Master thesis

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Résumé et Abstract

Écrire le résumé français ici...

Write the english abstract here...

Acknowledgments

I would like to thank...

Introduction

Sutainable forest management in the tropics (i.e. managed selective harvesting of timber) has been widely promoted internationnaly to combat tropical deforestation and degradation [Zimmerman and Kormos, 2012]. Currently tropical logging accounts for one eight of global timber production [Blaser et al., 2011] and is still increasing. Most tropical timber production originates from selective logging, the targeted harvesting of timber from commercial species in a single cuttint cycle [Martin et al., 2015].

On the other hand, tropical rainforests have fascinated ecologists due to their outstanding diversity [Connell, 1978]. Effectively tropical forests host over half of the Earth's biodiversity [Scheffers et al., 2012]. High biodiversity from tropical rainforests is the source of many ecosystem functions. Amongst others, tropical forests play a key role in biogeochemical cycles, including carbone storage [Lewis et al., 2004]. **Add insights into carbon storage role of tropical forest.** Ecosystem functions from tropical forests support numerous ecosystem services, such as timber production and climate regulation.

But several authors argue that selective logging represents a major threat to biodiversity [Carreño-Rocabado et al., 2012, de Avila et al., 2015, Gibson et al., 2013, Martin et al., 2015, Zimmerman and Kormos, 2012], challenging the sustainable definition from current selective logging. We consequently need to assess both short and long term impacts of selective logging on tropical forest ecosystems to implement better syslvicultural practives in order to reach sustainability.

The question of selective logging impact on tropical forest can be directly related to the emerging field of biodiversity and ecosystem functionning [Loreau, 2000]. Tropical forest outstanding biodiversity will be both a factor and a result of forest ecosystem response to logging disturbance. And forest ecosystem response to logging disturbance will directly modify ecosystem functionning in both short and long term. Consequently assessing selective logging effect on tropical forest linking biodiversity and ecosystem seems an obvious and promising way [Loreau, 2010]. **Paragraph to fully review !**

Negative short term impacts of selective logging have been assessed [Carreño-Rocabado et al., 2012; de Avila et al., 2015; but see Martin et al., 2015]. Much less is known about the long term impact [Osazuwa-Peters et al., 2015]. The main reason is the difficulty to conduct long term empirical study [but see Herault et al., 2010], which can be completed by the use of forest simulators [Huth et al., 2004, Köhler and Huth, 2004, Rüger et al., 2008, Tietjen and Huth, 2006]. Individual-based models of forest dynamics present the perfect framework to develop such joint biodiversity-ecosystem approaches [Maréchaux and Chave]. Individual-based models describe forest 'patches' accumulating carbon through time, assessing tree growth within the patch, or releasing carbon through gap opening [Bugmann, 2001]. Up to several dozens of different Plant Functional Types (PFTs) are generally defined and models can sometimes be fully spatially explicit [Pacala et al., 1996]. Recently, the forest growth simulator TROLL [Chave, 1999], an individual-based and spatially explicit forest model, was developped to introduce recent advances in plant physiological community. TROLL model relates physiological processes to species-specific functional traits [Maréchaux and Chave]. Consequently, TROLL model allow to simulate fully a neotropical forest biodiversity to study biodiversity-ecosystem functionning link response to logging disturbance.

Major question greater diversity (taxonomic and functional) brought a better resilience to disturbance ?

1 Model description

1.1 Overview

TROLL model each tree indivdually in a located environment. Thus TROLL model, alongside with SORTIE [Pacala et al., 1996, Uriarte et al., 2009] and FORMIND [Fischer et al., 2016, Köhler and Huth, 1998], can be defined as an individual-based and spatially explicit forest growth model. TROLL simulates the life cycle of individual trees from recruitment, with a diameter at breast height (dbh) above 1 cm, to death with growth and seed production. Trees are growing in a located light environment explicitly computed witin voxels of 1 m^3. Each tree is consistently defined by its age, diameter at brest height (dbh), height (h), crown radius (CR), crown depth (CD) and leaf area (LA) (see figure 1). Tree geometry is calculated with allometric equations but leaf area vary dinamically within each crown following carbon allocations. Voxels resolution of 1 m^3 allow the establishment of maximum one tree by 1x1 m pixels. Each tree is flagged with a species label

Table 1: Species-specific parameters used in TROLL from @Li. Data originates from the BRIDGE [@Baraloto2010] and TRY [@Kattge2011] datasets.

Abbreviation	Description	Units
LMA	leaf mass per area	$g.m^-2$
N_m	leaf nitrogen content per dry mass	$mg.g^-1$
P_m	leaf phosphorous content per dry mass	$mg.g^-1$
wsg	wood specific gravity	$g.cm^-3$
dbh_{thresh}	diameter at breasth height threshold	m
h_{lim}	asymptotic height	m
a_h	parameter of the tree-height-dbh allometry	m

inherited from the parent tree through the seedling recruitment. A species label is associated to a number of species specific parameters (see table 1) related to functional trait values which can be sampled on the field.

Carbon assimilation is computed over half-hourly period of a representative day. Then allocation is computed to simulate tree growth from an explicit carbone balance (in contrast to previous models). Finally environment is updated at each timestep set to one month. Seedlings are not simulated explicitly but as a pool. In addition belowground processes, herbaceous plants, epiphytes and lianas are not simulated inside TROLL. The source code is written in C++ and available upon request. All analyses were conducted in R version 3.4.0 **Cite R, add entry in Mendeley**.

1.2 Abiotic environment

A voxel space, with a resolution of 1 m^3, is used to explicilty model the abiotic environment. For each tree crown, leaf area density is calculated on tree geometry assuming a uniform distriution across voxels occupied by the crown. Leaf area density is computed within each voxel summing all tree crowns inside the voxel v, and is denoted $LAD(v)$ (leaf area per voxel in $m\check{s}.m^-3$). The vertical sum of LAD from voxel v to the ground level defines $LAI(v)$ (leaf area per fround area in $m^2.m^-2$ commonly called leaf area index):

$$LAI(v) = \sum_{v'=v}^{\infty} LAD(v') \tag{1}$$

Daily variations in light intensity (photosynthetic photon flux density PPFD in $\mu mol_{photons}.m^-2.s^-1$), temperature (T in degrees Celsius), and vapor pressure deficit (VPD in kPA) are computed to assess carbon assimilation within each voxel of the canopy and for a representative day per month (see Appendix 1 from Maréchaux and Chave for further details). Variation of PPFD Within the canopy is calculated as a loacal Beer-Lambert extinction law:

$$PPFD_{max,month}(v) = PPFD_{top,max,month} * e^{-k*LAI(v)} \tag{2}$$

The daily maximum incident PPFD at the top of canopy $PPFD_{top,max,month}$ is given as input. The extinction rate k is assumed as constant (see table **??** for parameters value), besides is variation with zenith angle and species leaf inclination angle [Meir et al., 2000]. Moreover only vertical light diffusion is considered ignoring lateral light diffusion, which can have an important role especially in logging gaps. Finally, intra-day variation at half hour time steps t for a representative day every month are used to compute $PPFD_{month}(v,t)$, $T_{month}(v,t)$ and $VPD_{month}(v,t)$. Water and nutrient process both in soil and inside trees are not simulated.

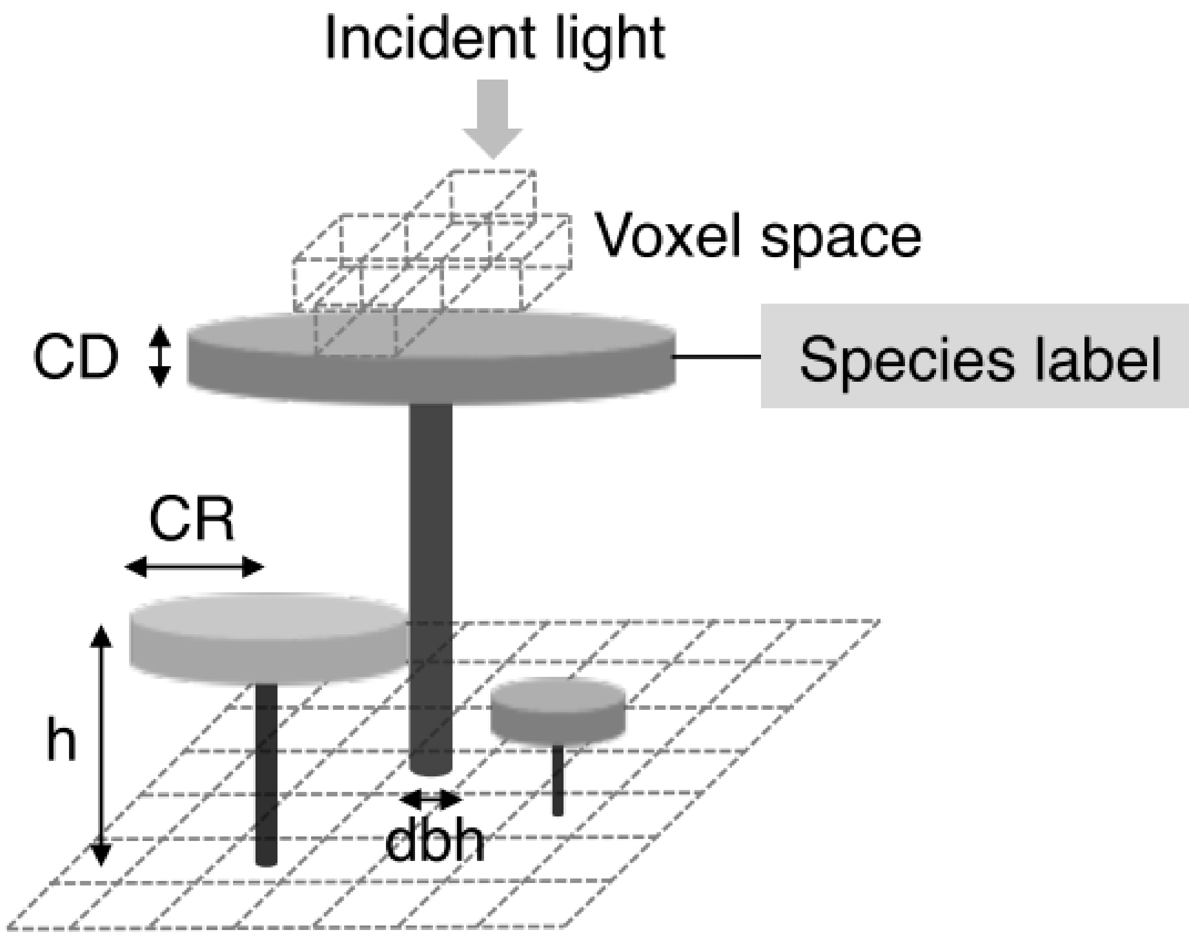

Figure 1: Individuals tree inside TROLL explicit spatial grid from Maréchaux and Chave. Tree geometry (crown radius CR, crown depth CD, height h, diameter at breast height dbh) is updated at each timestep following allometric relationship with assimilated carbon allocated to growth. Each tree is flagged with a species label linking to its species-specific attributes. Light is compputed explicitly at each timestep for each voxel.

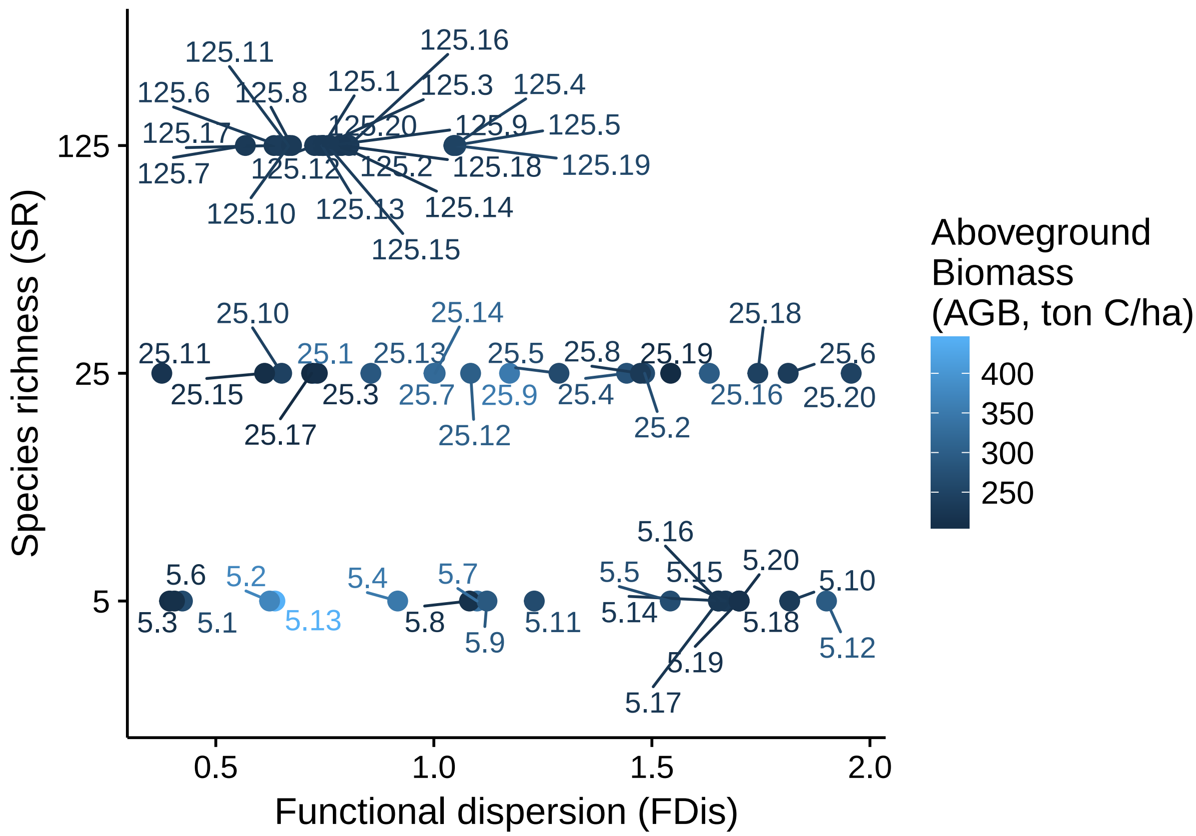

Figure 2: Experimental design before disturbance. Communities are implemented along a gradient of species richness (SR) and functional dispersion (FDis) resulting in a broad range of aboveground biomass (AGB). FDis was caluclated based on 4 functional traits (leaf mass per area, wood specific gravity, maximum diameter, maximum height).

1.3 Photosynthesis

1.4 Autotrophic respiration

1.5 Carbon uptake

1.6 Tree growth

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5 Results

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