework will enrich this family of models and offer new possibilities for addressing scientific questions in various domains of application (health, seismology, reliability, ecology, etc).

Are JSDMs useful to reveal biotic interactions ?

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Funding	projet ANR EDENE

Keywords : JSDMs, biotic interactions, systematic review, validation methods, invaded communities

The Anthropocene has disrupted the natural balance of ecosystems, by habitat destruction and affecting rates of species introduction and extinction. Species newly introduced into ecosystems compete with natives for space and resources, and can also be facilitated by mutualistic interactions with natives or other exotics, or by undermining mutualistic interactions between natives. The decline or extinction of species leads to a breakdown in previously maintained interactions, with cascading effects on other members of the community, who also become vulnerable to extinction. Natural interaction networks are now globally disorganized, as are ecosystem functioning and evolutionary trajectories. Thus, predictive tools are needed more than ever to unravel the nature and potential outcome of interactions.

Joint Species Distribution Models (JSDMs) have recently emerged as a tool improving the species distribution modelling by incorporating multi-species co-occurrence data. A key innovation of JSDMs is the capacity to decompose co-occurrence patterns in residual components after accounting for that of the environment. Species are not considered independently from each other, the model rather jointly models them in view of their responses to the environment and their co-occurrences, and calculates the probability of associations between species two-by-two. JSDMs give therefore insights of ecological or evolutionary processes taking place in the community, like environmental filtering or biotic interactions. Indeed, this method is supposedly useful for revealing the interactions maintained by organisms in a given community. Nevertheless, many authors call for cautious interpretations of the residual associations between species, as they could represent variance induced by unmeasured environmental variables instead. Indeed, inferring biotic interactions from even strong and significant pairwise correlations obtained with a purely statistical approach can be hazardous. Those should rather be considered as interesting clues of biotic interactions, which have to be investigated more thoroughly with relevant cross-validation methods.

In this context, I investigate (1) in which cases JSDMs are used to reveal biotic interactions and (2) whether validation methods are used to support those results. Furthermore, I am interested in the composition of the communities studied and would like to (3) determine whether there is a difference between the study of invaded and non-invaded communities.

To answer these questions, I am conducting a systematic literature review. I have collected and analyzed all articles using JSDMs since 2014. Beyond a geographical and taxonomic description of the communities studied, I seek to understand trends in the use of JSDMs in relation to the study of biotic interactions and the validation methods employed. I would like to identify the best procedures to conduct to reliably approximate interactions while avoiding overinterpretation.

Inter and intra-specific diversity of biomechanicals properties of Amazonian's palm fibers in woodlandscape of french Guiana

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	Julie BOSSU (CNRS)

Funding	ERC STARTING GRANT

Keywords : Palms, Fiber, biomechanical properties, interspecific variability, intraspecific variability, elastic modulus, hygroscopicity, Amazonian landscape, pre-Columbian societies, basketry, tensile test

The Amazon rainforest is a vital ecological zone with exceptional biodiversity shaped by intricate interactions between ecosystems and human societies. Recent research emphasizes the significant influence of pre-Columbian societies on the Amazon's landscape, highlighting their agricultural practices, fire management, and the introduction of beneficial plant species. These activities have contributed to the formation of anthropogenic forests rich in domesticated plants.

Palms are a key component of Amazonian ecosystems, thriving in various forest types and holding cultural and economic significance for local communities. Despite their importance, there is limited understanding of the biomechanical properties of palm fibers, which are crucial for their applications in traditional crafts and construction. Previous studies have primarily focused on the uses of palms without delving into the intrinsic characteristics of the fibers that determine their suitability. Research into the biomechanical properties of palm leaf fibers is essential for assessing their strength, stiffness, and flexibility, which are critical for crafting durable objects. However, variability in these traits among palm species remains largely unexplored. Accurately measuring these properties poses methodological challenges due to factors such as fiber microstructure and moisture content, which significantly influence mechanical properties.

This thesis which is parts of the DOPAMICS project led by Louise Brousseau (IRD), posits that the biomechanical properties of palm leaf fibers exhibit variability at both interspecific and intraspecific levels, reflecting species differences and adaptations to environmental conditions influenced by pre-Columbian societies. Employing rigorous characterization methods will facilitate robust measurements that enhance our understanding of these properties.

This research aims to address knowledge gaps regarding palm fibers within Amazonian ecosystems by exploring historical human interactions that have shaped their biomechanical traits. The findings may contribute to sustainable resource management practices that respect indigenous knowledge while promoting ecological conservation. The presentation will outline significant developments from the first year of research and future experimental plans.

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Hollistic modeling of ecosystem services in social-ecological systems

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Funding	Eco2adapt

Keywords : ecosystem service, social-ecological system, network modeling, forest resilience

Forest landscapes are complex social-ecological systems with diverse social or natural components and interactions involving biological, economic and social-cultural processes. They support large human populations and a variety of social, economic or recreational activities, by which they provide many ecosystem services. In the context of global change and increasing local disturbances (e.g. droughts, fires), it is crucial to understand the resilience of these landscapes and to predict the responses of the associated ecosystem services under different management scenarios. Modeling is a key tool for understanding such dynamics, and network-based models have become popular due to their holistic approach, which is especially essential for complex systems. This PhD project will investigate the network-based model DORIAN first developed by AMAP colleagues, which represents social-ecological systems as networks of discrete nodes (components) and edges (interactions). DORIAN is fed on literature knowledge, social data and expert opinions acquired from interviews and questionnaires. This model will be tested in several selected Living Labs of the ongoing project eco2adapt, including European and Chinese forest social-ecological systems. To conclude, this project aims to standardize the use of discrete modeling for forest ecosystem services and to predict the impacts of different risks and forest management strategies on the provision of ecosystem services.