AAPG2021	ALT		Funding instrument PRC
Coordinated by:	Jérôme CHAVE	Duration 48 months	ANR Requested Funding: **735926€**
Scientific evaluation committee: CE32			

Amazonian landscapes in transition

Summary table of persons involved in the project:

Partner	Name	First name	Current position	Role & responsibilities in the project (4 lines max)	Involvement (person.month) throughout the project's total duration
EDB	*CHAVE*	*Jérôme*	*Scientist CNRS*	*PI, Coordinator WP4*	*14p.month*
EDB	*PLAISANCE*	*Laetitia*	*IR CNRS - CDD*	*Participant WP0, outreach*	*4p.month*
EDB	*IRIBAR*	*Amaia*	*IR CNRS*	*Participant WP2, DNA barcoding*	*6p.month*
EDB	*LABRiERE*	*Nicolas*	*Postdoc - CDD*	*Participant WP3, remote sensing*	*8p.month*
EDB	*FISCHER*	*Fabian*	*Postdoc - CDD*	*Participant WP1, TROLL model*	*4p.month*
EDB	*TAO*	*Shengli*	*Postdoc - CDD*	*Participant WP3, remote sensing*	*5p.month*
EDB	*FISHER*	*Rosie*	*Scientist*	*Coordinator WP1, FATES model*	*12p.month*
ECOFOG	*DERROIRE*	*Géraldine*	*Scientist CIRAD*	*Coordinator WP2, Paracou manager*	*7p.month*
ECOFOG	*JAOUEN*	*Gaëlle*	*Scientist AgroParisTech*	*Participant WP2, data management*	*2p.month*
ECOFOG	*PETRONELLI*	*Pascal*	*T CIRAD*	*Participant WP2 head botany*	*2p.month*
ECOFOG	*TRAISSAC*	*Stéphane*	*Scientist AgroParisTech*	*Participant WP4 management scenarios*	*5p.month*
ECOFOG	*AUBRY-KIENTZ*	*Mélaine*	*Scientist AgroParisTech*	*Participant WP4 management scenarios*	*3p.month*
ECOFOG	*COSTE*	*Sabrina*	*Scientist UG*	*Participant WP1 trait database*	*1p.month*
ECOFOG	*CAZAL*	*Jocelyn*	*ITA INRAE*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*STAHL*	*Clément*	*Scientist INRAE*	*Participant WP1 trait database*	*4p.month*
ECOFOG	*SALZET*	*Guillaume*	*Doc – CDD*	*Participant WP4 management scenarios*	*4p.month*
ECOFOG	*BAISIE*	*Michel*	*Tech CIRAD*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*NAISSO*	*Petrus*	*Tech CIRAD*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*SANTE*	*Richard*	*Tech CIRAD*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*ongoing recruitment*	*NA*	*Tech CIRAD*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*ongoing recruitment*	*NA*	*Tech CIRAD*	*Participant WP2 field collection*	*1p.month*
ECOFOG	*PROUX*	*Laetitia*	*Tech CIRAD*	*Participant WP2 Paracou coordination*	*2p.month*
ECOFOG	*GAQUIERE*	*THOMAS*	*Doc – CDD*	*Participant WP2 spatial analysis*	*4p.month*
AMAP	*MARECHAUX*	*Isabelle*	*Scientist INRAE*	*Coordinator WP1*	*8p.month*
AMAP	*PELISSIER*	*Raphaël*	*Scientist IRD*	*Participant WP2 spatial analysis*	*2p.month*
AMAP	*VINCENT*	*Grégoire*	*Scientist IRD*	*Coordinator WP3*	*3p.month*
AMAP	*VIEILLEDENT*	*Ghislain*	*Scientist CIRAD*	*Participant WP4 joint species modelling*	*3p.month*
AMAP	*FORTUNEL*	*Claire*	*Scientist IRD*	*Participant WP1 trait database*	*4p.month*
AMAP	*BAUMAN*	*David*	*Post-doc – CDD*	*Participant WP1 trait database*	*2p.month*
AMAP	*MOLINO*	*Jean-François*	*Scientist IRD*	*Participant WP2 head botany*	*3p.month*
AMAP	*ENGEL*	*Julien*	*Scientist IRD*	*Participant WP2 head botany*	*3p.month*
CESBIO	*VILLARD*	*Ludovic*	*IR CNRS*	*Coordinator WP3*	*6p.month*
CESBIO	*KOLECK*	*Thierry*	*Scientist CNES*	*Participant WP3 Sentinel-1/2*	*4p.month*
LEEISA	*COURTOIS*	*Elodie*	*IR CNRS*	*Coordinator WP2*	*7p.month*
LEEISA	*CHATELET*	*Patrick*	*ITA CNRS*	*Participant WP2 field collection*	*2p.month*
LEEISA	*JEANNE*	*Florian*	*ITA CNRS*	*Participant WP2 field collection*	*2p.month*
LEEISA	*MARCHAND*	*Nina*	*ITA CNRS*	*Participant WP2 field collection*	*2p.month*

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LEEISA	*SELLAN*	*Giacomo*	*Postdoc - CDD*	*Participant WP2 fieldwork coordination*	*12p.month*
LEEISA	*BETIAN*	*Wemo*	*ITA CNRS*	*Participant WP2 field collection*	*2p.month*
LEEISA	*LE PLAT*	*Bran*	*ITA CNRS*	*Participant WP2 field collection*	*2p.month*
ONF	*BRUNAUX*	*Olivier*	*ONF*	*Participant WP0&4 user consultation*	*4p.month*
ONF	*BEDEAU*	*Caroline*	*ONF*	*Participant WP3 remote sensing*	*4p.month*

Any changes that have been made in the full proposal compared to the pre-proposal

The full proposal does not differ with the one submitted as a pre-proposal.

I. Proposal's context, positioning and objective(s)

a. Objectives and research hypothesis

Amazonian forests, the largest tract of continuous tropical forest, are of major significance to climate change[1]. Amazonia is both a large store of carbon, and an important global sink for atmospheric carbon[2]. Amazonia is also essential to other major ecosystem services, such as water filtration, flood buffering, soil health, biodiversity habitat, and the provisioning of forest resources[3].

However, Amazonian forests are subject to risks from human activities and climate change. Nearly a quarter of Amazonia's surface has already been converted into human-modified landscapes[1] and an even greater proportion has been degraded[4]. It is therefore crucial to evaluate the services provided by disturbed forests, and to evaluate pathways of recovery[5,6]. Additionally, modelling approaches have evaluated the likelihood of ecosystem shifts[7,8], and suggest a major drought-related threat for Amazonia[9,10]. Concurrently, remote sensing studies have demonstrated that Amazonia responds strongly to intense droughts[11]. Such a shift will likely have serious and adverse impacts on ecosystem services of both natural and production forests[3,12], and more generally on Amazonian socio-ecosystems[13]. However, forest multifunctionality and the response to climate change are yet to be fully accounted for in tropical forest management plans[14]. **A fundamental question is whether Amazonian forests will be able to withstand the simultaneous impacts of climate and local anthropogenic disturbances.**

This question is of global relevance. The short-term greenhouse gas emission goals set by the Paris Agreement can only be met through mitigation approaches involving forests, such as increased carbon sequestration, and limited emissions through conservation and management[5,15]. To comply with the Paris Agreement, all countries are required to establish nationally determined contributions and monitor the progress in achieving the agreed goals (the global stocktake approach[16]). France is directly involved in negotiations on the potential of its forests to both offset carbon emissions and mitigate the biodiversity crisis. Accurate information on the status and vulnerability of forests is therefore crucially needed. **The present project, Amazonian Landscapes in Transitions (ALT), seeks to address this key challenge in French Guiana**. The approaches developed in ALT would be applicable elsewhere in the tropics.

According to modelling scenarios, French Guiana is especially vulnerable to future climate shifts[10,17]. This region covers a range of soil and climate conditions, the latter being one of the least documented of South America[18]. French Guiana's forests store about as much biogenic carbon as mainland France[19], but in 1/8th the area, and with low levels of prior disturbance (high structural integrity[20]). Currently, forest degradation, due to selective logging or gold mining activities, has a more pervasive impact than climate anomalies on the forests of French Guiana[21] and so our proposal addresses both climatic and anthropogenic threats. A baseline survey of ecological indicators has recently been published[19], related to the regeneration potential of forests, timber stock, carbon storage, biodiversity, and threats. **Ecological indicators**, as defined in this proposal, include: woody biomass, net primary production, tree diversity, mortality rates, and the regeneration potential of major timber species. However, **to be successful, management trajectories must be informed by accurate information on the status and vulnerability of tropical forests**. Put in another way, the baseline ecological indicators are insufficient because they do not account for forest vulnerability. Current models of forest dynamics could be helpful for the provision of quantitative projections.

However, forest dynamics models still struggle to account for **tree demography** and the large plant functional diversity of tropical rainforests, and for the micro-environmental variation that is potentially important for its maintenance (Wright 2002), leading to large uncertainties in model predictions[22,23]. **Tree recruitment** and **tree mortality** are indeed still poorly represented in vegetation models[24], mainly because of a critical **lack of relevant field data**. The regeneration potential of both natural and managed forests lies in the forest understory, yet no observational system is currently in place to quantify the density, composition, and distribution of small diameter trees in French Guiana's forests. Also, canopy tree mortality is the primary process shaping forest micro-environmental heterogeneity[25]. Yet, its accurate quantification is challenging both from field inventories and remote sensing. Providing novel data on both small tree size classes and tree mortality would be needed to constrain model development and provide evidence-based projections. **The goal of the ALT project is to fill these data gaps, and to produce territorial model-based estimates of ecological indicators for tropical forests of French Guiana, across tree size classes, and with reduced uncertainty**.

Specifically, the ALT project will use an innovative combination of 1) two forest dynamics models, both including a detailed representation of the micro-environment and tree demography, 2) highly detailed forest inventories, and 3) high-resolution remote sensing approaches to establish maps of forest ecosystem services in terms of carbon retention, timber resources, and tree diversity. We will further explore the impact of management strategies on these ecological indicators, based on prescribed forestry operations. We will explore the strategies of forest management compatible with both the multifunctionality of tropical forests and territorial development. Our results will be directly relevant to the nationally determined contributions of the UNFCCC, and they will also be relevant as contributions by France to upcoming reports to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

We will test the following specific hypotheses: ***H1**. The regeneration potential and timber provision of tropical forests depend on tree species diversity and micro-environmental heterogeneity; **H2**. The distribution of understory trees is determined by dispersal limitation, micro-climatic and micro-edaphic factors; **H3**. Canopy tree mortality is determined by both topography and climatic anomalies. We will then use these findings to explore how forest indicators depend on environmental variables across French Guiana forests, and they will be altered by future climatic conditions, including fire risk.*

b. Position of the project as it relates to the state of the art

The ALT project will harness the potential of demographic vegetation models to integrate diverse sources of information to forecast the interacting effects of degradation and climate changes on the state of tropical forests. We will (1) parameterize demographic vegetation models locally at two sites, (2) survey understory vegetation to improve model representation for forest regeneration, (3) use Earth observation techniques to quantify tree mortality, and (4) upscale the models across the French Guiana (ca. 80,000 km^2) to generate improved maps of ecological indicators.

We will use two complementary modelling approaches to **perform virtual experiments aimed at exploring the processes underpinning the regeneration potential of natural and production forests**[26]. Dynamic vegetation models embedded in Earth System Models (ESMs) can be used to discern global biosphere-climate feedback and impacts of climate on interconnected land surface processes. Such schemes, however, typically struggle to account for the functional diversity or ecological structure of tropical forests, undermining their ability to capture responses to climate variation and to disturbances[22,27]. The most advanced and recent models better represent ecological demographics and plant functional diversity. Here we will use the Functionally Assembled Terrestrial Ecosystem Simulator, **FATES**, one of this new class of 'vegetation demographic' models. FATES implements a cohort-based representation of ecosystem demography[28] and is driven largely by plant trait information[29]. It is coupled with three ESMs, and has been recently used to assess the impacts of selective logging in Amazonian tropical forests[30]. Our team has a first-hand experience with the FATES model[28-31] (RA Fisher co-leads FATES development and is at EDB). The cohort-based representation of ecosystem dynamics in FATES, which is designed to be computationally tractable at large scales, must be validated, especially its description of understory dynamics.

To that end, models that simulate the dynamics of individual trees, such as **TROLL**[32,33], can serve as 'data integrators' and plausibly as benchmarks for the behaviour of more aggregated schemes. In TROLL, each stem ≥ 1 cm in trunk diameter is modelled explicitly in 3D, and is assigned to a taxonomic species. It thus describes the forest at the scale at which data are acquired in the field and captures a detailed representation of tree diversity and of the individual-scale variation that is widely considered to have important ramifications for ecosystem composition. Partner EDB has developed the TROLL model[32,33]. Based on the local calibration of FATES and TROLL, and building on advances on the forest understory and on canopy dynamics, **we will generate maps of ecosystem services across French Guiana, and unravel the causes of tree regeneration for timber species**.

Calibration of both models requires three sets of input parameters: plant physiological traits, climatic/edaphic, and global parameters (allometric exponents, allocation proportions, light interception etc.). Climatic parameters are inferred from global climate data[34], with plant physiology derived from a local plant functional trait database. TROLL can be initialized with precise tree inventory and airborne lidar[35] (see below) and FATES with an aggregated version of the same inventory information. In TROLL, model parameterization can be conducted through a data assimilation procedure, comparing the outputs of many simulations to empirical summary statistics related to forest structure and carbon dynamics (Figure 1). This generates local parameterizations, together with uncertainties on these parameter sets[32]. A similar approach will be developed for use in FATES. Based on the calibrated models, tests of optimal strategies for logging timber tree species can be implemented, for instance by exploring various harvesting frequencies and minimal cutting diameters[3,36], as well as strategies regarding non-timber species[12,37].

Vegetation models are a promising route to quantify ecosystem services, **key knowledge gaps** are hampering the quality of projections for tropical forests, and ALT seeks to address them.

First, understanding **understory tree dynamics** is essential to predicting the regeneration potential of tree species[38], and therefore the sustainability of production forests[3,36]. Seed production, seed dispersal, germination, and seedling demography[39,40] are mediated by the understory micro-habitats generated by the forest canopy and biotic interactions, such as plant interactions, pathogens, and predators. The forest understory also buffers climatic anomalies[41], being a nurturing environment for future canopy trees[42], and it can be dramatically modified by natural disturbances or degradation. As a result, the response of the understory vegetation to climate change and disturbances remains poorly documented[43]. Our team includes the leaders of the GUYAFOR consortium, led by ECOFOG, which includes long-term inventories across French Guiana managed by CIRAD, ONF-Guyane and CNRS. These comprise the **Paracou and Nouragues Research Stations**, two of the longest-running field sites of Eastern Amazonia, where part of the ALT project will be conducted. Together they account for the tree dynamics over 235 ha of forest monitored every five years, since the mid-1980s. Comparatively less attention has been paid to the understory in French Guiana, and this is a major data gap in constructing a comprehensive understanding of tropical forest dynamics, particularly in the context of logging and recovery. ALT's unique contribution to this long-term monitoring program will be to establish two large inventories with all trees greater than 1 cm in trunk diameter (a much more comprehensive survey than previously conducted, which recorded trees ≥10 cm in diameter). **ALT will set up detailed forest understory inventories and will leverage this data to decipher the spatial distribution of saplings with respect to soil conditions and microclimate. This will shed light on environmental filters and biotic interactions impacting the regeneration potential of trees, with a focus on timber species**[44,45]. We have already implemented a pilot study at a 2-ha site, and the ALT project builds on this experience. These new inventories would offer much international visibility to the French research community[46].

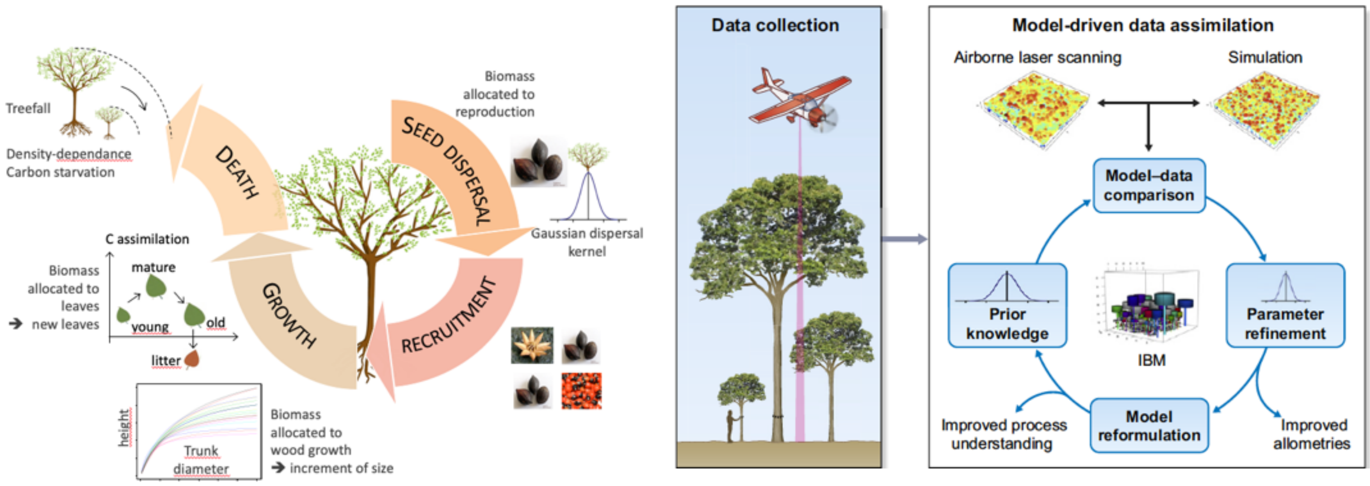

Figure 1. Left: TROLL individual-based forest model[32]. Right: Ground-based censuses and airborne laser scanning (ALS) are jointly used to parameterize a spatially-explicit IBM, such as TROLL, which operates at a spatial resolution of 1m. ALS and inventories are used to infer allometric relationships[35].

The second knowledge gap relates to the representation of tropical tree functional diversity in models. Our group has been at the forefront of quantifying the plant functional responses to biotic and abiotic constraints, for example through the ANR project BRIDGE (2006-2010), and the subsequent NEBEDIV (2013-2018). In these projects we have quantified key resource use traits of many tree species, and work especially by scientists involved in the team has unraveled the main functional dimensions of tropical trees, laying the basis for important conceptual generalizations[47-49]. This notably includes identifying tree bark thickness as a key determinant of the susceptibility to fire[49,50]. Here we will expand our trait databases to include understorey species. Our group has then capitalized on this comprehensive characterization on tree functional diversity in French Guiana to develop trait-based parameterization of forest dynamics models. The resulting models are both easily transferable and able to jointly simulate tree diversity and forest functioning, a rare but highly needed feature[51]. In ALT, **we plan to expand our database of functional traits to include understorey species**.

The third and complementary knowledge gap addressed by ALT is to understand the landscape-scale patterns of **tree mortality** within tropical forests. The drivers of canopy tree mortality in tropical forests include droughts, blowdowns, or mass dieback, while human-caused canopy gaps generate different types of degradation. All of these events generate distinct spatial structures. Describing the patterns of canopy tree mortality from different causes and in space and time – through high-resolution canopy cover change – is a prerequisite to anticipate the sustainability of tropical forest landscapes and addressing H3[52,53]. Repeated-pass **airborne lidar scanning** (ALS) now offers a detailed description of canopy gap formation, and ALT can build upon one of the best historical archives on ALS data ever collected in the tropics[54,55]. Over 300,000 ha of French Guiana forest has already been acquired using ALS over both managed and pristine forest[56]. Notably, ALS has been used to improve forest management by ONF-Guyane (improvement of skid-trail design, optimization of logging with respect to slopes and identifying particular habitats). ALS data are ideal to detect individual gap openings and distinguish between real gap openings and false positives. They also help quantify the microenvironmental variability in the understory (relevant to our H2)[57]. ALS data have been acquired in 2007, 2012, 2015, 2016 and 2019 at the Nouragues Station (ca 2000 ha), and 2004, 2009, 2013, 2015, 2016, 2019 at the Paracou Station (ca 1200 ha), but have not yet been analyzed with respect to these questions. Nonetheless, one issue with ALS data is that they cannot cover the entire territory of French Guiana. New high-resolution **radar remote sensing** is also poised to revolutionize our way of detecting natural and human-caused canopy dynamics over large areas. As members of our team have shown, Sentinel-1 has the capacity to detect canopy gaps even in cloudy conditions, and in near real time[58,59], a significant improvement over the most recent optical technology[4], and a development that has been first published by partner CESBIO[58]. Finally, **remote sensing now gives access to forest structure** information, notably the NASA GEDI lidar instrument onboard the International Space Station, and, soon, the BIOMASS ESA satellite (due to launch in 2023; N Labrière and J Chave are involved in both projects). **Within ALT, we will harness the potential of remote sensing methods to unravel the patterns of tree mortality and forest degradation at landscape- to regional-scales.**

A fourth knowledge gap relates to fires. In addition to climatic risks, studies have suggested that fires could mediate a tipping point for Amazonia[60]: in today's climatic conditions, French Guiana belongs to a low-risk region for fires in Amazonia[61], and direct evidence of fires affecting intact tropical forests is from much drier Southeast Amazonia[60,62]. The most likely scenario is that deforestation and drought will jointly contribute to an increased likelihood of fire[63,64], and models parameterized in the ALT project will enable a reevaluation of this hypothesis. In our modeling framework, the outcomes of the mechanistic SPITFIRE[65] model used in FATES will be compared with those of a much simpler model, as recently published[66]. TROLL will also generate predictions of the susceptibility of rain forests to fire. Both FATES and TROLL can use bark thickness[48] as a key predictor of susceptibility to fire mortality (bark thickness has previously been measured in French Guiana forests[47]).

In ALT, we will address all this set of epistemological and observational knowledge gaps to better constrain process representation, initialization and parameterizations in our two state-of-the-art vegetation models. The models will then be used to provide our maps of ecological indicators. Model upscaling across 80,000 km^2 of forest in French Guiana is a specific challenge. FATES is designed to be deployed at regional and global scales, with the fidelity of simulations being related to the availability of appropriate meteorological, edaphic and vegetation inputs[67]. FATES has been developed with a particular focus on tropical forest simulations[67-69]. Diurnal surface energy fluxes can be compared with the outcomes of Monteith's light-use efficiency model as constrained by Fluxnet tower data[71], with remote sensing data (solar induced fluorescence, which is related to GPP)[72], and also with a range of land surface data products within the International Land model Benchmarking project[73] (www.ilamb.org).

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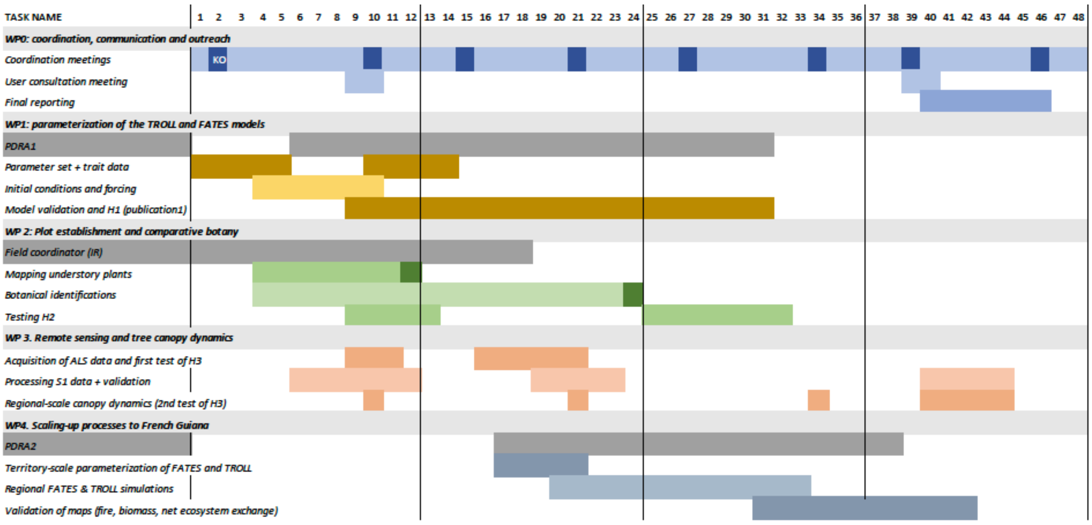
We will compare FATES results with a regional gridded version of TROLL at the scale of French Guiana. A wall-to-wall simulation of TROLL is not realistic because of computing limits. Instead, we will run representative simulations at grid points across the territory. A separate project based on tree diversity information available in French Guiana[74] will produce gridded probabilities of occurrence for tree species across French Guiana, using joint species distribution models (G Vieilledent, J Clement, CEBA project METRADICA). Based on this information, a species input dataset will be produced at each grid point. These simulations will be performed on representative plots per grid, and both FATES and TROLL will be forced with CRU-NCEP meteorological drivers[75].

c. Methodology and risk management

The project is organized around five workpackages (WP), each subdivided into tasks. Its planned duration is 48 months, and its execution is summarized in the GANNT chart below (Figure 5)



WP0: coordination, communication and outreach (J Chave).

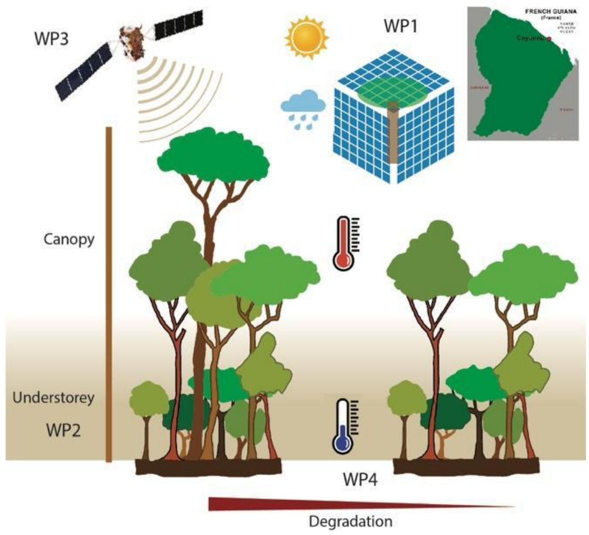
Objectives and methods. WP0 will ensure steady progress of all project parts, and will establish collaborative tools. We will build and maintain a dedicated website for the project, and ensure a regular flow of information across project participants. Data acquired through the project will comply with French open-access rules. This includes the distribution of field data and computer codes (sharing/versioning will be in git).

A user consultation meeting will be organized near the kick-off of the project, involving stakeholders, forest managers, and state representatives. This will help share an efficient strategy for data dissemination, and regarding the user needs. On a regular basis, we will provide a synthesis of our results, to the attention of stakeholders, forest managers, and state representatives, in the form of map products, but also on scientific paper briefs.

Risks. The project's success is dependent on frequent discussions and adjustments due to field conditions. Project participants have a long experience of collaboration, and know each other well. Regular missions will be planned to ensure face-to-face meetings. E-meeting will be organized on a monthly basis to report on project progress, and reporting meetings will be convened twice a year. In case the covid crisis continues into 2022, much of the coordination activity would still be possible (as it has been for other projects in 2020/21).

WP1: Environmental heterogeneity and forest regeneration (I Maréchaux & RA Fisher).

Objectives. In WP1 we will (1) provide a local parameterization for two dynamic vegetation models at two tropical forest sites in French Guiana; (2) address **H1**, '*The regeneration potential and timber provision of tropical forests depend on tree species composition and micro-habitat heterogeneity*'; associated with H1, we will explore the optimality of timber harvesting at the two sites.



Methods. We will use two of the most advanced forest models currently available, TROLL and FATES. Both models will be parameterized based on French Guiana data, building on recent experience in Panama[30]. Two reference sites will be selected: the Paracou and Nouragues Research Stations.

FATES can be run in several 'reduced complexity' modes to isolate sets of model processes (e.g. driven with observed leaf area, growth rates, or vegetation distribution). In case of model biases, we will use this feature to improve the fidelity of the model. We will benchmark FATES against observations from the two permanent research sites. FATES model experiments will explore parametric and structural uncertainty in the model and how trait uncertainty can combine with vegetation dynamics to feed back on model predictions. Specifically, predictions on plant functional type complexity, and type of coupled land models, will be performed[30].

A comparison between FATES and TROLL outputs will be an important step to gain confidence. We will use common meteorological and soil boundary conditions, and will harmonize model outputs to facilitate meaningful comparison. TROLL simulates individual and species level dynamics of forests, whereas FATES aggregates trees across size/disturbance classes and into 'plant functional types' (the granularity of both being at the discretion of the user). Thus, we can use TROLL to illustrate the consequences of the spatial and biological aggregation used in FATES. Benchmarking of both models will be conducted against tree inventories (see WP2), LAI (inferred from airborne lidar, see WP3), and flux data (Paracou Guyaflux tower).

Both models require inputs in the form of plant functional traits. Species-specific model parameters have already been collected, but data harmonization will be needed. We will generate a data set of trait inter- and intra- specific variation at both sites. Because understory tree species are often missing in functional trait databases, we will collate a plant trait dataset focusing on understory trees. We will sample 200 species in triplicates and including leaf mass area (LMA), nitrogen and phosphorus leaf contents. Hydraulic traits (e.g. leaf water potential at turgor loss point) will be also measured. Sampling will be based on plants identified as part of WP2.

Timber provision will be simulated with a special focus on the two major timber species, angélique (*Dicorynia guianensis*), and gonfolo (*Qualea rosea* and *Q. albiflora*). We will assess their population-level response to selective logging, varying logging intensity and frequency. In TROLL we will parameterize the life cycle of these species directly. For FATES, we will use the functional characteristics of the timber species to create a new plant functional type representation. We will address **H1** based on virtual experiments with both models. These will focus on the impact of alternative representations of the heterogeneity of the system on regeneration potential and timber provision: (1) representation of soil heterogeneity (20x20 m cells will be either assumed homogeneous, or drawn from a distribution of soil types, representative of the site), (2) the representation of plant functional diversity (using different degrees of species aggregation, from a single mean plant type up to the full species-specific representation), (3) the representation of microclimate (explicit microclimatic model, versus the use of above-canopy climatic conditions); and (4) assumptions controlling understory vegetation, (using the new trait database) including light penetration, canopy disturbance intensity and regeneration rates.

Validation of the model outcomes will be performed by comparing (1) the modelled timber yields with empirical ones; (2) the modelled regeneration trajectories to observations at the Paracou silvicultural treatments for the past 35 years[76,77]; (3) the simulated understory community with data on understory forest structure and composition from WP2; and (4) the simulated mortality patterns with remote sensing observations of canopy dynamics from WP3.

Deliverables. Local parameterization of two vegetation models at two sites in French Guiana, with confidence value; an extended local plant functional trait database; a test of the role of microenvironmental heterogeneity and community diversity in forest regeneration and the provision of timber resources.

Risks. FATES parameterization is low risk and it will be conducted by RA Fisher, who has led model development for the past years. TROLL parameterization is also low risk and it will be led by the TROLL development team: I Maréchaux, F Fischer, and J Chave; the microclimatic coupling and water module is still work in progress, but it builds on well-established theory[78]. In FATES, microclimate representation is also in progress. New functional trait collection and analysis will be led by experts in the team (C Fortunel, S Coste). WP1 does not critically depend on possible covid restrictions.

WP2: Understory plant monitoring and dynamics (G Derroire & E Courtois).

Objectives. WP2 will address a key gap in existing data for French Guiana, namely the monitoring of understory trees. Based on novel field inventory, WP2 will then address **H2**: *the distribution of understory trees is determined by micro-climatic factors.*

Methods. We will establish two 10-ha permanent sampling plots including all trees ≥ 1 cm in trunk diameter at breast height (dbh), at the Paracou research station and at the Nouragues research station, both equipped with micrometeorological stations. Soil sensors (temperature+moisture) will be set up (50 per plot; Tomst TMS-4). Each stem ≥1 cm dbh will be tagged with a plastic tag (attached to the stem using a nylon rope), mapped and identified. Trunk diameters will be measured with dbh-meters or with calipers.

All trees ≥ 10 cm dbh have previously been identified taxonomically in the plots, but about a third of the understory flora is composed of exclusively understory plant species. Species identification is a challenge for which the Pl@ntNet application (https://plantnet.org) that has been developed by partner AMAP will be leveraged. We will use field-taken photographs on understory plants to train the Pl@ntNet deep learning image recognition software. The feasibility of this approach is being tested (L. Moreno, Msc project). We will also improve identifications on the most difficult morphospecies using DNA barcoding. All collections of biological material will comply with the 2016 French law on biodiversity (implementing the Nagoya protocol in France). These permanent sampling plots will be the first to undergo such intensive monitoring for Eastern Amazonia. They will be included within the ForestGEO[46] global forest monitoring program.

To test **H2**, we will explore the spatial distribution of saplings (< 10 cm dbh) and adults (≥10 cm dbh) using spatial point processes[44,45]. We will then seek to predict the spatial position of trees using information on understory microclimate (light intensity, temperature and air moisture) as inferred from airborne lidar data (ALS, as measured in WP3), following a recently published method[57]. We will also attempt to spatialize soil information derived from soil sensors based on ALS (especially topography), combined with existing intensive pedological surveys conducted at both sites. We will especially focus on the determinants of regeneration for the main timber species for French Guiana.

Deliverables. Two 10-ha plots in French Guiana, with a mapping of all tree stems ≥ 1 cm dbh within the two plots; development of an image-recognition method for the identification of understory plants in French Guiana; inclusion of the new plots in the global ForestGEO initiative; a test of H2 about the early-stage establishment of tree species in the forest understory.

Risks. The establishment of two large plots in French Guiana is a logistically challenging part of WP2. The Paracou and Nouragues coordinators are leading this effort, with a dedicated database management referent (G Jaouen). We have mitigated risk through a pilot project funded by Labex CEBA, with the full mapping of a 2-ha plot. A skilled project manager has been hired (G Sellan). Our team includes expert botanists for French Guiana (JF Molino, J Engel; P Pétronelli). The application of Pl@ntNet in this project is a realistic short-term goal, and the Pl@ntNet PI is involved (P Bonnet). WP2 is contingent on covid restrictions into 2022 (travel of personnel), but this would only slow down progress, as shown during the 2020/21 pilot study.

WP3. Canopy tree dynamics (PI: L Villard & G Vincent).

Objectives. WP3 will analyze temporal series of high-resolution remote sensing data to explore forest canopy dynamics at large scales. In landscapes of 2000 ha, we will use repeated ALS to detect gap formation, both in undisturbed and in managed forest. We will complement the ALS analysis with a novel analysis of Sentinel-1 across French Guiana. This will enable us to test **H3**: *Canopy tree mortality is determined by both climatic anomalies and topography*.

Methods. At Paracou and Nouragues, we will explore the canopy dynamics using repeated-pass ALS. ALS offers very-high resolution canopy height (and height change) maps at ≤ 1 m resolution. At both sites, ALS offers access to 15 years of canopy dynamics. ALS coverage has been planned for Paracou in 2021, and ALT will fund the 2022 Nouragues ALS survey. Raw metrics of canopy change will be quantified, and their relationship to topography, and period will be tested. Important droughts have been detected at the end of 2015 and again in 2019 and could be associated with anomalies in the canopy cover dynamics. This will provide a first test of **H3**. Spatial patterns of canopy turnover[74] will also serve as validation data for WP1. ALS data will also be used to produce maps of microclimatic heterogeneity in space and time to help test **H2**.

One limitation of ALS is that it is available on ≤ 10 km^2, and thus few large canopy gap openings. To explore the frequency of large and rare canopy openings, we will detect canopy cover changes at ≥0.2 ha resolution using Sentinel-1[58] across all of French Guiana. We will then seek to attribute changes to natural or anthropogenic disturbances from 2016 onwards. For validation, we will rely on the ground-truthing efforts of partner ONF-Guyane to attribute anthropogenic disturbance to activities (gold mining, logging, agriculture, urban development). We will also use very-high-resolution (< 1 m) DigitalGlobe images to validate Sentinel-1 (ALS data do not cover enough area for this purpose). Canopy cover changes will then be related to climatic anomalies (especially the 2019 drought) and to topography (second test of **H3**). We will also explore how to use the Sentinel-1 canopy gap detection product as an emerging constraint to the vegetation models (comparison of gap size distributions).

Deliverables. Landscape-scale maps of forest structure, and forest structure change, based on ALS (1-m canopy height models); monthly maps of canopy gaps for French Guiana with an attribution to the anthropogenic *versus* natural causes.

Risks. ALS data are available and the exploration of multitemporal ALS has already been conducted[74] (G Vincent, T Gaquière). Regarding Sentinel-1 data, a first reference map has been published[59], but focused on gold-mining activities. Expanding this to natural gap dynamics may be a challenge and exploratory analyses are currently being carried out (N Labrière, EP Rau). The team includes the Sentinel-1 algorithm developers (L Villard, T Koleck). WP3 does not critically depend on covid restrictions.

WP4. Scaling-up processes to French Guiana (PI: J Chave)

Objectives. We will generate predicted maps for forest indicators over French Guiana based on running the two models (TROLL and FATES) across the whole territory. In this model deployment WP, we will explore the extent to which forest indicators depend on environmental variables across French Guiana forests, and they will be altered by future climatic conditions.

Methods. We will run both models in regional mode, to generate spatially distributed maps of indicators that respond to variations in meteorological, edaphic and land use drivers across the French Guiana domain. Both models will use calibrations deduced from the local optimization performed at the two intensively studied sites in (WP1).

FATES, on account of its aggregation of plant size and diversity, is natively designed to run in global and regional simulations. TROLL, simulating individuals, has a higher computational burden. To run a regional version of TROLL, we will grid French Guiana into 10x10 km pixels, resulting in ca. 800 pixels, with current-day meteorology inferred from CRU-NCEP meteorological drivers[75]. In each grid point, we will simulate a random sample of the forest with initial species trait conditions inferred from joint species distribution modelling.

For both models, we will run a set of simulations designed to capture the influence of uncertainty in global parameters on regional forest dynamics. For TROLL, a representative set of 80 pixels (10% of the total) will be selected. A total of 100 simulations per pixel will be run based on representative sets of parameter variation, which is well within the range of simulation sizes available today (TROLL is running on the Olympe supercomputer of CALMIP, Toulouse; if more CPU time is needed, we will apply to CPU time of the Jean Zay CNRS supercomputer). FATES will also be run for a sample of 100 alternative parameterizations[79]. Building on previous sensitivity analyses, we will select the 10% best parameter sets, and then extrapolate these in space to propagate parametric uncertainty in the forest indicator deliverables.

Both models will generate regional predictions of productivity, biomass, functional diversity, and mortality. In principle, TROLL will generate different responses to environmental variation than FATES on account of its finer spatial resolution, and these contrasting response functions will be assessed. Both models will produce unique outputs. TROLL will also allow a mapping of the potential for regeneration of specific timber species. FATES, in turn, will produce a set of complementary ecological indicators, e.g. soil carbon stocks, diurnal surface energy fluxes, runoff, fire danger and net ecosystem carbon exchange, and also allow scaling of the findings of our proposal back into coupled models of the Earth system (which will occur by default, both on account of FATES continuous code integration at https://github.com/ngeet/fates, and as R. Fisher is the external co-chair of the land model working group of the Community Earth System Model). Validation of the fire risk map will be particularly explored through an intercomparison of several products[61] and previously published model outputs[60,65].

Finally, we will simulate the dynamics of French Guiana's forests when exposed to forecast climate anomalies (and elevated CO_2) derived from a recent midrange socio-economic scenario (SSP2-4.5)[18,80], using output of a recent climate model inter-comparison project[34]. A socio-economic scenario based on urban expansion, gold mining and the forestry sector has already been proposed for the territory (S Traissac, G Vieilledent). We will run additional simulations to discern the balance between increasing forest productivity under elevated carbon dioxide, versus the impacts of elevated temperature, drought and fire risk.

Deliverables. Maps of current and future forest indicators for French Guiana, together with model-based uncertainty maps.

Risks. Regional simulations for FATES are relatively low risk, given the recent advances in model validation elsewhere in the Neotropics; regional simulation for TROLL has never been conducted and is challenging at calibration and validation phases. WP4 does not depend on possible covid restrictions.

II. Organisation and implementation of the project

a. Scientific coordinator and its consortium

Coordinator. Jerome Chave is Senior Scientist with CNRS (DR), at EDB research unit. He is a tropical forest ecologist and a modeler. He has been actively involved in data-model fusion, and biodiversity research. He has worked on the response of tropical forest biomass to environmental changes
He is the PI of Laboratory of Excellence CEBA (CEnter for the study of Biodiversity in Amazonia; French Guiana; 2011-2024), which has been instrumental to the consolidation of the research landscape on Amazonian biodiversity research over the past decade. This project is firmly implanted in French Guiana. Since 2007, he has been scientific director of the CNRS Nouragues Ecological Research Station. He has supervised 12 PhD students and 14 post-doctoral research associates. His research is on the study of complex systems, with an emphasis on the coordination between model development and data collection. J Chave has been the lead author of the TROLL forest simulator since 1999. He is a member of ESA's Mission Advisory Group of the upcoming BIOMASS satellite (Earth Explorer) and is co-leading ESA's Forest Observation System (https://forest-observation-system.net/). (Chave et al. Phil Trans Roy Soc 2004; Chave et al. Glob Change Biol 2008).

Implication of the scientific coordinator in on-going project(s)

Name of the researcher	Person. month	Call, funding agency, grant allocated	Project's title	Name of the scientific coordinator	Start - End
J Chave	4/yr	PIA	Labex CEBA	J Chave	2011-24
J Chave	1/yr	ANR, PRC	GlobNEts	W Thuiller	2017-21

Consortium. The consortium involves six complementary French partners, including skills ranging from field work to ecological modelling and remote sensing. The broad network of expertise provided by the project participants ensures access to a large database of existing forest inventories and remote sensing data for French Guiana. The strong connection with the French Guiana forestry sector through ONF-Guyane and CIRAD is a key asset to the capacity of valorizing the results directly. The team includes a balanced representation of early-career and senior scientists and it actively promotes a path to career consolidation through visible and direct responsibilities.

1. EDB (Evolution et Diversité Biologique), CNRS, Univ Paul Sabatier, IRD Toulouse, France.

EDB is a leading research unit in ecology and evolution, with long-term collaborations in Amazonia. The team will be led by **Jérôme Chave** (see above), and will involve **Rosie Fisher** (scientist, co-lead developer of FATES), **Amaia Iribar** (IR2 CNRS, platform & fieldwork coordination), Laetitia Plaisance (IR CDD CNRS, valorisation and outreach), **Fabian Fischer** (PDRA CNRS, model development), **Nicolas Labrière** (PDRA CNRS, lidar and forest inventories), **Shengli Tao** (PDRA CNES, remote sensing), **E-Ping Rau** (PhD student, model development).

2. ECOFOG (Ecologie des Forêts de Guyane), CIRAD, INRAE, AgroParisTech, Univ Guyane, Univ Antilles, CNRS, Kourou, Guyane française.

ECOFOG is a leading research unit in tropical forest ecology, it is operating the Paracou Research station (with long-term programs from CIRAD and INRAE), and it will facilitate the implementation of WP2 and contribute to WP4. The team will be led by **Géraldine Derroire** (CIRAD, head scientist of the Paracou station), and will involve **Stéphane Traissac** (AgroParisTech, ecology and modelling), **Pascal Pétronelli** (CIRAD, chief botanist); **Gaëlle Jaouen** (AgroParisTech, database management); **Clément Stahl** (INRAE, functional traits); **Sabrina Coste** (U Guyane, functional traits); **Mélaine Aubry-Kienz** (AgroParisTech, ecology and modelling), **Jocelyn Cazal** (INRAE, field collection); **Laetitia Proux** (Cirad, logistican of Paracou station), **Michel Baisie**, **Petrus Naisso**, **Richard Sante**, and two others field technicians (CIRAD).

3. AMAP (Botanique et Modélisation de l'Architecture des plantes et des végétations), Univ Montpellier, CIRAD, CNRS, INRAE, IRD Montpellier, France.

AMAP is one of the main research units in tropical ecology and botany in France. It brings expertise in forest modelling, remote sensing and emerging methods in tropical plant identification. The team will be led by **Isabelle Maréchaux** (INRAE, development of the TROLL model, WP1); **Claire Fortunel** (IRD, plant functional ecology and community dynamics); **Jean-François Molino** (IRD, botany and deep learning); **Raphaël Pélissier** (IRD, tropical ecology and modelling); **Julien Engel** (IRD, botany); **Ghislain Vieilledent** (CIRAD, spatial modelling); and **Grégoire Vincent** (IRD, remote sensing, terrestrial lidar).

4. CESBIO (Centre d'Etudes Spatiales de la Biosphère), CNRS, UPS, CNES, IRD Toulouse, France.

CESBIO is a leading French lab in Earth Observation, and has a confirmed expertise in radar instruments. The team will be led by **Ludovic Villard** (CNRS, data analysis and processing); and it will also include **Thierry Koleck** (CNES, specialist in signal processing and monitoring).

5. LEEISA (Laboratoire Ecologie, Evolution, Interactions des Systèmes amazoniens), CNRS, Ifremer, Univ Guyane, Cayenne, Guyane française.

LEEISA is a multidisciplinary research unit based in Cayenne, French Guiana. It operates the Nouragues Research Station, and will facilitate the implementation of WP2. It also hosts the executive coordination of Labex CEBA. The team will be led by **Elodie Courtois** (CNRS, head of the Nouragues station); **Florent Jeanne**, **Nina Marchand, Bran Le Plat, Wémo Bétian,** and **Patrick Châtelet** (CNRS, field camp managers).

6. ONF Guyane, Guyane française.

Office National des Forêts, Guyane manages the largest forest of France, over 6 million ha, to valorize them, protect ecological services, engage stakeholders to better know tropical forests, and contribute to knowledge discovery. The RDI unit covers various themes (diversity and natural dynamics; management and forestry; low-impact forestry; energy wood; timber plantations; carbon expertise and adaptation to climate change; biodiversity; etc...), mainly from an "applied research" and operational angle. The team is led by **Olivier Brunaux** (head of the research unit), and it includes **Caroline Bedeau** (remote sensing, GIS, and database management).

b. Implemented and requested resources to reach the objectives

The full cost of the proposal is provided in the tables below. Staff expenses have been taken from the institutions managing the funds of the respective teams. Instruments and material costs include consumables; no building or ground costs are requested; subcontracting involves publication costs and analytic costs; ALT being implemented in French Guiana (henceforth FG), travel costs will be a non-negligible proportion of the costs; we have assumed a typical cost of 1k€ for a round-trip flight, and 1k€ for accommodation costs for a 2-wk duration.

Partner 1: EDB

EDB will be in charge of coordinating the project (WP0) and contributing to WP1 (model parameterization) and WP4 (model upscaling). WP1 will be conducted based on the experience built in French Guiana over the years with the TROLL model, and collaboration with the NGEE-Tropics project (https://ngee-tropics.lbl.gov/ led by J Chambers and L Kueppers at Berkeley Lab) will offer the opportunity to collaborate closely with the development of the FATES model (C Koven at Berkeley Lab, and R Fisher co-lead EDB). WP1 and WP3 build on large plant trait databases acquired through ANR-funded research (BRIDGE, NEBEDIV), and through Feder-funding long-term tree monitoring.

Staff expenses One post-doctoral research associate (PDRA; 2-7 yr experience) will be hired to implement model upscaling and for the provision of ecological service maps (WP4). He/she will be skilled in ecological modelling, tropical ecology and environmental science, and will have a good knowledge in environmental management. Cost: 105012€; Duration: 18 months.

Instruments and material costs Computers for PDRA and RA Fisher (3k€); taxonomic identification by DNA barcoding to aid with WP2 (5 k€)

Building and ground costs None.

Outsourcing / subcontracting Article publication costs (2 k€); media outlets for WP0 (2 k€); chemical analyses for leaf functional traits in WP1 (9k€: 3x200 at 15€/sample).

General and administrative costs & other operating expenses Organisation of a user consultation meeting with stakeholder of French Guiana for reporting in year3 (4 k€); four trips to FG for coordination and two international conference for outreach (6x2 k€); travel to FG for kick-off meeting (beginning of year1 4x1k€).

Partner 2: ECOFOG

ECOFOG will be primarily in charge of WP2, establishment of two 10-ha plots (Paracou and Nouragues). This WP is based on experience built during the *Understory* project, funded by Labex CEBA, and aimed at censusing four ha of forest at each site (2020-2022; 230 k€). In ALT, we will census 52000 trees ≥1 cm dbh (positioning, tagging, measurement, species identification). This represents 12 months of fieldwork for 6 persons, at an estimated 50 trees/person/day (173 days of fieldwork per person, plus 25 days of travel+coordination). We will hire a team of

5 (manager, funded by LEEISA, plus four personnel funded by ECOFOG), and one site staff will join the team. ECOFOG will also equip each plot with new-generation soil sensors (Tomst TMS4), and will contribute model parameterization with the collection of new hydraulic plant functional traits (π_{tlp} or leaf hydraulic potential at turgor loss point).

Staff expenses Four collaborators will be hired for 12 months to help complete WP2 (field work), as “Volontaires service civique” (cost 28020 € per annum). Highly motivated candidates will be sought. Two 6-month Msc students will be hired (660x12 €), one associated with fieldwork, data analysis and spatial point processes, the other with micro-environmental database construction and analysis of leaf hydraulic traits.

Instruments and material costs For WP2: tags/rope/paint at 0.33€ for 52000 plants (17160€) and field gear (boots, dbh tape: 7 k€); these costs are based on the pilot study conducted on 2-ha so far. Tomst TMS-4 temperature/moisture soil sensors for Paracou (50 x 80€); liquid nitrogen and consumables for the analysis of hydraulic leaf traits (2 k€).

Building and ground costs None.

Outsourcing / subcontracting Tree climbing service to aid for botanical identification in WP2 (350 € x 8 days = 2.6 k€); Article publication costs (2 k€).

General and administrative costs & other operating expenses Travel for the 2 Msc students (2x1 k€); field crew travel from Kourou to Paracou, including car rental for 65 days and gas (20400€) plus mid-day lunches in Paracou (basis of 65 days of effective field work); Cirad expatriation costs (2741 €)

Partner 3: AMAP

AMAP will have a cross-cutting role in the ALT project, being involved as co-lead in model and trait activities of WP1 (one PDRA hired at AMAP), but also in WP2 (botany) and as co-lead of WP3 (airborne lidar remote sensing). Research at AMAP will be supported by a PDRA, and by operating costs as summarized below. Prior findings based on several sources of funding on ALS acquisition (PI G Vincent), botanical surveys (JF Molino), and spatial biodiversity modelling (G Vieilledent) will be mobilized here.

Staff expenses One PDRA will be hired to develop the model parameterization, and compare FATES and TROLL outputs (WP1). He/she will be skilled in ecological modelling, tropical ecology and will preferably have prior experience in programming (cost: 107880€; duration: 24 months). One 6-month Msc student will be hired (660x6 €) to process and analyze the new trait database (WP1).

Instruments and material costs Voucher collections and management in botany (4k€).

Building and ground costs None.

Outsourcing / subcontracting Article publication costs (2 k€).

General and administrative costs & other operating expenses Travel to French Guiana for trait dataset consolidation (3k€); travel to French Guiana for field work (3 x 2 k€) and international conferences for outreach activities (2x2 k€); travel to FG for kick-off meeting (4x1k€).

Partner 4: CESBIO

CESBIO is a leader in remote sensing of the environment and has demonstrated the feasibility of detecting canopy gaps based on the Sentinel-1 sensor. This has been based on co-funding in French Guiana from ONF and WWF and has led to the PhD thesis of Marie Ballère. Originally intended to be used for gold-mining detection, ALT will extend its application to the detection of natural canopy gaps. Needs from the project include data processing costs, and the hiring of a research engineer for 6 months to reprocess the latest S1 data (and apply, if needed, different sensitivity filters).

Staff expenses One Research Engineer will be tasked with producing Sentinel-1 analyses over French Guiana using the CESBIO algorithm (6 mo; 20967€).

Instruments and material costs Storage and processing costs for large datasets produced by Sentinel-1 (7 k€).

Building and ground costs None.

Outsourcing / subcontracting Article publication costs (2 k€).

General and administrative costs & other operating expenses One travel for the research engineer (2 k€); travel for kick-off meeting (2x1k€).

Partner 5: LEEISA

LEEISA is operating one of the two field sites central to the ALT project, the Nouragues station. Nouragues represents an inland forest, differing in several aspects from Paracou. LEEISA will be tasked with the co-lead of WP2, and the field manager will be hired by LEEISA. Travel to and from Nouragues for the field crew, as well as Nouragues plot soil sensors are budgeted at LEEISA. LEEISA will also organize the kick-off meeting (Cayenne, February 2022).

Staff expenses One Research Engineer will be hired to lead the field inventory of WP2; she or he will have excellent team management skills, and an interest in Neotropical botany (18 mo; 80244€).

Instruments and material costs Tomst TMS-4 soil sensors for Nouragues (50 x 80€).

Building and ground costs None.

Outsourcing / subcontracting Article publication costs (2 k€).

General and administrative costs & other operating expenses Field costs for the field team to travel from Cayenne to Nouragues (1 return trip every 15 days for 2 months: 9360€); field costs at Nouragues (6 persons 65 days 30€/day = 11700€); kick-off meeting organization (4k€); travel to France for Research Engineer (2x2 k€).

Partner 6: ONF-Guyane

ONF-Guyane manages most of French Guiana's natural forests. As such, it will be a key contributor in ALT, advising what deliverables are expected from the stakeholders through the organization of a user consultation meeting during year1. This meeting will be key for the modellers to adapt the models to the needs of users, but also to explore the potential and shortcomings of the modelling exercise. ONF-Guyane is also an expert in spatial forest management and has a strong expertise in airborne lidar.

Staff expenses None.

Instruments and material costs Computer for ALS analysis (2 k€).

Building and ground costs None.

Outsourcing / subcontracting Airborne lidar survey (Nouragues 2022; 15 k€); subcontracted to ALTOA.

General and administrative costs & other operating expenses Organization of the first user consultation meeting in French Guiana (6 k€); travel to sites in French Guiana and to France (6 k€)

AAPG2021	ALT		Funding instrument PRC
Coordinated by:	Jérôme CHAVE	Duration 48 months	ANR Requested Funding: **735926€**
Scientific evaluation committee: CE32			

Requested means by item of expenditure and by partner*

		Partner *AMAP*	**Partner** *CESBIO*	**Partner** *ECOFOG*	**Partner** *EDB (coord)*	**Partner** *LEEISA*	**Partner** *ONF*
Staff expenses		111879	20967	120000	105012	80244	0
Instruments and material costs (including the scientific consumables)		4000	7000	30160	8000	4000	2000
Building and ground costs		0	0	0	0	0	0
Outsourcing / subcontracting		2000	2000	4800	13000	2000	15000
General and administrative costs & other operating expenses	Travel costs	18000	4000	41955	20000	29060	12000
	Administrative management & structure costs**	16305	4076	23629	17521	13838	3480
Sub-total		**152184**	**38043**	**220545**	**163533**	**129140**	**32480**
Requested funding		**735926**					

* The amounts indicated here must be strictly identical to those entered on the website. If both information are not consistent, if they were badly filled in or lacking, the information entered online will prevail on those reported in the submission form / scientific document.

** For marginal cost beneficiaries, these costs will be a package of 12% of the eligible expenses. For full cost beneficiaries, these costs will be a sum of max. 68% of staff expenses and max. 7% of other expenses.

III. Impact and benefits of the project

The ALT project will provide novel results on the functioning of French Guiana forests. The main outcomes of the project will be: a flexible assimilation system for forestry and ecology data within vegetation models (WP1); a novel French Guiana node of a global network of long-term forest monitoring (WP2); a high-resolution and near-real time disturbance detection system by radar remote sensing (WP3); a regional map of mature forest resilience for Amazonia (WP4).

A Data Management Plan will be produced in time of the kick-off meeting, and it will be updated on a need basis. Common rules for data management will be shared and applied by the project participants in order to guarantee their interoperability. Any decision concerning data management and data access will be discussed and agreed upon in the project. The data management plan will consist in implementing a strategy for the collection, quality-control, and documentation of the newly acquired data. It will be supervised by G Jaouen (EcoFoG). The data will be stored in existing or newly built thematic and secured SQL databases (censuses, plant traits and ALS) on dedicated servers, with regular backup and long-term management plan. Data will be made available, in agreement with FAIR principles, to the project members through an internal data repository (DataVerse) dedicated to the project. No sensitive data will be created during this project. An expertise on data management and data control already exists in the different labs included in the project.

After the end of the project, the results will be published in scientific papers and the data, when fully analysed, will be published on open access in the DataVerse or any other appropriate data repository. Software will also be published based on open-access principles. Both FATES (https://github.com/NGEET/fates) and TROLL (https://github.com/TROLL-code/TROLL) are openly accessible and future versions will also be made open-access. A documentation will be soon available for both codes.

One key added value of ALT for France will be the establishment of a state-of-the-art forest observatory in French Guiana. This will allow international scientists to increase collaboration with French teams based on this newly established facility. ALT will close a key gap in the coverage of ForestGEO sites, the eastern part of Amazonia. Both Nouragues and Paracou sites are part of the new ANAEE-Europe infrastructure, and both access and visibility will be increased greatly.

User consultation meeting will be organised twice during the project, once at the beginning, to ensure that the modelling strategy meets the key demands of stakeholders, including CTG (Collectivité Territoriale de Guyane), DGTM (Direction Générale des Territoires et de la Mer de la Guyane), OFB (Office Français de la Biodiversité), PAG (Parc Amazonien de Guyane), ADEME, CENG (Conservatoire d'Espaces Naturels de Guyane), and environmental associations. The second meeting, towards year 4, will gather the same actors to report on the key findings of the project, especially in relation with WP3 and WP4. The ALT project is relevant as support of IPBES (Intergovernmental Panel for Biodiversity and Ecosystem Functioning), because it will provide case studies for the response of ecosystem services to environmental changes, across a large territory.

Finally, we will showcase our research at international conferences (Association for Tropical Biology and Conservation, European Geological Union). WP0 is in part devoted to implementing a communication for the project towards the public in French Guiana and beyond. This will be made possible through several outreach formats, including classic online dissemination channels (website, twitter feed), innovative work with communication professionals in French Guiana.

IV. References related to the project

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