AMAP PhD +

JOURNÉE DES DOCTORANTS, POSTS-DOCTORANTS ET NON PERMANENTS DE L'UMR AMAP

EDITION 2019

AMAPhD +

JOURNÉE DES DOCTORANTS, POSTS-DOCTORANTS ET NON PERMANENTS DE L'UMR AMAP ÉDITION 2019

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REMERCIEMENTS

L' équipe organisatrice remercie la direction d'AMAP, Rémi Knaff, Valérie Roinel, Noémie Cauquil, Nathalie Hodebert, les tutelles du laboratoire AMAP ainsi que l'ensemble des participant·e·s à cette journée

6 Programme

12 Gislain II Mofack
Isolation manuelle des arbres individuels des nuages de point LiDAR et validation des algorithmes de segmentation automatique

14 Claudia Milena Huertas Garcia
Contributions of multitemporal lidar to the characterization of turnover in tropical forests

16 Anthony Laybros
Identification d'espèces d'arbres d'intérêt en forêt tropicale par utilisation de données LiDAR et hyperspectrale

18 Camille Girard-Tercieux
Role of intraspecific variability in species coexistence in tropical forests

20 Corentin Dupont
Visual and olfactory communication in the Asian hornet: study of selective cues in attractive carnivorous plants

22 Boris Flotterer
Dynamique naturelle et aménagement durable de la forêt boréale : apports des modèles discrets pour caractériser les trajectoires

24 Maximilien Cosme
Discrete modelling of ecosystem dynamics: West-African savannas as a case study

26 Dimitri Justeau-Allaire
Systematic conservation planning for sustainable land-use policies: A constrained partitioning approach to reserve selection and design

28 Raphaël Conde Salazar
An ontological approach to data management in agroforestry

30 Lee Sue Han
Deep learning approach for plant diseases identification

32 Quangqi Zhang
Linking structural traits, non-structural carbohydrate and tree ecological strategies in different climates

34 Sébastien Levionnois
Diversity of the vascular and hydraulic architecture of the leafy shoot of tropical trees in French Guiana

36 Innocent Adji Beda
Développement architecturale et modélisation de la croissance de trois espèces forestières indigènes savanicoles : appliquée à la mise en place d'essais de provenances le long d'un gradient bioclimatique du Centre-ouest au Nord de la Côte d'Ivoire

38 Ahmed Mahmood
Biodiversity assessment and conservation needs in Kurdistan region of Iraq: the study case of wild and edible leeks, garlics and onions (genus Al-lium)

40 Daniel Hernández Cáceres
Disentangling the key drivers of mountain soil microbial taxonomic and functional diversity along an altitudinal gradient

42 Olivier Martin
Convergence of tree architecture with increasing canopy position. An approach from terrestrial laser scanning in central Africa

44 Grégoire BLANCHARD
Extintion-immigration lag behind environmental filtering in shaping taxonomic and functional composition of tropical dry forest in a changing landscape

46 Nereyda Nathalie Cruz Maldonado
Adaptation des plantes d'altitude au réchauffement climatique: comparaison entre des régions alpines tempérée (France) et tropicale (Mexique)

48 Fidèle Evouna Ondo
Exploring the evolutionary history of Gabonese savannas using termites

50 Alessandro Fraccica
Hydro-chemo-mechanical multi-scale soil-roots interactions

52 Le Bienfaiteur Sagang Takougoum
Linking vegetation structure and composition to past dynamics in forest savanna transitions

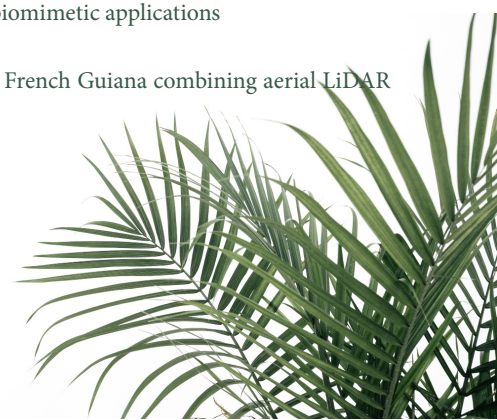
54 Camille Salmon
The adaptive significance of monocarpy in woody perennial plants : investigations around the genus Cerbceriopsis

56 Stéphane Momo
Weighing trees with lasers: what about wood density and life-traits strategies?

58 Pierre Ploton
Evaluating the potential of MODIS and environmental data for the interpolation of tropical forest AGB in large-scale studies

60 Tom Hattermann
Plant secretory tissues and their exudates from forests of French Guiana: their functional roles, ecological significance and biomimetic applications

62 Mélaine Aubry-Kientz
Tree crown delineation in a tropical forest in French Guiana combining aerial LiDAR and multispectral data



PROGRAMME

10 OCT. 2019

9h	Cérémonie d'ouverture
9h15	Gislain Mofack Isolation manuelle des arbres individuels des nuages de point LiDAR et validation des algorithmes de segmentation automatique
9h45	Claudia Milena Huertas Garcia Contributions of multitemporal Lidar to the characterization of turnover in Tropical Forests
10h15	Anthony Laybros Identification d'espèces d'arbres d'intérêt en forêt tropicale par utilisation de données LiDAR et hyperspectrale
10h45	Pause café
11h	Camille Girard-Tercieux Role of intraspecific variability in species coexistence in tropical forests
11h30	Corentin Dupont Visual and olfactory communication in the Asian hornet: study of selective cues in attractive carnivorous plants
12h00	Boris Flotterer Dynamique naturelle et aménagement durable de la forêt boréale : apports des modèles discrets pour caractériser les trajectoires
12h30	Déjeuner

14h — Présentation des nouveaux doctorants

Souhaitons leur bonne chance

14h30 — Maximilien Cosme

Discrete modelling of ecosystem dynamics: West-African savannas as a case study

15h — Dimitri Justeau-Allaire

Systematic conservation planning for sustainable land-use policies: A constrained partitioning approach to reserve selection and design

15h30 — Raphaël Conde Salazar

An ontological approach to data management in agroforestry

16h — Pause café

16h15 — Lee Sue Han

Deep learning approach for plant diseases identification

16h45 — Quangqi Zhang

Linking structural traits, non-structural carbohydrate and tree ecological strategies in different climates

17h15 — Sébastien Levionnois

Diversity of the vascular and hydraulic architecture of the leafy shoot of tropical trees in French Guiana

17h45 — Social event - AMAPéro - Ice breaker

NOTES

NOTES

Après le succès de la saison 2018, voici la monture 2019 du livret AMAPhD+ qui restitue sous forme de résumés les travaux de recherche des doctorants et post-doctorants d'AMAP. Cet événement reste un marqueur fort de la vie scientifique de l'unité. Il est un moment privilégié d'échanges entre les étudiants et les chercheurs, jeunes et moins jeunes, sur des thématiques très diversifiées. La lecture du programme met déjà en évidence le caractère interdisciplinaire des travaux et leur forte valence tropicale. Les mots-clefs arbre, forêt, biodiversité, changements climatiques, télédétection, modélisation donnent une parfaite image des approches et enjeux de notre projet de recherche, même s'ils ne sont pas exclusifs.

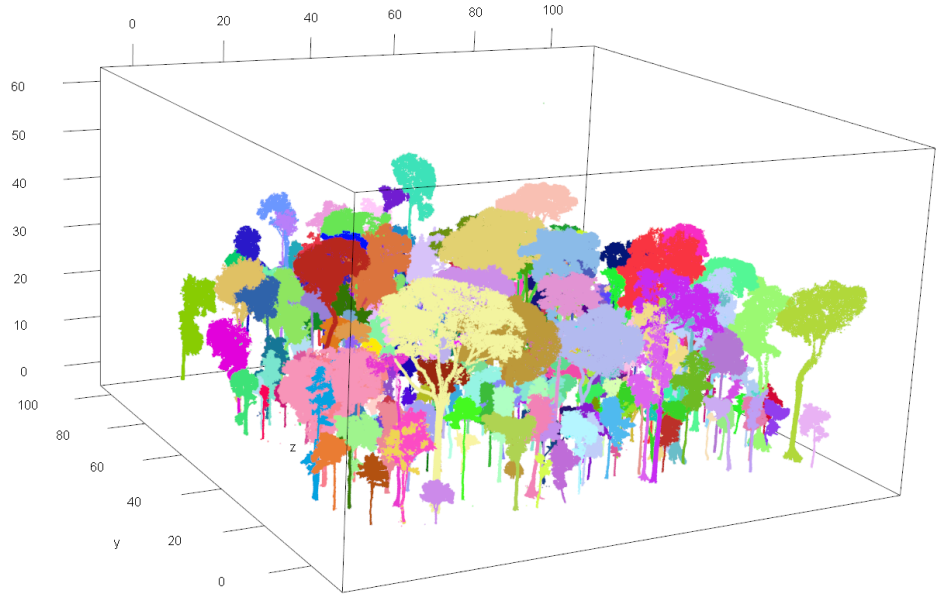
Au-delà de l'événement scientifique, AMAPhD reste un moment de partage et de convivialité mettant les relations humaines au cœur de nos valeurs. La direction d'unité remercie donc vivement les organisateurs et les participants, sans oublier les personnes ayant contribué aux aspects logistiques, pour leur implication et le succès (anticipé !) de cette journée.

La Direction d'Unité

Thierry FOURCAUD et Raphaël PELISSIER

Résultat d'une isolation des individus contenus dans un nuage de point pour une parcelle d'1 ha de forêt. En a) nous avons le résultat d'une isolation manuelle sur un jeu de donnée LiDAR-T et en b) le résultat d'une isolation faite à partir de l'algorithme de segmentation automatique AMS3D appliqué sur un jeu de donnée obtenu à partir d'un drone.

a)



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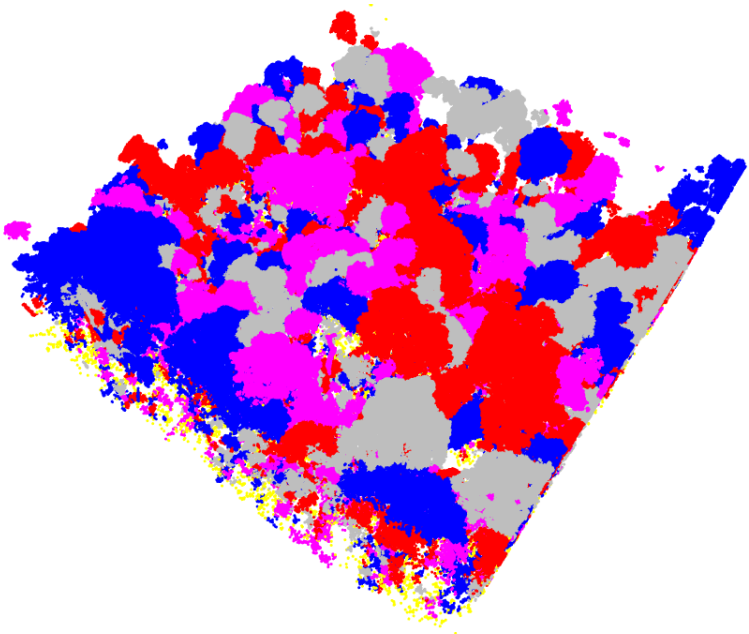

Isolation manuelle des arbres individuels des nuages de point LiDAR et validation des algorithmes de segmentation automatique

Presenter: MOFACK Gislain II
Email: mgislain2@yahoo.fr
Scientist Supervisor: Nicolas BARBIER, UMR AMAP, Montpellier, France.

Des études récentes ont démontré le potentiel des méthodes dérivées du lidar dans l'écologie végétale et la foresterie. L'une des limites de ces méthodes est l'accès au contenu d'information des nuages de points à partir desquels les mesures à l'échelle des arbres peuvent être récupérées. Ceci est actuellement entrepris par la segmentation manuelle laborieuse et chronophage des nuages de point sur des vastes étendues de forêt, un effort qui est impraticable à travers des milliers de tiges.

L'objectif de cette étude est d'évaluer la qualité des reconstructions automatiques obtenues par l'algorithme AMS3D sur une superficie donnée.
Pour ce faire, nous avons effectué d'une part un travail d'extraction manuelle sur une centaine d'arbres dans des parcelles inventoriées et scannées au LiDAR terrestre. Ces arbres isolés servent ainsi de référence pour effectuer une validation croisée des résultats obtenus à partir de l'algorithme d'AMS3D appliqué aux données drone obtenus sur la même parcelle. Les parcelles sont localisées dans la forêt de Bouamir (forêt tropicale non pertubée) situé à l'Ouest de la réserve forestière du Dja; région de l'Est Cameroun.

La validation de cet algorithme permettra son application sur des dizaines ou des centaines de parcelles, et par conséquent l'extraction de centaines ou de milliers de couronnes d'arbres, avec une bonne estimation de l'erreur associée à ces résultats.

Ce procédé permet ainsi un accès rapide aux informations à l'échelle des couronnes des arbres contenues dans les nuages de point lidar. Ces résultats pourront contribuer à la validation des méthodes dérivées du lidar et des applications allant de l'estimation des stocks de carbone jusqu'à la description de la forme et de la fonction des plantes.

Keywords: LiDAR; isolation; écologie; foresterie; algorithme; nuage de points

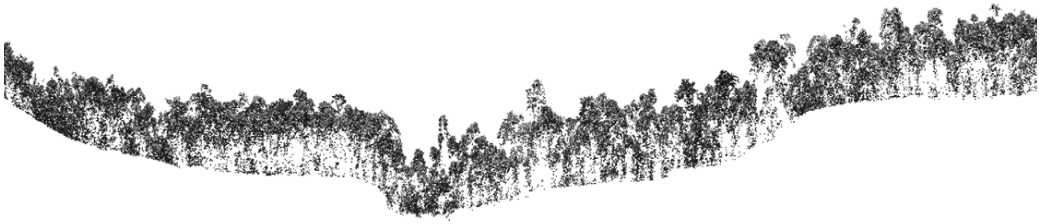

Figure 1. LiDAR point cloud profile of the site Nouragues 2016

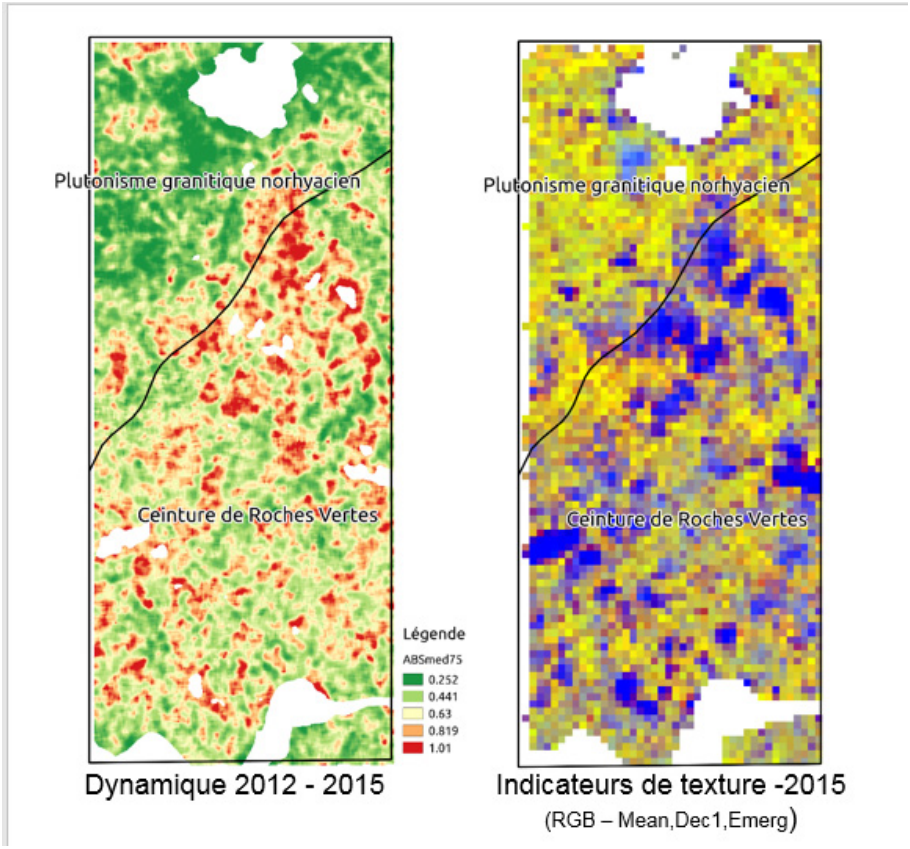

Figure 2. Visual comparison between indicators derived from the Lidar surface models against the dynamic indicators obtained by the DynforDiv project ((Sabatier, Guitet, et Vincent 2017)) in two geologically distinct units of the Nouragues site.

Contributions of multitemporal Lidar to the characterization of turnover in Tropical Forests

Presenter: Claudia Milena HUERTAS GARCIA

Email: clauhuertas@gmail.com

Scientist Supervisor: Grégoire Vincent, UMR AMAP, Montpellier, France.
Raphaël Pélissier, UMR AMAP, Montpellier, France.

Large-scale mapping of vegetation, characterized by repeated Airborne Laser Scanning (ALS - Lidar), should significantly improve our ability to model forest turnover. Furthermore, it has improved decrease the uncertainty of global models of forest carbon stocks and flows in tropical forests. This thesis aims to contribute to a better understanding of forest dynamics at different scales (from individuals through populations and up to landscape level analysis).

In the first place, we study different methods to model the relationship between canopy and stand dynamics (mortality and recruiting) to link canopy dynamics with carbon fluxes and reconsider the current interpretation of forest turnover and its impact on stand composition in the Amazon forests, based on permanent plot data.

Second, we explore the relationship between forest dynamics and environmental factors using multi-temporal data from the airborne LiDAR and ancillary information. We test the hypothesis presented in the results of DynForDiv project (Sabatier, Guitet, et Vincent 2017) that revealed the existence of spatial patterns in forest dynamics at the landscape and regional scales that are strongly contrasted and closely associated with geology, geomorphology and topography.

Finally, this project aims to develop a morpho-dynamic typology of Guyanese forests in terms of dynamics and structure. The relevance of this typology will be assessed on two levels: on the one hand as a predictor of the organization of diversity (taxonomic and functional), and thus a key for biodiversity mapping, and on the other for the mapping of carbon flows.

Cited references:

Sabatier, Daniel, Stéphane Guitet, et Grégoire Vincent. 2017. « Forçages environnementaux et anthropiques du turnover forestier, conséquences sur la diversité des communautés d'arbres en forêt tropicale ».

Keywords: Canopy turnover; forest dynamics; Airborne Lidar; modeling; tropical forests; mortality

Identification d'espèces d'arbres d'intérêt en forêt tropicale par utilisation de données LiDAR et hyperspectrale

Presenter: Laybros Anthony
Email: anthony.laybros@onf.fr
Scientist Supervisor: Grégoire Vincent, UMR AMAP, Montpellier, France.

L'identification et la cartographie des espèces végétales à large échelle est un enjeu pour l'exploitation raisonnée et raisonnable des forêts tropicales. Nous évaluons le potentiel de données hyperspectrales et de données LiDAR acquises par avion, pour identifier des espèces d'intérêt commercial dans un contexte de méga-biodiversité sur le site de Paracou en Guyane Française.
Nous utilisons un inventaire botanique où chaque tronc est identifié au sol ainsi qu'un inventaire partiel des couronnes délimitées sur des images de très haute résolution. Les houppiers des arbres de canopée sont délimités grâce aux données lidar.

D'une part, nous évaluons comment la précision de classification individuelle d'espèce évolue en augmentant progressivement le nombre d'espèces considérées. En effet, nous rendons progressivement le problème d'identification d'espèce cible plus complexe par l'ajout de nouvelle espèce. D'autre part, nous comparons 3 types de méthodes de classification (machine learning).

La création d'objet par la segmentation LiDAR permet de raffiner la classification faite à l'échelle pixel en une classification objet. Habituellement, le vote à la majorité permet de définir la classe d'attribution. Ici, nous avons reconsidéré l'approche par vote majoritaire, en redéfinissant un seuil optimal pour chacune des espèces.

L'ensemble de cette méthodologie permet de connaitre le potentiel de l'imagerie hyperspectral pour l'identification d'espèces cibles en forêt tropicale par des méthodes de machine learning couramment utilisées.

Keywords: Hyperspectral ; LiDAR ; identification des espèces ; forêt tropicale

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11. IPBES, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem, Bonn, Germany, 2016, p. 32.

Role of intraspecific variability in species coexistence in tropical forests

Presenter: Camille Girard-Tercieux
Email: camillegirardtercieux@gmail.com
Scientist Supervisor: Raphaël Pélissier, Isabelle Maréchaux & Ghislain Vieilledent, UMR AMAP, Montpellier, France.

Context and issues :In an hectare of tropical forest, it is possible to encounter several hundreds different tree species. Understanding how such diverse species competing together can coexist locally remains one of the oldest and most crucial questions in ecology [1,2]. Different mechanisms contributing to maintaining this diversity within communities have been identified [3-5]. However, studies have so far largely neglected intraspecific variability, although the latter can account for a large part of the variability among individuals within a community [6]. Intraspecific variability is often supposed to contribute to the coexistence of species, but such an effect and the mechanisms underlying it remain unclear and discussed [7,8].

Scientific objectives :This thesis aims at contributing to a better understanding of the role of intraspecific variability on species coexistence within tropical trees communities using different modelling approachs. The main objective is to test different hypotheses about the effect of intraspecific variability on species coexistence in tropical forests, using two differently constructed forest dynamics models, TWOE and TROLL. TWOE is a demographic model [9] simulating growth, recruitment and mortality processes while integrating competition for resources. TROLL is a mechanistic model [10] simulating resource acquisition and utilisation processes (e.g. photosynthesis, respiration, evapotranspiration) using a parameterisation based on functional traits. The comparison of these models will allow to highlight and discuss structural incertitude in biodiversity analysis and predictions [11]. More specifically, this will involve to (i) synthesise the different hypotheses found in literature about the role of intraspecific variability on species coexistence, and more generally about coexistence mechanisms ; (ii) integrate intraspecific variability in each model and calibrate them with the database of Paracou, French Guiana ; (iii) establish a simulation design to test the hypotheses highlighted in (i) ; (iv) compare the results obtained with the two models.

Keywords: Biodiversity ; Tree communities ; Demography ; Functional traits ; French Guiana

Visual and olfactory communication in the Asian hornet: study of selective cues in attractive carnivorous plants

Presenter: Corentin Dupont
Email: corentin.dupont@cirad.fr
Scientist Supervisor: Laurence Gaume UMR AMAP, Montpellier, France.

The pollinator decline threatens agriculture, plant biodiversity and food safety. Consequence of increased trades and climate change, the Asian hornet, Vespa velutina, is an invasive alien species, which rapidly spreads in Europe and jeopardizes honeybee populations, Apis mellifera, and their pollination services. However, eradication campaigns are inefficient and harmful to biodiversity, calling for the development of traps with a selective bait. While no insect-based pheromonal trap has yet emerged from ongoing research, the thesis is part of a project, which proposes to draw inspiration from a plant, which naturally traps the hornet. The project aims at identifying the visual and olfactory cues of carnivorous plants of the genus Sarracenia observed to trap the Asian hornet but not the honeybee, to quantify their attractiveness and to identify the selective cues, with the aim of developing a specific biomimetic trap for the hornet. The thesis will focus on the search of selective cues that will be identified and tested first in laboratory and ultimately in the field. It will be supported by a consortium involving researchers specialized in carnivorous plants, hornets and bees, as well as advanced and complementary skills in ecology of plant-insect interactions, volatile compounds chemistry, spectral signature, vision modelling and electrophysiology, all necessary to identify the sensory cues, which will specifically attract the hornet.]

Keywords: Plant-insect communication; invasive species; behavioral ecology; Sarracenia; Vespa velutina; Apis mellifera

Projet de thèse : Dynamique naturelle et aménagement durable de la forêt boréale : apports des modèles discrets pour caractériser les trajectoires

Presenter: Boris Flotterer

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Scientist Supervisor: Christelle Hélly-Alleaume, UMR ISEM, Montelier, France.
Cédric Gaucherel, UMR AMAP, Montpellier, France.

La forêt boréale représente un tiers de la couverture forestière de la planète, soit 400 millions d'hectares. Elle constitue l'un des plus grands réservoirs terrestres de carbone et participe donc à l'équilibre climatique de la planète. Depuis la fin de la dernière glaciation, les deux perturbations qui régissent sa dynamique naturelle sont les incendies et les invasions d'insectes, mais à celles-ci vient s'ajouter, de manière significative depuis un siècle environ, la coupe forestière. Au cours des derniers milliers d'années les changements climatiques ont induit des changements significatifs dans le régime des feux (fréquences et surfaces) et pourtant les quelques espèces qui constituent la forêt boréale se sont maintenues grâce à des stratégies de régénération très efficaces. C'est en se basant sur l'impact des perturbations naturelles que l'aménagement forestier durable au Canada se fonde depuis deux décennies environ. Le projet de thèse consiste donc à définir, puis implémenter, un modèle d'écosystèmes intégrateur et qualitatif qui permettra d'étudier les forêts boréales canadiennes dans un premier temps. Ce modèle se basera sur les Graph Transformation, un outil en science de l'informatique encore peu utilisé en biologie et qui permet l'intégration d'un grand nombre de variables. Une première étape consistera à élaborer un modèle de « forêt boréale » générique, qui sera inspiré des dynamiques naturelles passées depuis les derniers 8000 ans environ, date de la fin de la déglaciation dans l'Est du Canada. Les trajectoires obtenues par le modèle seront analysées et appréciées par comparaison avec des reconstructions paléoécologiques (composition végétale, incendies...). Une seconde étape consistera à décliner ce modèle générique dans le cadre des changements globaux en plusieurs cas d'étude contrastés, naturels ou aménagés, en intégrant donc de nouvelles composantes et processus en lien avec différents aménagements. Il s'agira alors d'analyser l'ensemble de toutes les trajectoires (et processus associés) afin d'identifier celles permettant de conserver les états stables ou de provoquer le collapse de la forêt. Nous serons en effet particulièrement sensibles aux questions de stabilité (e.g. résilience) et de changements catastrophiques (tipping points) de ces écosystèmes forestiers.

Keywords: Changement Global, gestion forestière, processus, socio-économie, modélisation, perturbations, Graph Transformation.

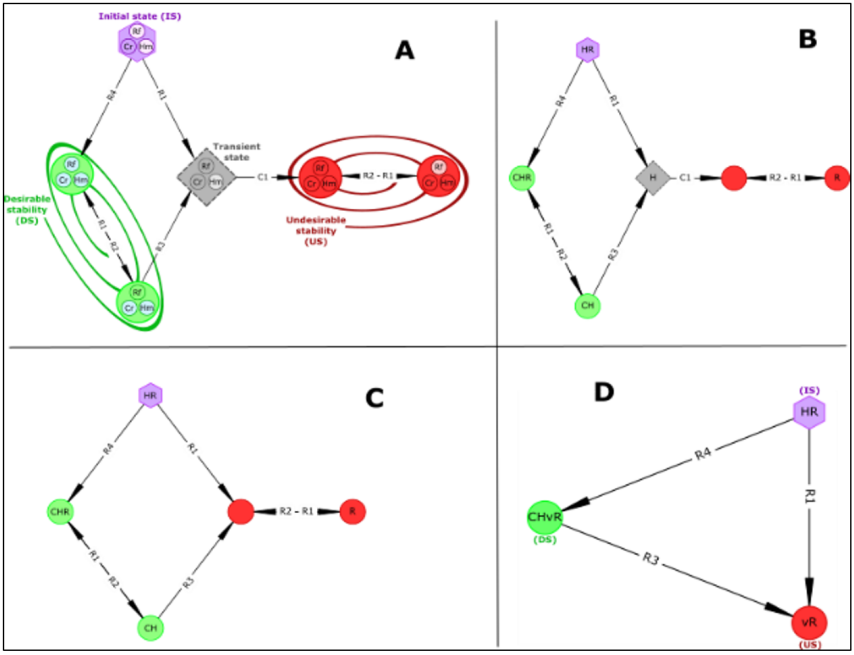

Fig. 1.

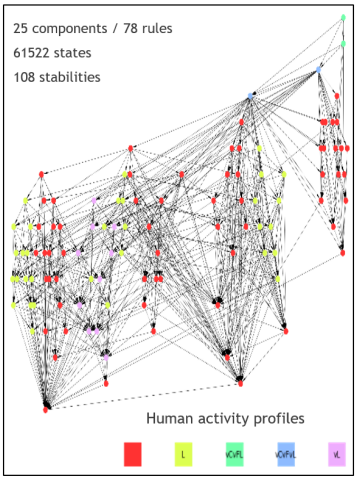

Fig. 2. Compact-merged state space of a West-African village model. Starting from an agro-pastoral savanna profile, the system may shift into different regimes, from human activities are resilient to disturbances to undesirable regimes where humans can no longer establish. Between these extrema, the system can cross many transient regimes where human population may locally switch from agricultural to pastoral livelihood, or the opposite.

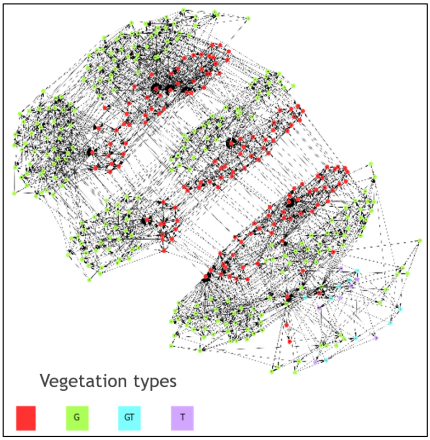

Fig. 3. Aggregation of the states in the same vegetation type and reversibly connected. Each node of the same color is a subset of strongly connected states sharing the same vegetation. Green (G): grassland; Blue (GT): tree-grass coexistence (i.e. savanna); Purple (T): trees (i.e. woodland); Red (nothing): bare soil. As a first interpretation, we see that savanna and woodland states are more connected (gathered in a few stabilities) to each other than are grassland or bare soil states.

Discrete modelling of ecosystem dynamics: West-African savannas as a case study

Presenter: Maximilien Cosme
Email: maximilien.cosme@cirad.fr
Scientist Supervisor: Cédric Gaucherel, UMR AMAP, Montpellier, France

Ecosystem are dynamical entities, continuously reconfiguring themselves according to their past and current state and external pressures. They have become subject of major concern in the recent past due to the increasing habitat degradation and subsequent changes in livelihoods. For instance, some regions in Africa currently undergo drastic modifications in their social and ecological structure and functioning. Experts have proposed many factors driving these transformations, from the very local to the global scale, from the short to the long term.

Using a discrete modelling approach, my thesis is about integrating these spatio-temporal scales and the diversity of social-ecological processes in a unifying qualitative modelling framework. I will present some early results on village dynamics, and some at the sub-catchment scale. I will discuss how these results may become the building blocks of a multiscale picture (or rather a movie) of a West-African savanna system.

Fig. 1. Illustration of the various outputs (called state space) with a toy model. Ecosystem components are Rf or R: Rainfall, Cr or C: Crops and Hm or H: Humans. R1-R4 and C1 are the rules, representing the transitions in the system state. A: Schematic view of a state space; B: full state space, including unrealistic states. Node labels represent the components present in one state; C: compact state space (i.e. without unrealistic states); D: compact-merged state space, where subset of reversibly connected states are aggregated in one node (called a stability). Letters preceded by a "v" indicate that this component is varying. Node colors represent the stabilities and initial state. The system converges toward an attractor (red) where humans are no longer present.

Keywords: Savanna dynamics; social-ecological systems; discrete modelling; trajectory analysis; multiscale.

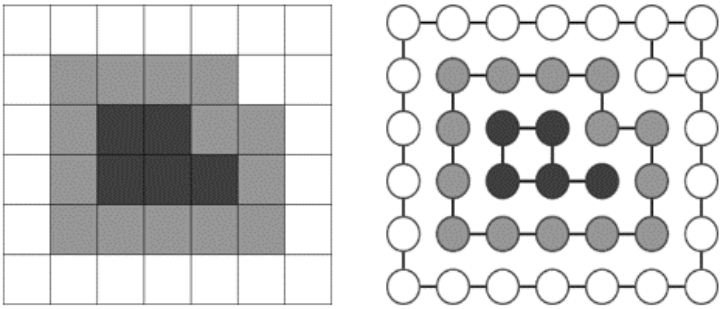

Figure 1: Space partitioning example and its associated graph representation, on a four-connected regular square grid tessellation.

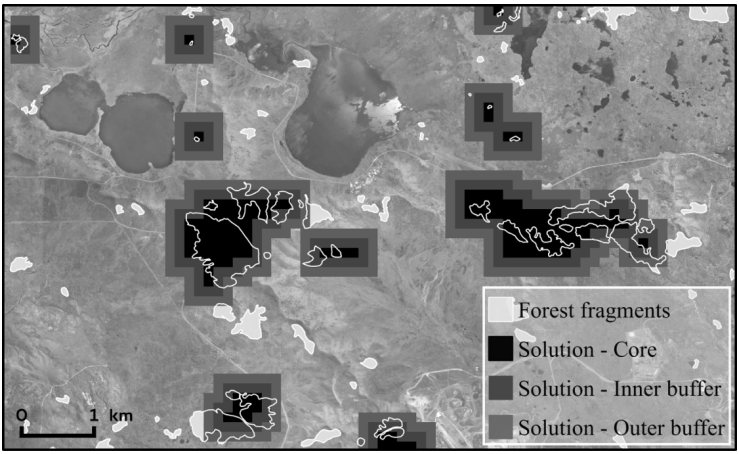

Figure 2: Output of a scenario from the use case of IJCAI 2019's paper.

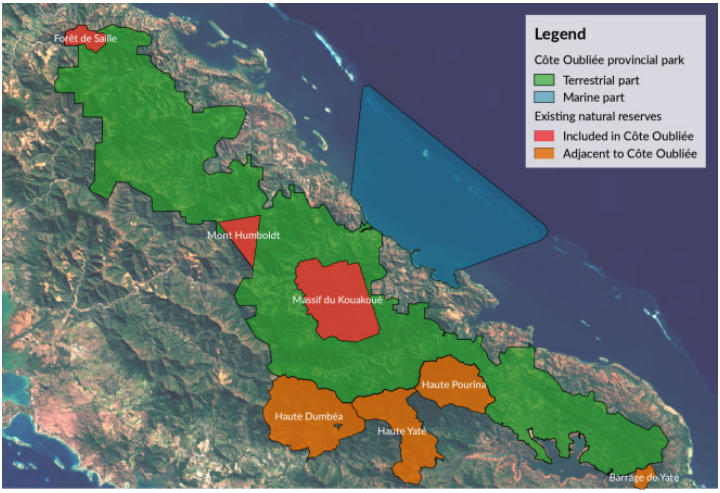

Figure 3: The "Côte Oubliée" provincial park.

Systematic Conservation Planning for Sustainable Land-use Policies: A Constrained Partitioning Approach to Reserve Selection and Design

Presenter: Dimitri Justeau-Allaire

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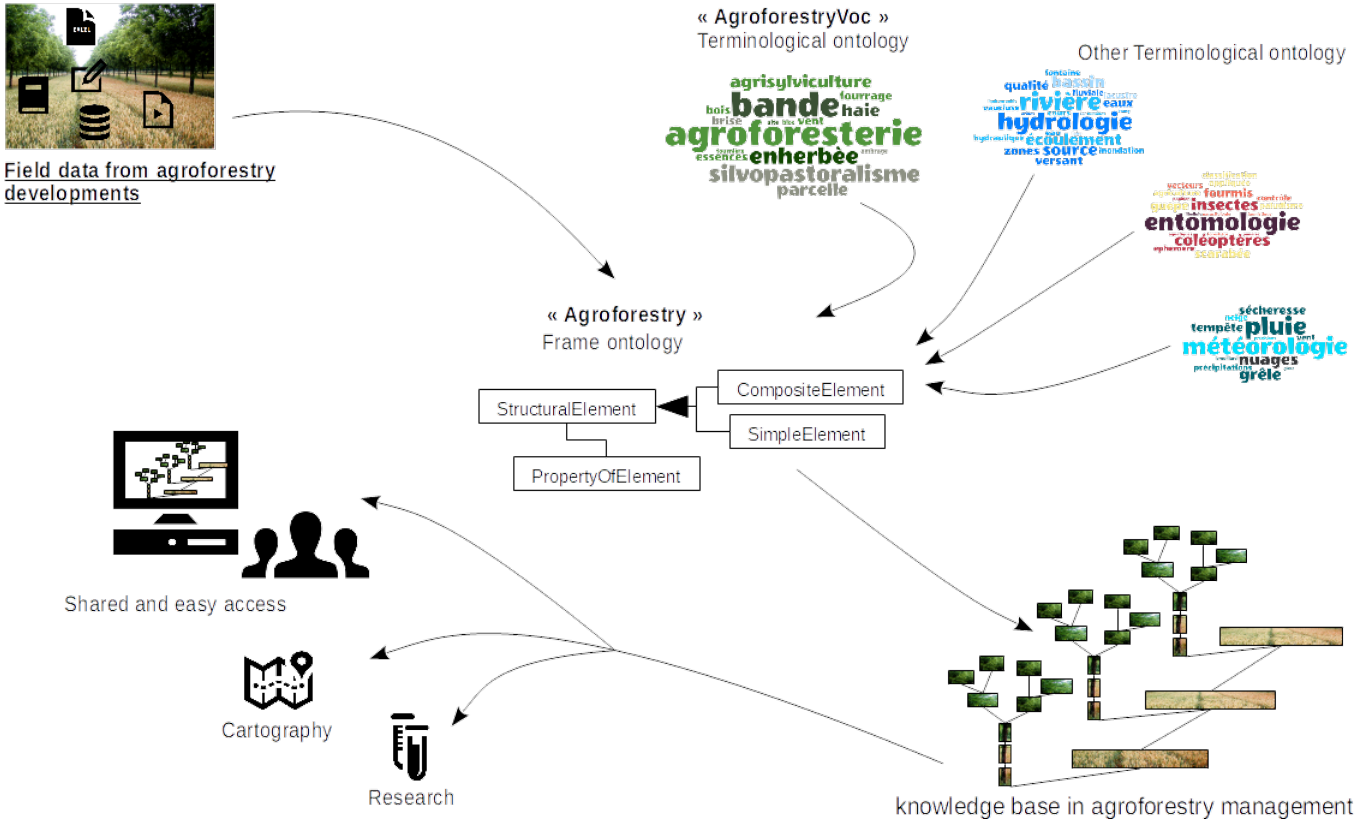
Scientist Supervisor: Xavier Lorca (IMT Mines Albi, ORKID) and Philippe Birnbaum (Cirad, AMAP)

Habitat degradation, fragmentation, and destruction are today the leading causes of species extinction on Earth. A major challenge for environmental managers is to implement sustainable land use policies promoting socioeconomic development and natural habitat conservation in a balanced way. In New Caledonia, the smallest biodiversity hotspot in the world, finding this trade-off is tedious. In particular, the conservation of its highly diverse forest ecosystems, distinguished by high rates of endemism, can be conflicting with mining activity, the major economic sector of New Caledonia. Relying on artificial intelligence and operational research, reserve selection and design models can be of assistance. In a paper published at IJCAI 2019 (the 28th International Joint Conference on Artificial Intelligence), we introduced a partitioning approach based on Constraint Programming (CP) for the reserve selection and design problem, dealing with both coverage and complex spatial constraints. Moreover, this paper introduced the first CP formulation of the buffer zone constraint, which can be reused to compose more complex spatial constraints. This approach has been evaluated in a real-world dataset addressing the problem of forest fragmentation in New Caledonia, and we are now collaborating with the South Province of New Caledonia on the "Côte Oubliée" project to provide decision support. This project was started in 2016 by the environmental managers of the South Province of New Caledonia. It aims at delineating a complex reserve system (about 930km² of terrestrial area and 270km² of marine area) in the southeast of New Caledonia in an area where an exceptional biodiversity is conflicting with different socioeconomic interests (e.g. 238 mining concessions, private and cultural lands, fisheries).

Keywords: Systematic conservation planning; Artificial Intelligence; Constraint Programming; New Caledonia; Côte Oubliée; Decision support



Schematic diagram of ontology-based modelling for agroforestry management

AMAP HD

An ontological approach to data management in agroforestry

Presenter: CONDE SALAZAR Raphaël
Email: raphael.conde_salazar@cirad.fr
Scientist Supervisor: MOUGENOT Isabelle, UMR ESPACE-DEV, Montpellier, France
STOKES Alexia, UMR AMAP, Montpellier, France.

Data from field observations acquired in partnership with several categories of actors (foresters, farmers, breeders, etc.) as part of agroforestry experiments have been accumulating for many years now. The management and reuse of this data is made difficult by the multiplicity of media and formats used and by the diversity of the actors and their language. In addition, agroforestry studies require systemic approaches to better understand, for example, agroforestry operations' response mechanisms to climate change, pests and soil pollution. This implies linking up with other fields of knowledge such as climatology, zoology or pedology.

To help the agroforestry community in the exploitation and sharing of their data, in order to report on the evolution and effectiveness of the developments they have carried out, we propose as a first objective, to set up a knowledge model (an ontology) dedicated to agroforestry. This ontology will serve as the basis for capitalizing and sharing data in agroforestry.

A second objective is to link agroforestry data with other data sets in other knowledge areas such as the environment and territories. For example, an agroforester manager should be able to easily compare the selling price of standing timber in his region for different tree species that he would be likely to plant on his agroforestry plot.

The dual challenge of sharing and interconnecting data in agroforestry brings us closer to what is currently practiced within the "semantic web" with different tools and methods to promote the sharing of open and linked data sources. Semantic web technologies provide standard procedures for describing and accessing resources on the web. The linked data is exploited and enriched by technologies such as RDF, SPARQL, OWL and SKOS. We reuse semantic web standards and exploit a range of terminological ontologies to provide an open and flexible knowledge model that can reflect the complexity of data already collected in agroforestry. This new model will be able to connect to other knowledge models already present on the Web. Agroforestry expertise linked to other expert areas on the web will facilitate the creation of decision support tools and thus provide new solutions to agroforestry practice.

Keywords: Agroforestry, ontology, semantic web.

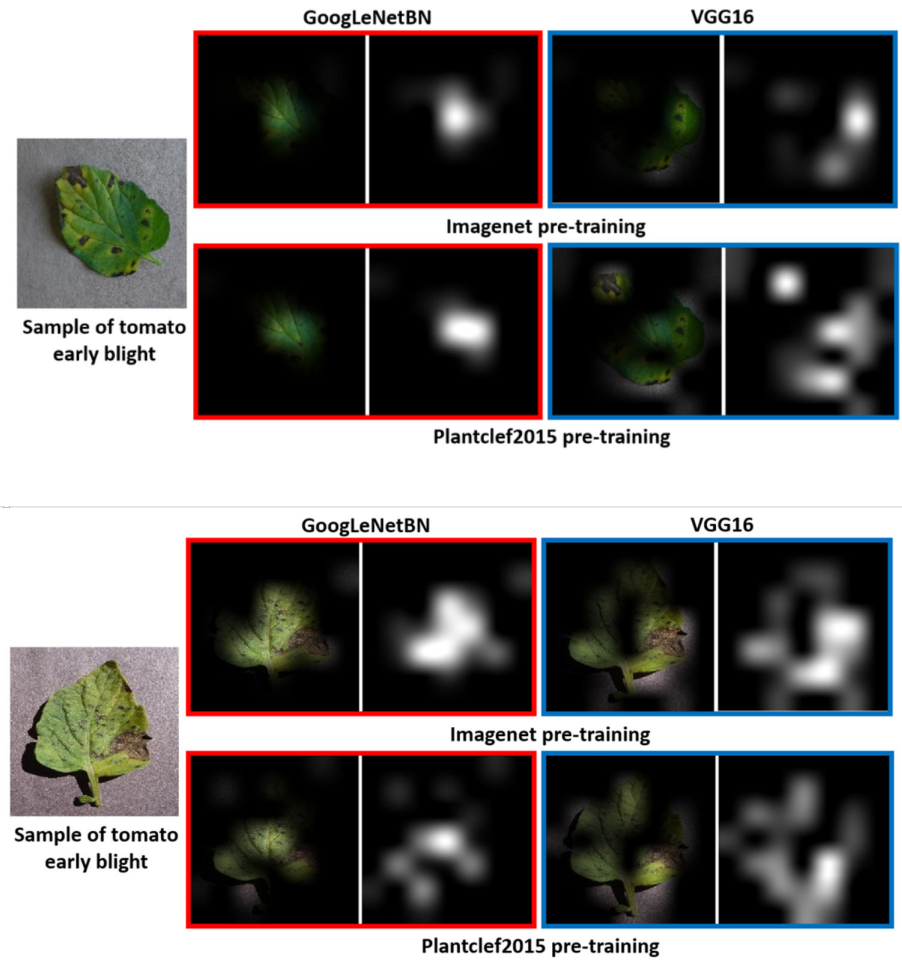


Fig 1: Visualization of the attention maps of the GoogLeNetBN and VGG16 for the PlantVillage sample. The upper and lower row images are the output visualization of the model pre-trained with ImageNet and PlantCLEF2015 respectively.

Deep Learning Approach for Plant diseases identification

Presenter: Lee Sue Han

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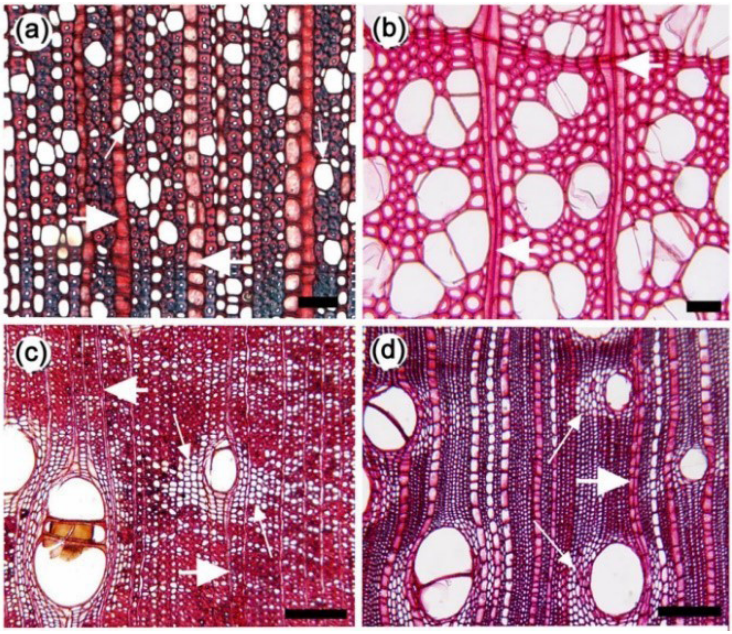
Scientist Supervisor: Pierre Bonnet, CIRAD UMR AMAP, Montpellier, France.

The control of plant diseases is a major challenge to ensure global food security and sustainable agriculture. Several recent studies have proposed to improve existing procedures for early detection of plant diseases through modern automatic image recognition systems based on deep learning. In this article, we study these methods in detail, especially those based on convolutional neural networks. We first examine whether it is more relevant to fine-tune a pre-trained model on a plant identification task rather than a general object recognition task. In particular, we show, through visualization techniques, that the characteristics learned differ according to the approach adopted and that they do not necessarily focus on the part affected by the disease. Therefore, we introduce a more intuitive method that considers diseases independently of crops, and we show that it is more effective than the classic crop-disease pair approach, especially when dealing with disease involving crops that are not illustrated in the learning database. This finding therefore encourages future research to rethink the current de facto paradigm of crop disease categorization.

Keywords: Plant diseases, automated visual crops analysis, deep learning, transfer learning


(a)
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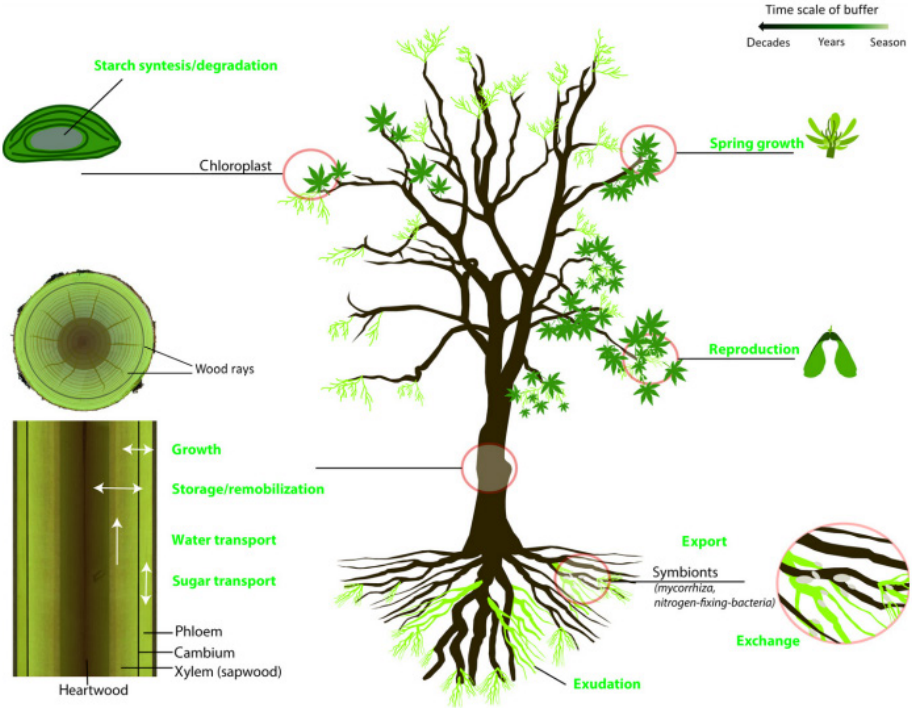
Time scale of buffer
Decades
Years
Season
Starch syntesis/degradation
Chloroplast
Spring growth
Wood rays
Reproduction
Growth
Storage/remobilization
Water transport
Sugar transport
Phloem
Cambium
Xylem (sapwood)
Heartwood
Export
Symbionts
(mycorrhiza, nitrogen-fixing-bacteria)
Exchange
Exudation

Linking structural traits, non-structural carbohydrate and tree ecological strategies in different climates

Presenter: Guangqi Zhang

Email: zh.guangqi@gmail.com

Scientist Supervisor: Alexia Stokes, UMR AMAP, Montpellier, France; Pascale Maillard, UMR SILVA, Nancy, France; Zhun Mao, UMR AMAP, Montpellier, France.

Functional traits have been examined in detail for several tree organs, but the relationship between traits, successional gradient and ecological strategies is poorly understood. The concept of an economics spectrum is currently used to describe the investment of a given species into different organs, depending on their position along an ecological succession gradient. It is now necessary to link functional traits of trees with knowledge of their ecological strategy and test whether similar strategies exist across different biomes. Results will help us better understand how different tree species can quickly colonise disturbed land, or maintain a position as a climax species in the canopy. Pioneer species that colonise a site rapidly must also mobilise energy from stored non-structural carbohydrates (NSC), which are stored in parenchyma cells. Nevertheless, climax species need to maintain their position in the canopy and may require large quantities of NSC and parenchyma for defence mechanisms. Moreover, study shows that the amount of axial parenchyma is related to vessel diameter and species with a high axial parenchyma fraction tend to have wide vessels, with most of the parenchyma packed around vessels. As yet, no specific relationships between ray parenchyma and any other anatomical traits (such as vessel size or density) have been found. Nor is it known if there is a relationship between ray parenchyma and ecological strategy of a species. A meta-analysis of existing data on functional traits, parenchyma volume and NSC will be performed to help disentangle relationships between all parameters. Extra analyses will be performed in the field along successional gradients (pioneer and climax) in three biomes (tropical rainforest, Mediterranean garrigue and temperate montane). A full characterization (climate, vegetation and soil variables) will be performed at each field site and 20 tree species per biome will be examined at the end of growing season, with three replicates per tree. The final outcome aims to find links between tree traits, carbohydrate supply and allocation and ecological strategies with regard to successional status in different biomes.

Keywords: Biomes; Ecological strategies; Functional traits; Non-structural carbohydrate; Ray and axial parenchyma; Successional gradient; Vessels

Diversity of the vascular and hydraulic architecture of the leafy shoot of tropical trees in French Guiana

Presenter: Sébastien Levionnois
Email: Sebastien_levionnois@live.fr
Scientist Supervisor: Patrick Heuret, UMR AMAP, Montpellier

Vascular and hydraulic traits are related to the fundamental functions of conduction and drought resistance, driving plant ecology, evolution, and processes related to climate change. However, these traits are still poorly documented for tropical rainforest, hindering our understanding of tropical tree ecology and the future of tropical forests. Through a trait-based approach combining leaf and stem in-depth anatomy and physiology, this thesis analyses the structure and the functioning of tree leafy shoots, a compartment exposed to the most severe water stress within a tree. (1) Leaf and stem vasculature and hydraulics are strong determinants of the leaf size diversity across 42 species findable in a given site. (2) Tackling several mechanisms through an in-depth anatomical observation (xylem, vessel, pit) increases the ability to predict the variability of stem embolism resistance across 25 species, with pit-related traits being the strongest determinants. (3) Vulnerability segmentation (i.e. differentiation of embolism resistance) at the leaf-stem interface is a spectrum of variation across 20 species, and has a massive role in enhancing the time to desiccation of shoots confirming the role of leaves as safety valves.

Keywords: Anatomy; conductivity; drought resistance; embolism resistance; functional trait; hydraulic; leaf-stem; segmentation; vasculature

Images représentatives des trois espèces étudiées (Pterocarpus erinaceus, Parkia biglobosa, Khaya sénégalensis)

Développement architecturale et modélisation de la croissance de trois espèces forestières indigènes savanicoles : appliquée à la mise en place d'essais de provenances le long d'un gradient bioclimatique du Centre-ouest au Nord de la Côte d'Ivoire

Presenter: Innocent Adji Beda

Email: adjibedainnocent@gmail.com

En Côte d'Ivoire, les ressources phytogénétiques sont très menacées par la déforestation (de 16 millions d'hectares en 1960 à moins de 3 millions d'hectares en 2019), et il est urgent de mettre en place des plans de gestion et d'utilisation durables permettant un maintien de leur productivité et de leur potentiel adaptatif. Le projet de thèse s'inscrit dans cette thématique générale, et contribuera via l'utilisation d'une approche multi-disciplinaire à l'acquisition de données scientifiques permettant une conservation durable (agriculture saine, durable et soucieuse de l'environnement). Le projet permettra d'acquérir les caractères architecturaux et de modéliser la croissance de trois espèces agroforestières : Khaya senegalensis (bois d'oeuvre et médicinale), Pterocarpus erinaceus (restauration de sol, fourrage, médicinale et bois d'oeuvre) et Parkia biglobosa (alimentation et médicinale). La méthodologie utilisée est dans un premier temps une analyse architecturale des espèces ciblée, puis dans un second temps une analyse rétrospective de la croissance qui permet via des marqueurs morphologiques laissés par les arrêts de croissance dus aux saisons sèches de retracer la croissance passée des arbres. Par cette approche, la variabilité intra-spécifique des espèces sera évaluée par l'étude des descendances. Les modalités de croissance sont endogènes. Les semences des espèces seront prélevées et mises en pépinière pour la réalisation de dispositifs expérimentaux. Des graines seront récoltées sur des individus en bordure Sud et Nord de l'aire de répartition des espèces. Les mesures de croissance sont prévues sur les jeunes plants en pépinière et sur des arbres en forêt. L'installation de trois sites expérimentaux le long d'un gradient de sécheresse (deux du Nord au Centre-Ouest de la côte d'Ivoire et un site dans le Sud du Burkina) est prévue également. Ce dispositif sera un dispositif de « plantations comparatives croisées » c'est-à-dire que les mêmes descendances seront plantées pour chaque espèce sur chaque site. Ce type de dispositif permettra à plus long terme d'évaluer l'adaptation des provenances sélectionnées au milieu et au changement climatique.

Keywords: Côte d'Ivoire; déforestation; conservation durable; caractères architecturaux; modéliser; changement climatique.

Biodiversity assessment and conservation needs in Kurdistan region of Iraq: the study case of wild and edible leeks, garlics and onions (genus Allium)
Identifying the diversity, distribution, and taxonomy of Allium in Kurdistan region
Updating the distribution (under GIS) of Alliums in Kurdistan region
Determining IPA (Important Plant Areas) for Alliums,
Reviewing genus Allium in Kurdistan region
Determining the ethnobotanical-socio-economic opportunities challenges and providing the solutions for conserving the ethnobotanical heritages in this region.
Identification of wild edible Allium in traditional markets of Kurdistan region
Economical botany study of Allium
Assessment public perception and local community benefices and influence on use of wild edible Alliums via IUCN assessments and consequent recommendations
Identifying the threats (redisting)
Suggesting in situ & ex situ solution for Allium conservation.
Proposing a regional strategy, conservation policy and legal framework for Allium as a proxy for global plant conservation and management in Kurdistan region.

Biodiversity assessment and conservation needs in Kurdistan region of Iraq: the study case of wild and edible leeks, garlics and onions (genus Allium)

Presenter: Ahmed Mahmood

Email: Ahmed.mahmood@etu.umontpellier

Scientist Supervisor: Errol Vela, UMR AMAP, Montpellier, France.

Kurdistan region of Iraq is a part of Irano-Anatolian hotspot of biodiversity, containing many endemic species. This region is considering as high biological diversity values and particular threatened natural ecosystem. Moreover, it is an intersection between Mediterranean, Temperate, Arid and Continental biogeographical regions. Furthermore, is considered as one of the richest irreplaceable sources for natural resources of economical importance as crops, medicinal, aromatic and edible plants. Human activities are the main threat to the Kurdistan region biodiversity heritage. Therefore, biodiversity conservation strategies aims might offer an option for national and international collaboration and cooperation for a best scientific advancement and achieving a lasting peace. The study case of this project would be the genus Allium, because it is distributing in various habitats from plain crop fields until mountain grassland summits. So that, the genus Allium would be a good proxy for studying conservation problems and suggestions.

This research, will study three major scientific axes in order to have a global vision about biological conservation strategies in Kurdistan region: 1) inventorying biodiversity, 2) studying ethnobotanical uses, 3) identifying anthropogenic pressure or impact and planning conservation actions). Therefore, numerous field samples of Allium will take according to their habitat occupation in NW Zagros area.

The specific objectives of this project are to fill the knowledge gap on diversity, distribution, and taxonomy of Allium in Kurdistan region. To suggest conservation policy and legal frame work for planning and integrated management of wild edible Allium for long-term conservation in Kurdistan region. To assess public perception and local community benefices and influences on use of wild edible Allium via IUCN assessments and consequent recommendations.

Keywords: Taxonomy; Biodiversity; Conservation; Ethnobotany; IUCN red list

Disentangling the key drivers of mountain soil microbial taxonomic and functional diversity along an altitudinal gradient

Presenter: Daniel Hernández Cáceres

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Guillermo Angeles INECOL, Veracruz, México

Mountains are natural ecosystems that constitute hotspots of biodiversity and present abrupt changes of the physical, edaphic and biotic environment over short geographic distances called altitudinal gradients. They offer a great opportunity to study the distribution and function of microbial communities adapted to local habitat. Changes in species richness along altitudinal gradients of plants and animals have been studied extensively and most taxa have been reported to display either a monotonic decline in richness with increasing elevation, a mid-elevation peak, or some combinations of the two, for example, low-elevation richness plateau followed by a mid-elevation peak or by a monotonic decline. However, bacterial and fungi taxonomic and functional diversity along altitudinal gradients, contrary to plants and animals in mountain ecosystems, do not seem to follow a clear pattern or trend. Knowledge about the spatial distribution and activity patterns of soil microbial communities in mountain ecosystems is critical to understand ecosystem functioning. The main objective of this study is to unravel the driving factors affecting bacterial and fungal taxonomic and functional diversities in bulk and rhizosphere soils along an altitudinal gradient. The study was conducted along an 8 km elevational gradient of six elevational bands ranging from 1400 to 2400 m located in Chamrousse, near Grenoble, France. Five 20m x 20m plots within each elevational band were chosen in order to present at least two of the following three target species: Picea abies, a tall evergreen tree; Juniperus communis, a prostrate evergreen shrub and Vaccinium myrtillus, a small deciduous shrub. Along the gradient, a decrease in soil organic carbon (Corg), cation exchange capacity (CEC), soil organic matter (SOM) and C/N ratio was observed at increasing altitude. In the other hand, an increase in sand content and pH occurred at increasing elevation. It can be noted that plant species had a poor influence on soil physicochemical properties along the gradient while altitude had a significant role influencing soil physicochemical properties.

Keywords: Altitudinal gradient; taxonomic diversity; mountain ecosystem; microbial ecology

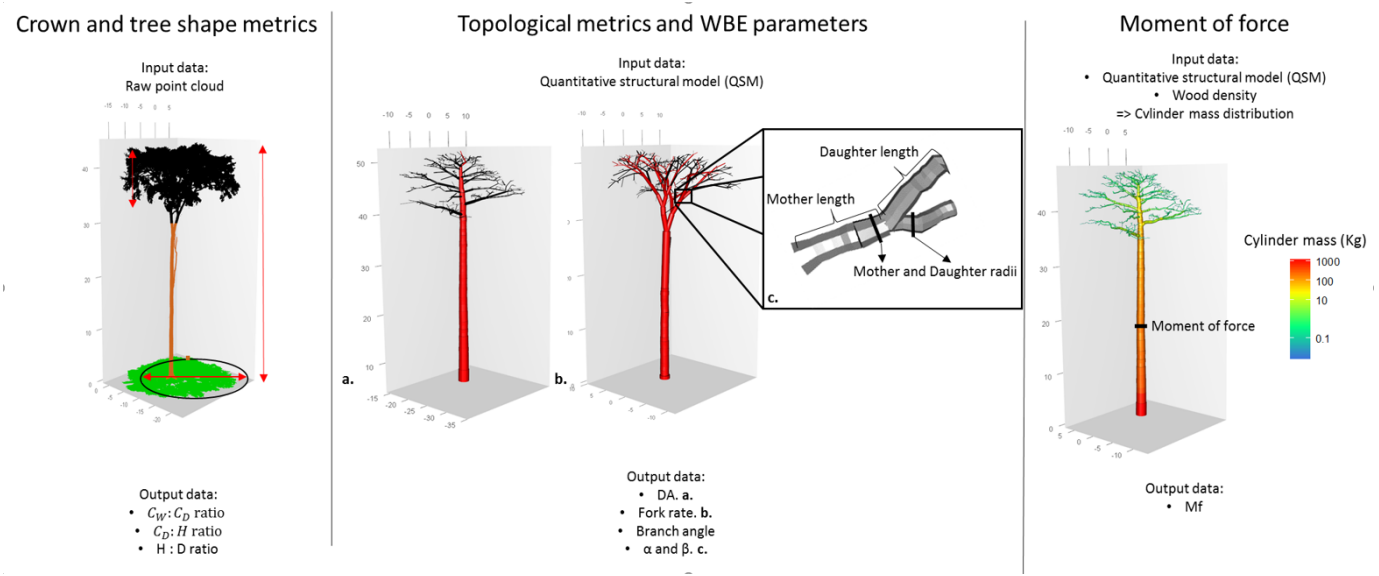

Figure 1: Architectural feature and mechanical constrains quantification illustration. On the left, simple crown shape metrics quantified on the raw point cloud. In the center, topology metrics and WBE α and β (branch radius and length scaling exponent) quantified using QSM. a) Represents the dominance of a principal axis metric (DA) with in red the principal axis (path with the highest A1 score) and in black the rest of the paths. b) Represents the fork rate metric with in red the successive connected fork and in black the rest of the structure that is discarded. c) Represents a ramification point with the mother and the daughter's length and radii used to quantify α and β. To the right a representation of the distribution of cylinder mass used to quantify the moment of force (Mf)

AMAPHD+

Convergence of tree architecture with increasing canopy position. An approach from terrestrial laser scanning in central Africa

Presenter: Olivier Martin
Email: olivier.martin@ird.fr
Scientist Supervisor: Raphaël Pelissier

Tree architecture characterizes how trees follow internal and external constrains to build their tri dimensional structure to fulfill growth and reproduction functions. Approaching crown structure and topological branch arrangement of large tropical trees is a challenging task considering their complexity, size and longevity. Terrestrial laser scanning (TLS) data offers a great opportunity to quantify for numerous big trees a large number of architectural traits of potential relevance. We investigated how canopy position, shade tolerance and mechanical constraints correlate with architectural traits and wood density of large trees.

Fifty nine trees in different canopy positions belonging to 14 co-existing Cameroon semi-deciduous forest species were reconstructed using quantitative structural model (QSM) on TLS data. The species belonged to contrasted shade tolerance groups. Classical global crown shape metrics, new topological metrics and West Brown and Enquist (WBE) tree parameters were quantified using QSMs. Wood density was measured in different tree compartments on the felled trees and the moment of force was estimated by coupling volume distribution in QSMs and wood density. Correlations between all the descriptors were analyzed through multivariate analysis.

Results revealed that topological and crown shape metrics were not correlated, since similar topologies led to contrasted crown shapes. Crown shape, but not topology, changed with the shade tolerance status of trees, while tree topology and convergence to expected WBE parameter values was observed for dominant canopy positions for all trees, independently of the shade tolerance status. This convergence is a consequence of reiteration processes occurring when trees attain the canopy. In parallel, mechanical constraints (moment of force) and wood density increase and crown relative depth decreases. This suggests that trees adjust wood volume and density to meet the biomechanical challenge of spreading large branches in the canopy.

Keywords: Quantitative structural model; Large tree; Shade tolerance; WBE model; Mechanical constrains; canopy position; liberation effect; convergence

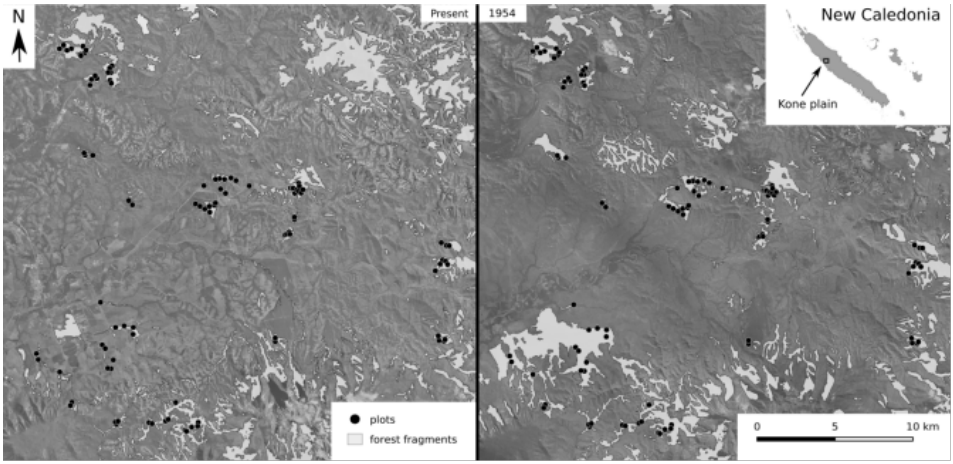

Figure 1. Maps of forest patches in the Kone-Pouembout plain (light grey), derived from recent (2012, left) and past (1954, right) aerial photographs. The positions of the 100 sampled plots are indicated on each map (black points).

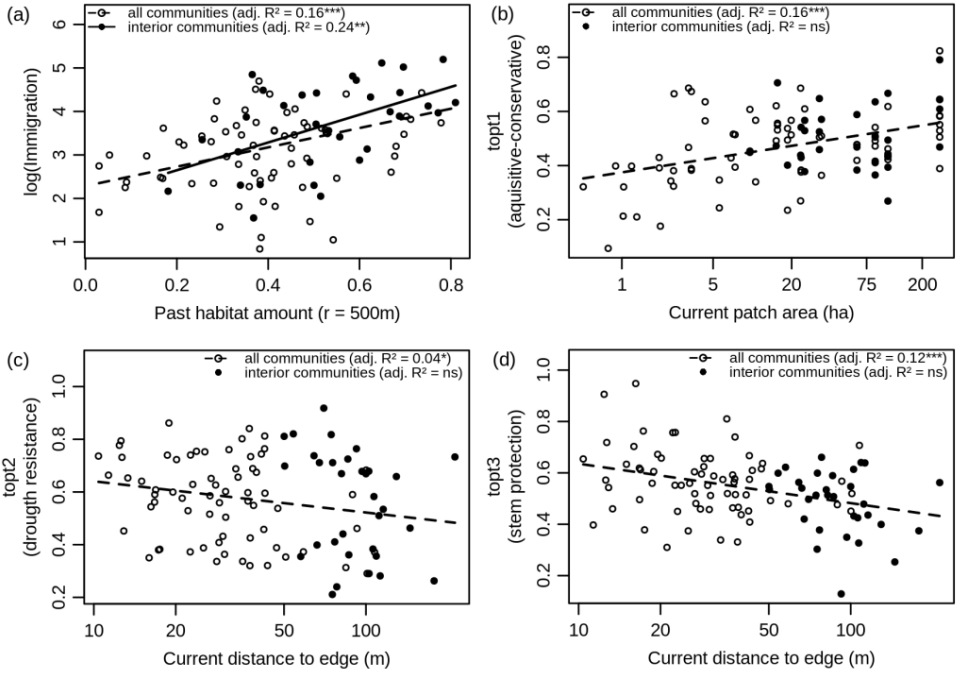

Figure 2. Effects of landscape metrics on estimated parameters of immigration (log-transformed immigration parameter) and environmental filtering (functional optimums : top1, topt2 and topt3) for all communities (n = 100 plots) and forest interior communities (n = 32 plots). Adjusted R^2 are reported when significant (ns: p-value ≥ 0.10; . : p-value ≥ 0.05; *: p-value < 0.05; **: p-value < 0.01; ***: p-value < 0.001).

Extintion-immigration lag behind environmental filtering in shaping taxonomic and functional composition of tropical dry forest in a changing landscape

Presenter: Grégoire Blanchard

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Scientist Supervisor: Philippe BIRNBAUM, UMR AMAP, Nouméa, Nouvelle-Calédonie.

The impact of rapid habitat loss and fragmentation on biodiversity is a major issue. However, we still lack an integrative understanding of how these changes impact biodiversity dynamics over time. In this study, we investigate the effects of these changes in terms of both niche-based and neutral dynamics. We expect that habitat loss has delayed effects on neutral immigration-extinction dynamics, while edge effects and environmental heterogeneity in habitat patches have rapid effects on niche-based dynamics.

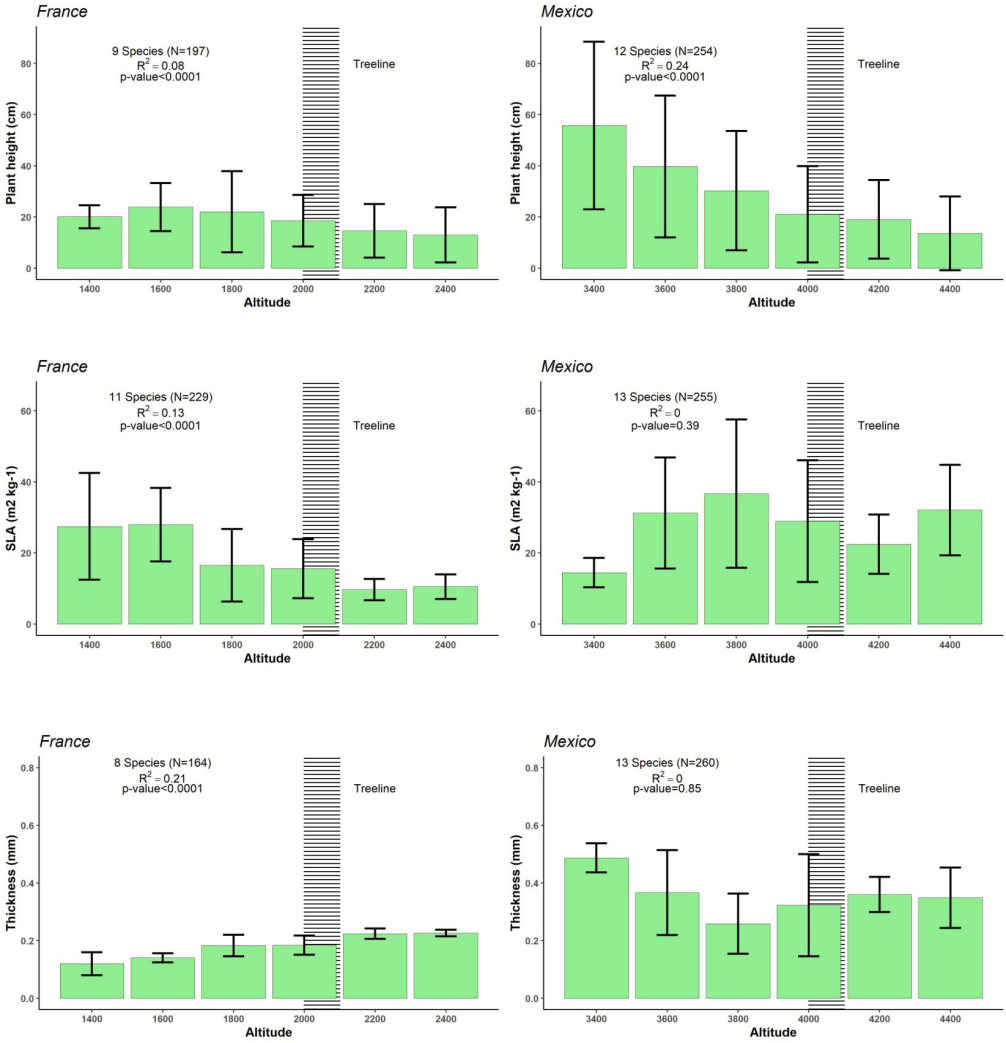
We analyzed taxonomic and functional composition of 100 tree communities in a tropical dry forest landscape of New-Caledonia subject to habitat loss and fragmentation. We designed an original, process-based simulation framework, and performed Approximate Bayesian Computation to infer the influence of niche-based and neutral processes. Then, we performed partial regressions to evaluate the relationships between inferred parameter values of communities and landscape metrics (distance to edge, patch area, and habitat amount around communities), derived from either recent or past (65 yrs ago) aerial photographs, while controlling for the effect of soil and topography.

We found that landscape structure influences both environmental filtering and immigration. Immigration rate was positively related to past habitat amount surrounding communities. In contrast, environmental filtering was mostly affected by present landscape structure and mainly influenced by edge vicinity and topography.

Our results highlight that changes in landscape structure can influence both niche-based and neutral assembly dynamics. First, landscape-level habitat loss and community isolation reduce immigration and increase demographic stochasticity, resulting in slow decline of local species diversity and extinction debt. Second, recent edge creation affects environmental filtering, incurring rapid changes in community composition by favoring species with edge-adapted strategies. Our study brings new insights about temporal impacts of landscape changes on biodiversity dynamics. We stress that landscape history critically influences these dynamics and should be taken into account in conservation policies.

Keywords: Community; assembly processes; ecological modelling; environmental filtering; immigration; extinction debt; fragmentation; habitat loss; edge effects; habitat amount

Functional traits in function of altitude for France and Mexico.



Adaptation des plantes d'altitude au réchauffement climatique: comparaison entre des régions alpines tempérée (France) et tropicale (Mexique)

Presenter: Nereyda Nathalie Cruz Maldonado

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Scientist Supervisor: Fabien Anthelme, IRD – AMAP, Montpellier, France.

Les effets du changement climatique sont attendus avec plus d'intensité en régions montagneuses alors qu'elles sont devenues des refuges thermiques pour les espèces essayant d'échapper à une augmentation des températures. En zones tempérées, les plantes alpines possèdent des adaptations les empêchant d'avoir la plasticité suffisante pour rivaliser avec ces nouvelles espèces, les menaçant de disparition.

En zone tempérée, les plantes sont protégées en hiver par un manteau neigeux augmentant avec l'altitude, lequel est absent en zone tropicale. Les plantes tropicales doivent affronter l'été toutes les journées, et l'hiver toutes les nuits. Si l'effet de ces contraintes sur les traits fonctionnels des plantes alpines tempérées est bien documenté, il existe un important vide d'information pour le zone tropicale. Nous comparons dans cette étude la variabilité des traits fonctionnels aériens le long de gradients altitudinaux en zone tropicale et tempérée pour des plantes alpines et subalpines.

Des résultats préliminaires montrent une covariance de traits fonctionnels (épaisseur et taille des feuilles, hauteur des plantes) avec l'altitude pour la zone tempérée, alors que ces traits varient très peu en zone tropicale, ce qui semble indiquer une nécessité pour les plantes tropicales de se prémunir contre une forte variabilité climatique journalière quelle que soit l'altitude.

Keywords: Réchauffement climatique ; zone tempérée; zone tropicale ; traits fonctionnels ; végétation ; plasticité.

Exploring the evolutionary history of Gabonese savannas using termites

Presenter: Fidèle EVOUNA ONDO
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Scientist Supervisor: Pierre COUTERON, UMR AMAP, Montpellier, France.

Understanding of the evolutionary history of the forest / savannah mosaic in the Congo Basin is poorly known today. This study aimed to explore the evolutionary history of Gabonese savannas using termites as a focal group. The choice of termites for this study is based on their low mobility, which gives them the role of bioindicator of ecosystem changes. Termite sampling was carried outacross Gabon in the central (Lopé), Southern (Mouila and Tchibanga) and eastern regions of Gabon (Batéké Plateau) in order to identify different termite communities along a forest-savannas gradient. Termites were collected across three habitat types (mature forest, long-unburned savannah and frequently burned savannah) using standardised transect methods with 21 sampling points across Gabon. Preliminary analysis revealed 21 genera of termites. The abundance and diversity of termites was highest in the Lopé forests and lowest the burned savannahs of Lopé. Termites composition differed between forest and savanna, with long-unburned savanna communities intermediate. Termites composition of Lopé savannas and the southern regions are also strikingly different. These findings suggest that the evolutionary history of the savannas of Lope is quite different to that of the southern savannas, and savanna termites communities in Lopé are not characteristic of ancient savannas.

Keywords: Termite; diversity; fire; savannah; soil, primary productivity

Figure 1 triaxial test large sample with roots before (left) and after (right) confined compression

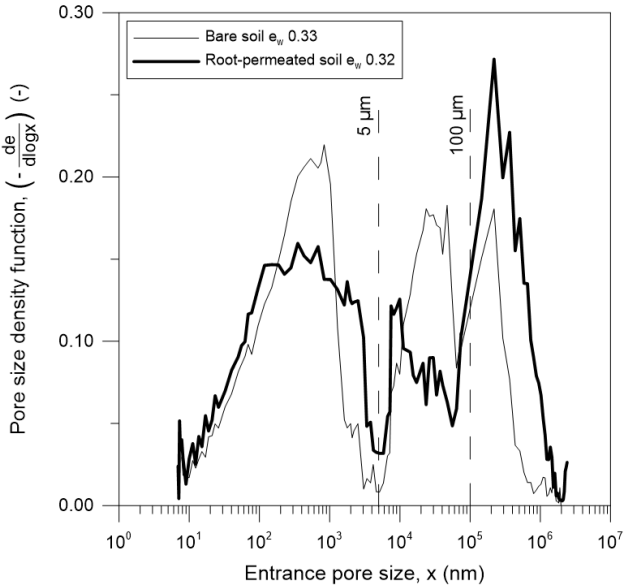
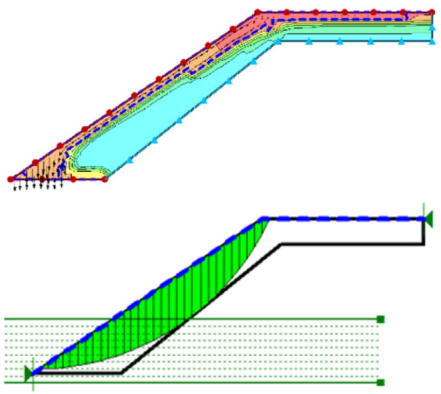
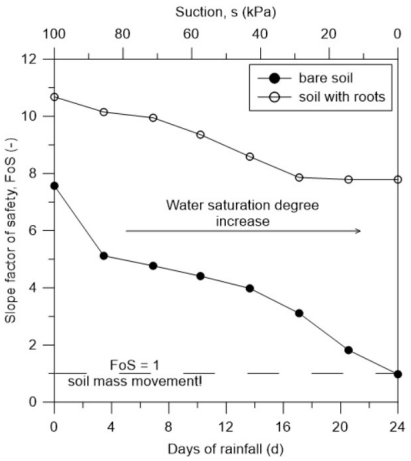


Figure 2 Pore size density functions for bare and root-permeated samples after a drying phase (Sr = 0.52)

Figure 3 (left) numerical simulation (lem) of the evolution of the hydraulic head and factor of safety within a soil slope during a rainfall and (right) evolution of the Factor of Safety along days and suction, for a slope with and without roots.





Hydro-chemo-mechanical multi-scale soil-roots interactions

Presenter: Alessandro Fraccica

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Scientist Supervisor: Thierry Fourcaud, UMR AMAP, Montpellier, France;
Enrique Romero, UPC, CIMNE, Barcelona, Spain.

The aim of the PhD thesis is to explore hydro-chemo-mechanical soil/roots interactions and propose a model to estimate the impact of vegetation on engineering applications (landslides, erosion problems).

Literature agrees on the fact that plants are enhancing soil shear strength due to the direct mechanical effect of root elements, while little is known about other indirect effects. Roots have various influences on soil physical and hydrological properties from the laboratory specimen's scale to soil- and pore-root interface. By return, soil characteristics, e.g. dry density, mechanical impedance or water content, have an effect on root growth, and consequently on their diameter, length and their ability of opening fissures and/or clog pores. A multi-scale experimental campaign and numerical simulations have been carried out in order to understand, quantify and model these interactions.

Different large-size mechanical cells (oedometer, direct shear box and triaxial cell) (example in Figure 1) allowed to determine how roots are enhancing soil shear and tensile strength increasingly with suction while they are decreasing its compressibility. Water saturated soil permeability, water retention and soil shrinkage upon drying were also evaluated. These studies were complemented with microstructural techniques (X-ray tomography, mercury intrusion porosimetry) to analyse the formation of fissures, pores clogging by mucilage, aggregate size and stability, and volume of roots. Soil microstructure is presented in terms of pore-size density function (Figure 2). Plant growth and development were also considered. Aggregate stability and fissures generated by root growth allowed to predict several changes of soil properties at a larger scale, e.g. modification of water retention behaviour (Figure 3) and volumetric strain behaviour under loads or drying.

Finally, numerical simulations were conducted to investigate the mechanical stability of a soil embankment, considering the results obtained in the laboratory. The macroscopic behaviour in terms of strength, permeability and water retention was reproduced during a rainfall event. Factor of safety was enhanced by roots during the whole rainfall period, even when soil was completely saturated.

Keywords: soil-roots interactions; multi-scale approach; aggregates stability; pore-size distribution; X-ray; MIP; shear strength; tensile strength; compressibility; slope stability

Figure 1: Transition from grassy savannah to dense forest

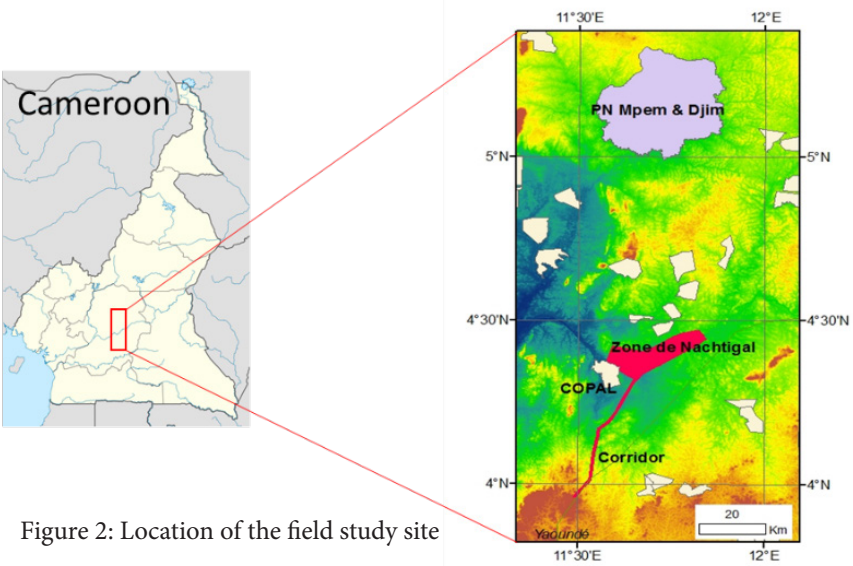

Figure 2: Location of the field study site

Linking vegetation structure and composition to past dynamics in forest savanna transitions

Presenter: Le Bienfaiteur Sagang Takougoum
Email: sagang.bienfaiteur@yahoo.fr
Scientist Supervisor: Nicolas Barbier, UMR AMAP, Montpellier, France

Considering the vast extent, heterogeneity, ecological and economic importance of forest-savannah (FS, Fig. 1) transition areas in Central Africa, significant efforts have to be made to strengthen landscape level aboveground biomass (AGB) and biodiversity characterization and our understanding of their drivers. Fire regimes, deforestation associated to economic activities, browsing and climate change have been identified as the key elements driving changes in vegetation structure and AGB fluxes within these FS transition areas. As a measure to support the sustainable management of the FS transition in Cameroon, this study intends to analyze the influence of disturbances on vegetation structure and AGB dynamic in a FS transition area at Central Region of Cameroon(Fig. 2). The first objective of the study is to describe the vegetation structure within the study area. We followed a stratified methodology which consist in upscaling the detailed structural information collected from field inventory plots to a larger spatial resolution using airborne liDAR metrics. This new spatial scale was used as reference data to calibrate prediction models based on Spot 6-7 vegetation indices for areas not covered by LiDAR. This method has proven to reduce errors along the scaling-up chain from field data to large-scale satellite-based maps. The second specific objective is to describe the temporal dynamics of vegetation and disturbances between 2000 and 2015. This analysis will be carried out on the basis of the Landsat time series thanks to a break point detection method. On the one hand, we will try to identify trends (ex. forest growth) and changes (ex. deforestation) in land cover classes , and on the other hand we will characterize the frequency of land cover change drivers (ex. fire regimes), which will allow interpreting the current vegetation structure.

Keywords: Central Africa; forest-savannah; Cameroon; aboveground biomass; vegetation structure; change drivers; vegetation dynamic.

Fig. 1: Cerberiopsis candelabra, espèce monocarpique endémique de Nouvelle-Calédonie.

The adaptive significance of monocarpy in woody perennial plants : investigations around the genus Cerbceriopsis

Presenter: Camille Salmon

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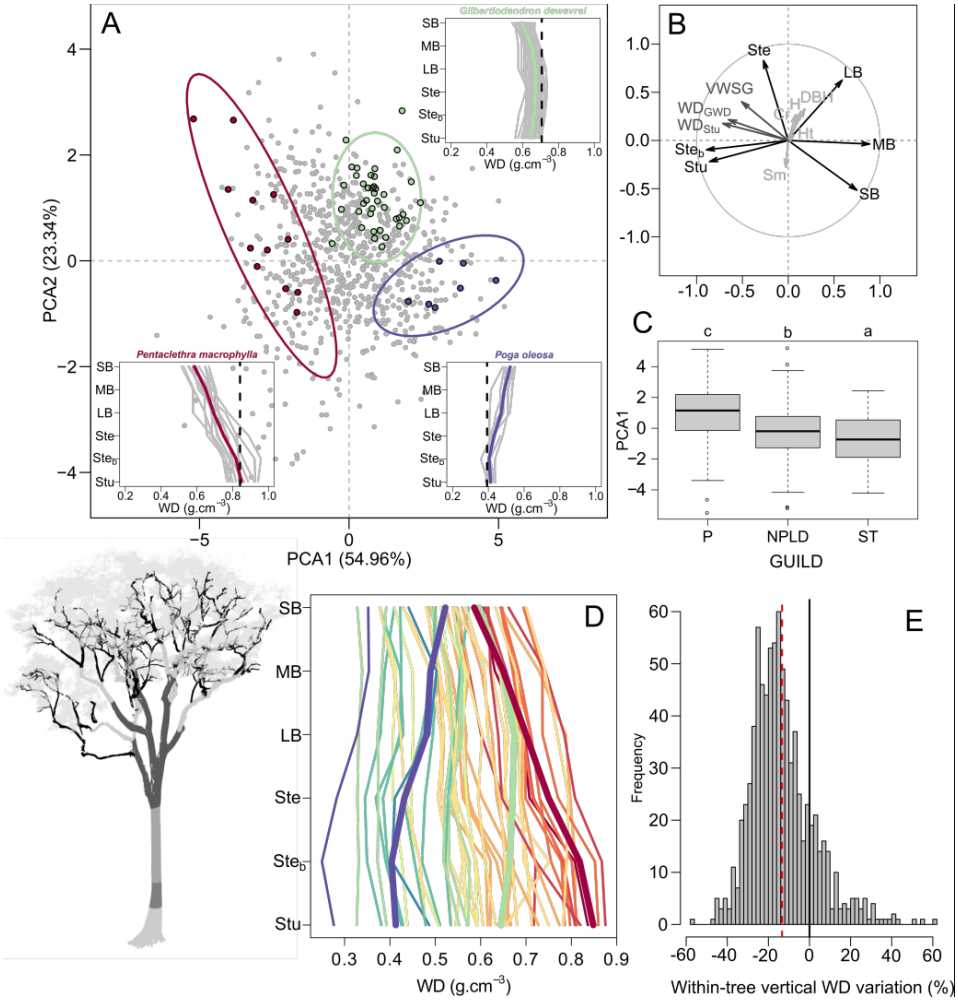
Scientist Supervisor: Eric Nicolini, UMR AMAP, Kourou, Guyane. Sandrine Isnard, UMR AMAP, Nouméa, Nouvelle-Calédonie. Patrick Heuret, UMR AMAP, Montpellier, France.

Monocarpy refers to perennial plants that live for several years before blooming once and dying. Represented in a few monocotyledonous families and in monocaulous plants, this strategy remains rare for long-lived dicotyledonous branched tree species. This thesis aims to better understand the adaptive significance of this strategy described as suicidal by several authors through three approaches. A first introductory part aims to make an inventory of our knowledge of monocarpic plants on the basis of a bibliographic synthesis and a survey in participatory sciences. The main body of the thesis deals with a comparative architectural study of three species of trees within the genus Cerberiopsis , one of which is monocarpic.

The relationships between the architectural stage, the chronological age or the dimensions of the tree will be explored in relation to the environmental conditions and the accession to the fertile stage of the individuals. Several hypotheses advanced on life-history traits associated with and necessary for monocarpy will be tested on these three species.

Keywords:



Tree wood, structure parameters and functional trait used as supplementary variables in the Principal Component Analysis (PCA) and their correlations with the two first PCA axes.

Weighing trees with lasers: what about wood density and life-traits strategies?

Presenter: Stéphane Momo
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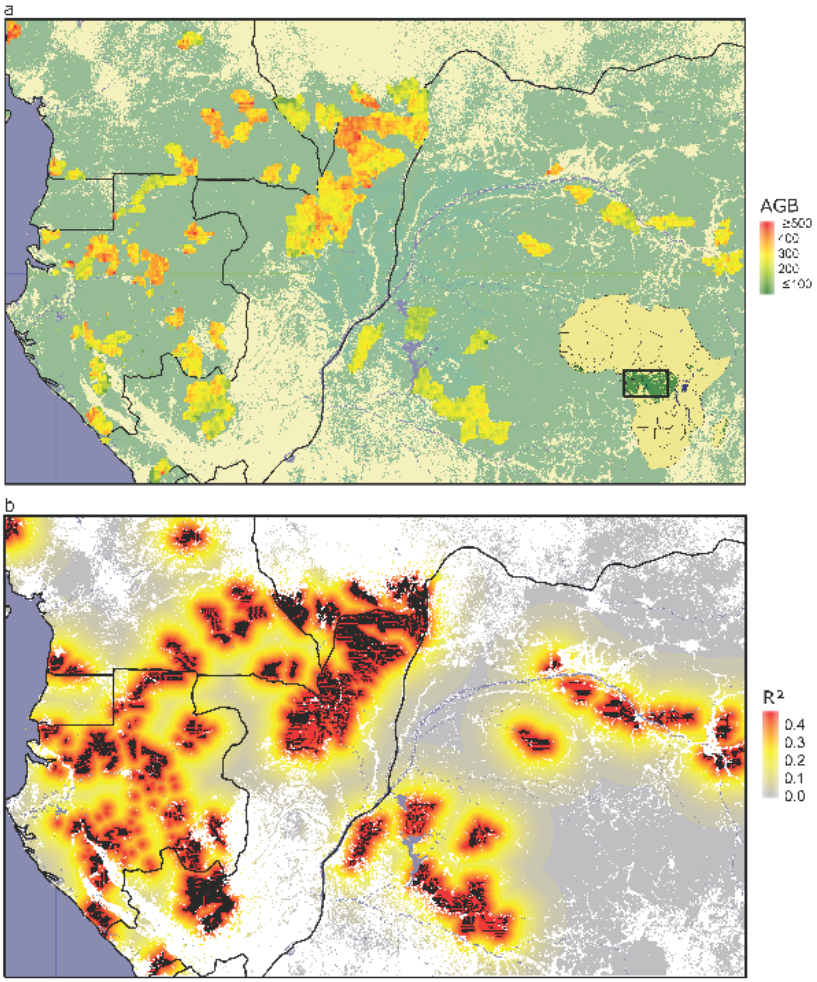
Wood density (WD) relates to important tree functions such as stem mechanics and resistance against pests and pathogens. Generally conserved within lineages, this functional trait can however exhibit large intra-individual variability both radially and vertically due to ontogenetic variation and heartwood formation. This variability in WD is inherently underestimated by the widespread use of database-derived species-average WD data when converting tree volume into aboveground biomass (AGB) estimates. With the rise of new LiDAR-based methodologies allowing for non-destructive tree volume estimations, failing to account for WD variations related to tree function and biomass investment strategies, may lead to large systematic bias in AGB estimations, unless appropriate correction factors can be introduced. Our study provides crucial information on carbon allocation and growth strategies in tropical trees, and resolves a key issue in forest biomass estimation from volumetric data, thus offering promising ways forward for using new technologies such as Terrestrial LiDAR scanning for (i) non-destructive calibration of tree allometries and (ii) forest-scale AGB estimations in tropical forests.

Here we use a unique destructive dataset of 822 trees belonging to 51 tree species phylogenetically dispersed (50 genera), harvested across forest types in Central Africa to determine vertical gradients in WD from the stump to branch tips within individual trees, how they relate to regeneration guilds and what are their implications for AGB estimations. We find a decrease in WD from the tree base to branch tips for 83% of the sampled trees, while the remaining individuals exhibit stationary or increasing vertical trends. Across all species, WD range is narrower in tree crowns than at the tree base, reflecting more similar physiological and mechanical constraints in the canopy. Vertical gradients in WD induce significant bias (10 %) in AGB estimates when using database-derived species-average WD data. However, the correlation between the vertical gradients and basal WD allows deriving general correction models. With the ongoing development of remote sensing products providing 3D information of entire trees and forest stands, our findings open promising ways forward to improve greenhouse gas accounting in tropical countries and advance our understanding of adaptive strategies allowing trees to grow and survive in dense rainforests.

Keywords: Wood density variation, Aboveground Biomass, functional traits, Tropical forest, Terrestrial LiDAR

Figure. a. Overview of study area and field data distribution. Forest AGB estimations derived from field inventories are depicted in a green-to-red color gradient and underlaid by the spatial distribution of moist forests (dark green) and countries borders. b. Correlation between model's predictions and field-derived AGB estimations (noted R^2) sharply declines with distance to training data.



Evaluating the potential of MODIS and environmental data for the interpolation of tropical forest AGB in large-scale studies

Presenter: Pierre Ploton
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Scientist Supervisor: Raphaël Pélissier, UMR AMAP, Montpellier, France.

An important stake to anticipate and mitigate climate change lies in our ability to accurately map tropical carbon stocks and stock changes over large areas (in the frame of e.g. REDD+). Over central Africa, current tropical biomass maps disagree on both the magnitude and the spatial distribution of forest carbon. A key methodological step and a potentially large source of error in generating such maps consists in interpolating reference, discrete AGB estimations with satellite data (typically derived from MODIS) and environmental drivers (e.g. elevation) to generate wall-to-wall AGB products. Medium resolution optical sensors have indeed often been considered of limited interest to infer AGB levels in carbon rich forests (notably due to signal saturation). Besides, model performance is often evaluated using k-fold cross-validation procedures whereby local AGB estimations are randomly drawn from model training set to serve as independent validation data. In spatially structure environment – i.e. when pixels close to each other tend to have similar AGB levels and environmental conditions – spatial autocorrelation in the data violates a central assumption of cross-validation schemes: the independence between training and validation sets. Overlooking this potential issue leads to over-optimistic estimates of model performances and misleading conclusions – notably on the utility of AGB interpolation predictors. With the upcoming availability of GEDI data, we need a better understanding of whether current wall-to-wall products (incl. MODIS, but also related to topography or climate) provide useful information to interpolate local AGB estimations. In this study, I use c. 200,000 commercial forest inventory plots distributed in six central African countries (~ 12 million trees, Fig. a) to evaluate the predictive power of MODIS and environmental conditions on dense tropical forest AGB at the 1 km resolution. Accounting for spatial autocorrelation in model cross-validation procedure revealed that MODIS and environmental conditions have a very weak, if any' predictive power over forest AGB (Fig. b).

Keywords: Tropical forest biomass, remote sensing, spatial autocorrelation, cross validation

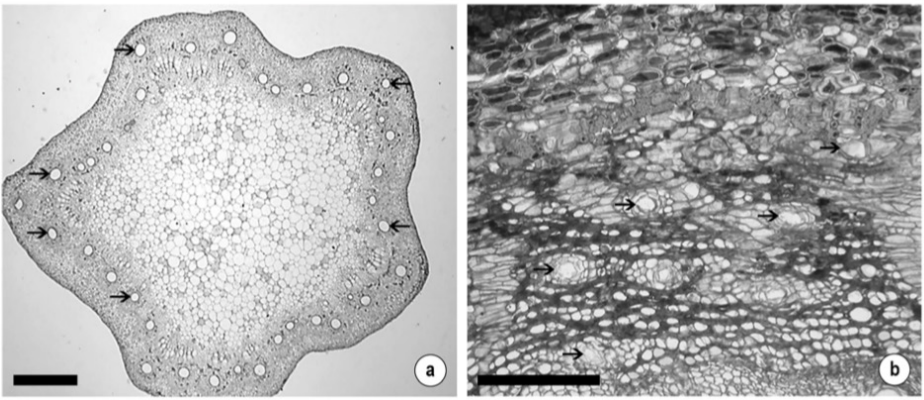

Fig. 1 (Palermo et al. 2018) : Cross sections showing secretory canals in Protium heptaphyllum (Burseraceae) stem. (a) Secretory canals (arrows) in the primary phloem. (b) Secretory canals (arrows) in the secondary phloem.

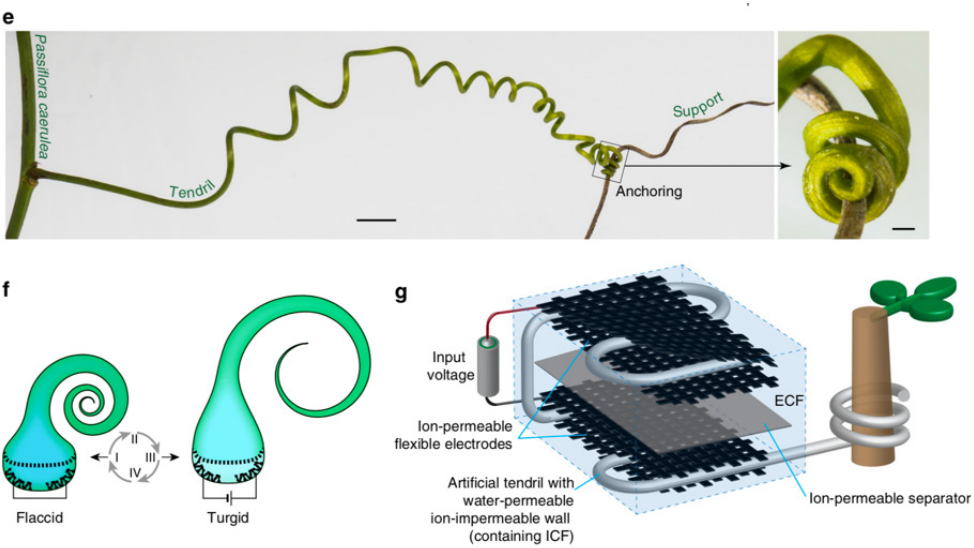

Fig. 3 (Must et al. 2019) : Osmosis-based reversible actuation: from liana strategy to a tendril-like soft robot. (e) Passiflora caerulea (Passifloraceae) tendril reaching and anchoring to an external support. Scale bars: 5 mm main image, 0.5 mm detail. (f) Artificial tendril actuation (schematic). (g) Tendril-like soft robot based on the osmotic actuator (schematic).

Plant secretory tissues and their exudates from forests of French Guiana: their functional roles, ecological significance and biomimetic applications

Presenter: Tom HATTERMANN

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Scientist Supervisor: Nicholas ROWE, UMR AMAP, Montpellier, France – Patrick HEURET, UMR AMAP, Montpellier, France

Secretory tissues are present in most vascular plants which produce secretions from the plant surface as well as inside stems, leaves, roots, flowers and fruits. These are generally distinguished by the type of structure they are derived from as well as their chemical composition. There exist five categories of exudates including: (i) gums (ii) mucilage (iii) resins (iv) kinos and (v) latex. The exudates are stored in secretory cells e.g. laticifers or within canals and cavities within various plant tissues. Secondary metabolites from secretory tissues are believed to have many functions; one aspect concerns their roles in biotic defence against phytophagous organisms and pathogens as well as sealing wounds. Other potential functions include roles in conduction, storage and investment for controlling hydraulic functioning. Authors have nevertheless commented on the general lack of understanding of these potentially important functional traits and this is particularly true for the exceptionally wide diversity of structures and substances in tropical ecosystems.

In terms of biomimetics, the deployment of secretions by specialized cellular structures and the self-repair and adhesive properties of exudates as well as their roles in volumetric and structural shape-changes actuated by relatively simple external actuation mechanisms are increasingly studied processes in innovative biomimetic applications. The diversity of specialized structures and exudates in this project therefore offers an exciting opening for developing new "smart" self-repairing materials and composites, especially for soft robotics systems.

The main objectives of this thesis are twofold: (1) to investigate the diversity, functional significance and ecological variability of secretory structures and their exudates within natural communities in French Guiana and (2) to transfer this knowledge to the chemists, micro engineers and robotics engineers within the GrowBot Consortium for bioinspired innovations in artefacts capable of plant-like growth and functioning (H2020 Biomimetics project).

Keywords: Tropical ecology; Secretory tissues; Plant hydraulics; Biomechanics; Chemistry; Growth form; Biomimicry

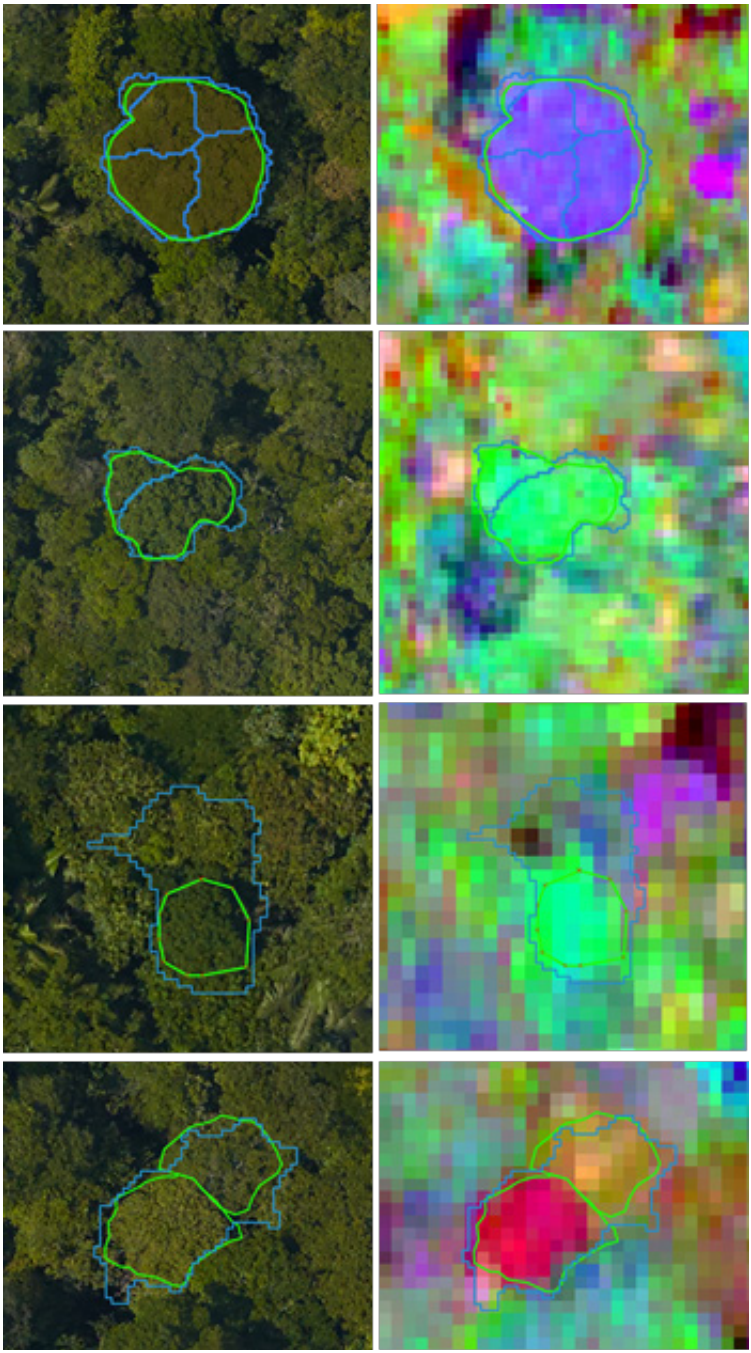

Figure: Two examples of over-segmentation (top) and two examples of under-segmentation (bottom). Reference manual segmentation in green and automatic segmentation in blue. Left: RGB photography. Right: selected 3 axes of the ACP realized with the hyperspectral data (VNIR).

Tree crown delineation in a tropical forest in French Guiana combining aerial LiDAR and multispectral data

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Scientist Supervisor: Grégoire Vincent, UMR AMAP, Montpellier, France.

The combined use of LiDAR and multispectral/hyperspectral sensors is a particularly promising avenue to characterize tree species diversity, both types of sensors having complementary characteristics. LiDAR data informs on the geometric structure of objects in three dimensions and penetrates the canopy thus providing some information on the understory. On the other hand, the high spectral and spatial resolution of multispectral imagery confers a strong discriminative power. Here we seek to identify the most effective method to consider multispectral and/or hyperspectral information during tree crown segmentation in addition to LiDAR point cloud.

Our test site is the neotropical forest site of Paracou, in French Guiana. The remote sensing data is composed of high density full-wave form LiDAR, high resolution RGB imagery, and hyperspectral data. A data set comprised of 1876 tree crowns, which were delineated and identified to species level, was collected as ground truth.

An initial unsupervised segmentation was achieved using an adaptive mean-shift algorithm (AMS-3D) applied to the LiDAR point cloud with a Pollock model bandwidth, and a dbscan algorithm to merge the modes obtained by the AMS algorithm. Comparison with our ground-truth crown database showed cases of under-segmentation (3% of the manually segmented crowns) and over-segmentation (13%) despite overall good congruence (74%).

Clusters of points defining individual crowns were turned into 2D polygons visible from above, which could be intersected with spectral/textural layers. The RGB images were used to compute texture indices. A principal component analysis was run on the hyperspectral data to reduce the dimensionality, and a small set of principal components were visually selected if they contained useful information for crown segmentation.

Over-segmentation often affected large emergent crowns for which spectral information was available. We therefore developed a model to compute the probability of two adjacent polygons belonging to the same crown based on their spectral and geometric similarity, reducing the portion of over-segmentation of the manually segmented crowns to 9%.

Spectral data can therefore be used to improve crowns segmentation of the higher layers of the canopy, leading to a better estimation of the tree number.

Keywords: Individual tree crown segmentation, Airborn LiDAR Scanner, hyperspectral imaging.

Rendez-vous à l'Amapéro afin d'échanger, se rencontrer et partager sur vos différents sujets.
L'organisation d'AMAPhD+ 2019 vous souhaite une bonne journée.