Consultancy Report n°3, by Ophélie Ratel – 31.07.2020

The objective of this first analysis of forest data is to study the relationships between variables between plots and within plots. The two datasets (Sesnie and CATIE) were analysed independently of each other because all information are not equal for both dataset. The aim was to study whether forest type and soil type have an impact on diversity and biomass (AGB). For this purpose, statistical analysis were carried out. The results are presented in the document below, to which is attached the R script that allowed the analysis to be carried out.

I. Species richness and abundance according to forest type

❖ CATIE data

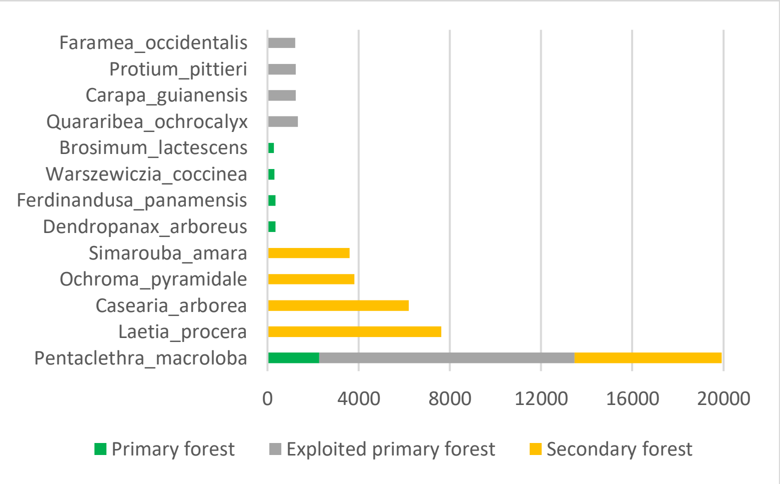

Figure 1. Dominant species in each forest type (only the 5 majority species are represented) in CATIE plots.

Here we see that the dominant species in both primary and exploited forests is *Pentaclethra macroloba*, which is a canopy tree native from Neotropics, from Nicaragua to Amazon basin. Its wood is used to make furniture and for general construction. The oil is extracted from the seeds and is used for cosmetics production. This use justifies the fact that it is largely dominant in exploited forests. We can see that this species is ten times more abundant than the other 4 main species. In secondary forests, the dominant tree species is *Laetia procera*, relatively frequent in neotropical secondary forests, mostly on sandy soils. It is also noted that, in general, abundances are lower in primary forests compared to the other two forest types. It can be explained by specific richness which is higher in primary forests (see *Figure 3*).

❖ Sesnie data

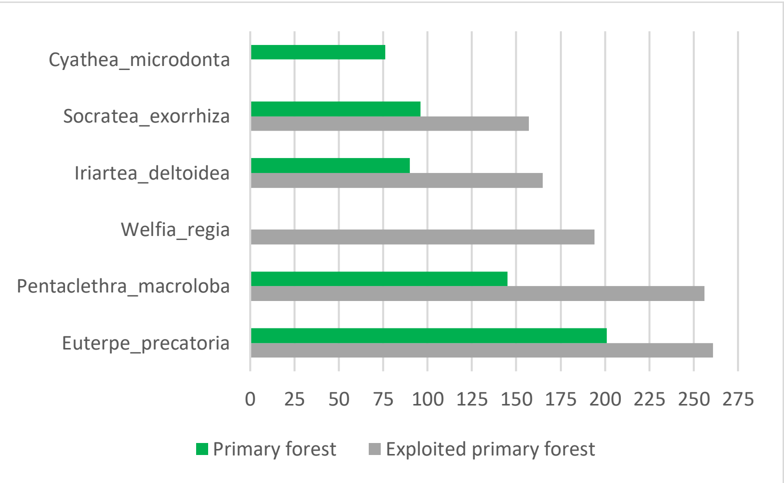

Figure 2. Dominant species in each forest type (only the 5 majority species are represented) in Sesnie plots.

First of all, it is important to note that 58 plots don't have the "forest type" information (out of 144), and that the secondary forest type is not referenced. In these plots the dominant species is not *Pentaclethra macroloba* (which is second) but *Euterpe precatoria*, a palm species native from Central America and commercially use for its fruits.

N.B: Values are strongly different between CATIE and Sesnie because plot area has not been considerate.

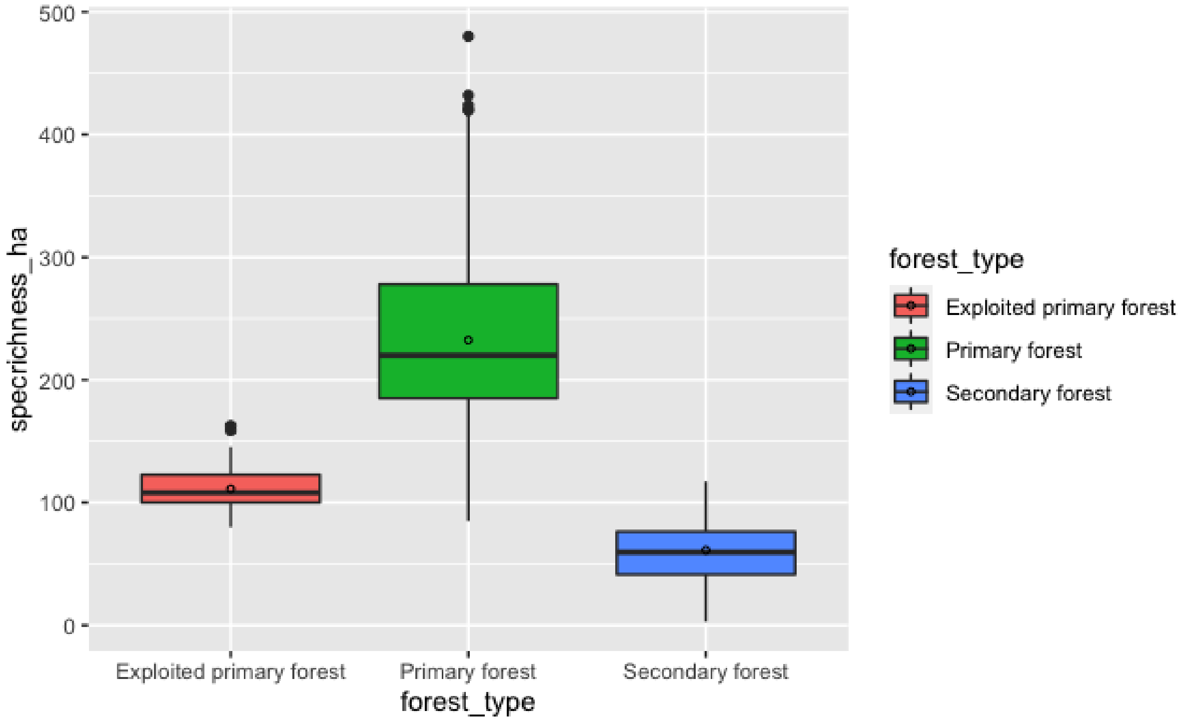

Figure 3a. Species richness per hectare depending on forest type for CATIE plots; Right: Sesnie plots.

Within CATIE data, an ANOVA test was carried out and showed significant differences in species richness between forest types (ANOVA, p-value < 2e-16). Differences between forest types were tested using a Tukey post-hoc test. Specific richness is significantly higher in primary forest than in the two others forest types (Tukey, p-value < 0.01). Specific richness in secondary forests is significantly lower than in exploited primary forest (Tukey, p-value < 1e-04).

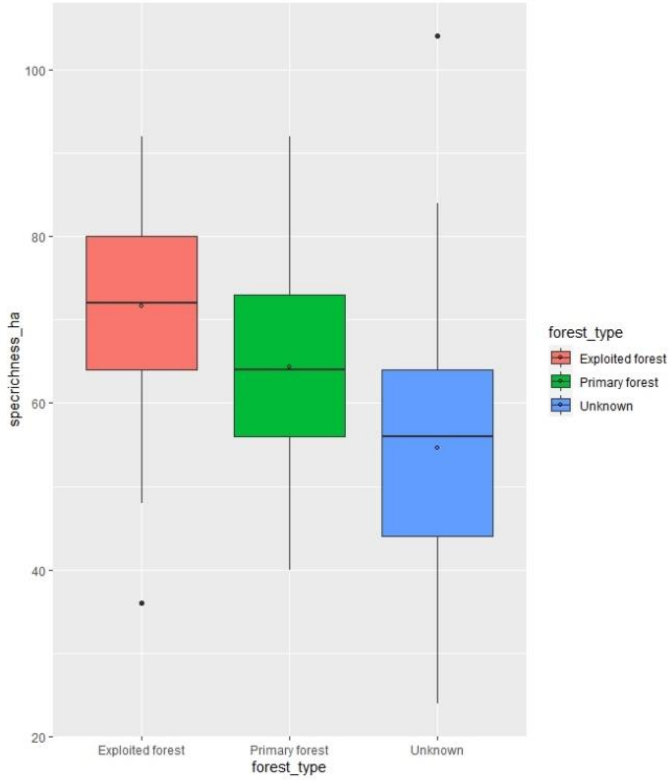

Figure 3a. Species richness per hectare depending on forest type for CATIE plots; Right: Sesnie plots

Concerning Sesnie data, an ANOVA test showed that specific richness was significantly different depending on forest type (p-value = 9.438e-8). Specific richness from the Unknown forest type class was significantly different from the two other one, highlighting a bias in the use of this class (Tukey, p-value < 0.001). There was no difference between primary forest and exploited forest types.

II. Relationship between Above-ground biomass (AGB) and Forest type

❖ AGB per hectare depending on forest type for all plots

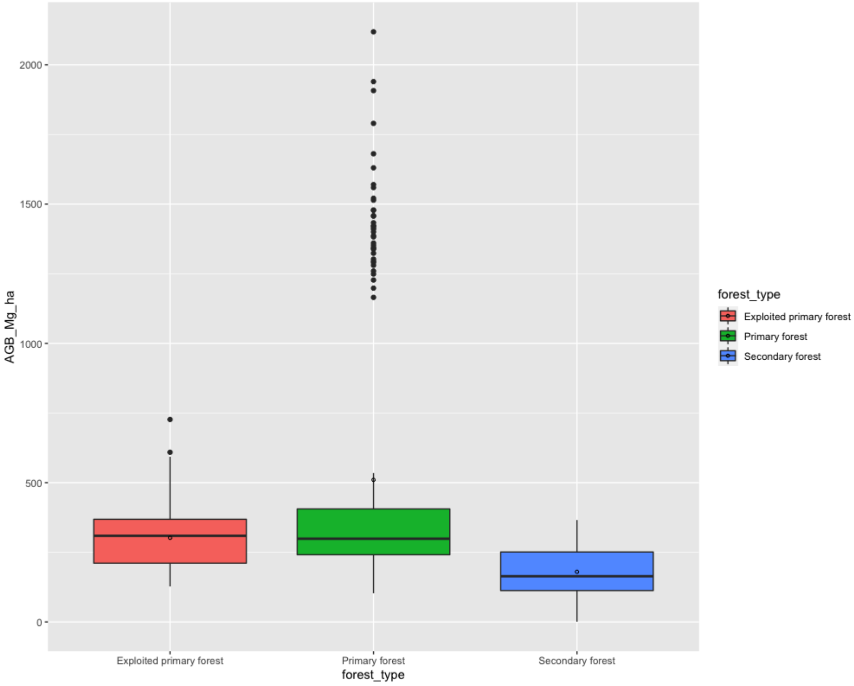

Figure 4. Above-ground biomass (AGB) in Megaton per hectare (Mg.ha) depending on forest type for CATIE plots.

Here we see that AGB rate is higher in primary forests than in exploited forests. Levels in secondary forests are lower because these forests are more recent and it can be explained by tree composition (species with lower wood density for example). An ANOVA test revealed significant differences between forest types (ANOVA, p-value < 2.2e-16). AGB values in secondary forests are significantly lower from AGB values in primary and exploited primary forests (Tukey, p-value < 1e-5). AGB values in primary and exploited forests are not significantly different (Tukey, p-value = 0.78).

Within Sesnie data the results are less conclusive given the lack of information for 58 plots for which we don’t know the forest type.

❖ AGB variation for each plot (*“parcela”*) depending on forest type

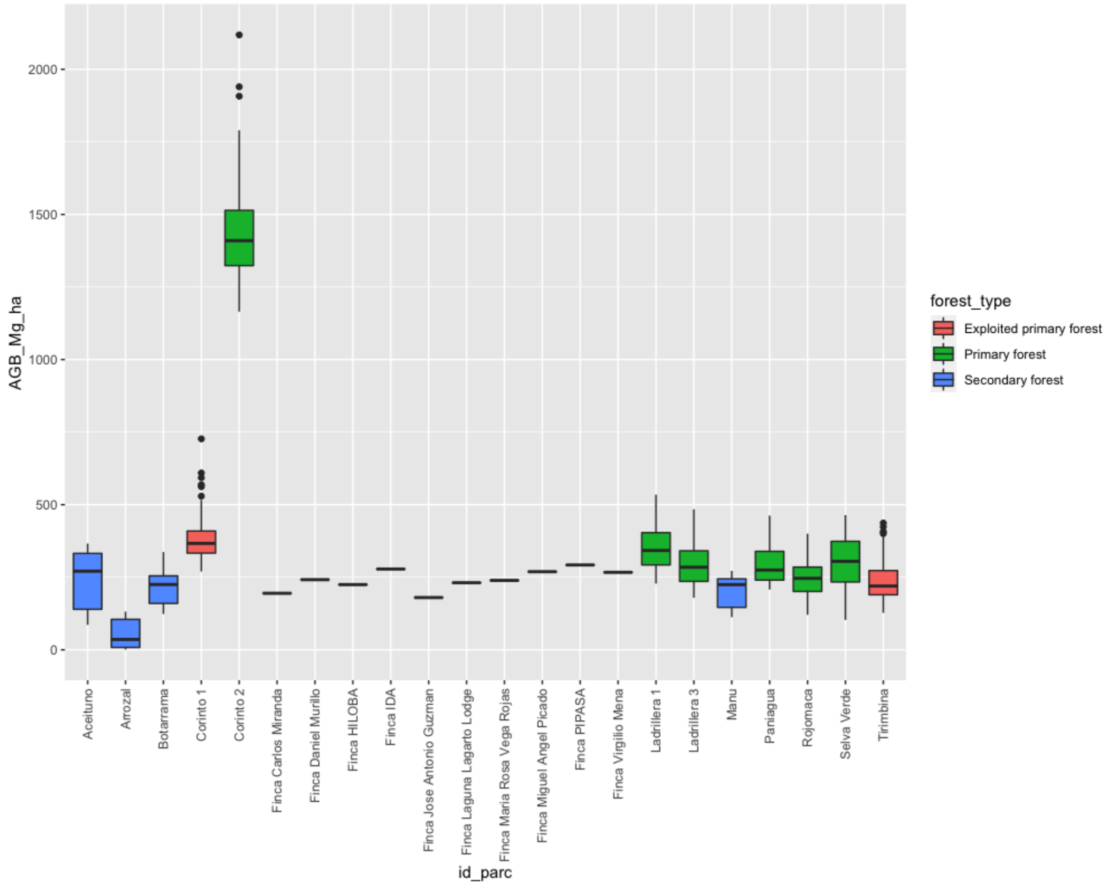

Figure 5. Above-ground biomass (AGB) in Megaton per hectare for each parcel and forest type for CATIE plots for all years studied. Sites called “Finca” have been inventoried only one time, which explains the non-boxplot appearance.

This graph shows that all *parcelas* within primary forests have a higher rate of above-ground biomass. There are significant differences in AGB values between *parcelas* (ANOVA, p-value < 2.2e-16). Variation inter-parcelas can be due to a difference in study time laps, with some plots having been followed for 20 years while others were only followed for 5 years. *Corinto 2* seems to have higher AGB values but it is difficult to test it because of the large number of *parcelas.*

III. Relationship between AGB and soil texture for Sesnie *parcelas*

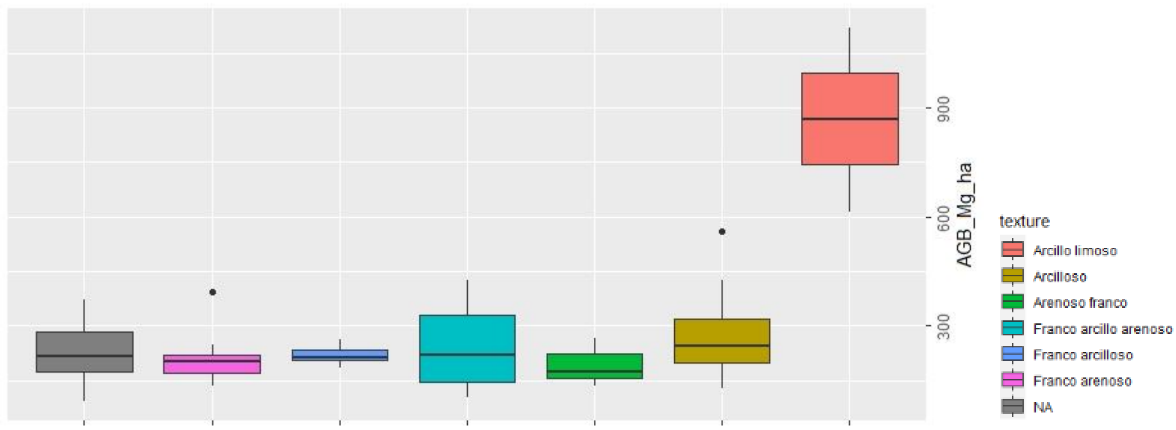

Figure 6. Above-ground biomass (AGB) in Megaton per hectare in Sesnie plots depending on soil texture. 17 plots don’t have the soil texture information (NA values).

AGB values are significantly different depending on soil texture (p-value = 3.972e-15). Within soil textures, *Arcillo limoso* is significantly higher than all others soil texture (Tukey, p-value < 0.001).

IV. Soil characteristics

In this section no graphs are presented as the values are very similar but means and standard error are summarized in the following tables.

For CATIE data soil characteristics were related to forest type, but for Sesnie data there were related to soil texture, as there are too many unknown values in forest type class.

❖ CATIE data

Forest type	pH *(mean ± se)*	Acidity *(mean ± se)*	Magnesium *(mean ± se)*	Potassium *(mean ± se)*	Phosphor** *(mean ± se)*	Organic matter *(mean ± se)*
Exploited primary forest	4.75 ± 0.29	2.03 ± 0.07	0.95 ± 0.08	0.10 ± 0.01	2	5.70 ± 0.27
Primary forest	4.95 ± 0.04	1.69 ± 0.08	1.12 ± 0.06	0.15 ± 0.01	2	4.59 ± 0.30
Secondary forest*	4.60	2.40	0.55	0.06	2	4.3

* Soil characteristics are constant for all secondary forest plots
** Phosphor measure is constant for all plots

Table 1. Soil characteristics (mean value ± standard error) for CATIE parcelas depending on forest type.

❖ Sesnie data

Soil texture	pH *(mean ± se)*	Acidity *(mean ± se)*	Magnesium *(mean ± se)*	Potassium *(mean ± se)*	Phosphor *(mean ± se)*	Organic matter *(mean ± se)*
Arcillo limoso	5.95 ± 0.45	1.68 ± 1.58	4.66 ± 0.74	0.17 ± 0.04	7.80 ± 5.80	3.01 ± 0.36
Arcilloso	4.52 ± 0.04	3.29 ± 0.12	0.43 ± 0.09	0.06 ± 0.01	2.73 ± 0.21	5.61 ± 0.20
Arenoso franco	4.53 ± 0.13	1.63 ± 0.54	0.15 ± 0.01	0.07 ± 0.01	2.07 ± 0.81	14.71 ± 4.76
Franco arcillo arenoso	4.52 ± 0.07	2.49 ± 0.20	0.23 ± 0.05	0.08 ± 0.01	2.58 ± 0.27	9.64 ± 0.45
Franco arcilloso	4.84 ± 0.30	2.58 ± 1.06	1.21 ± 0.86	0.17 ± 0.05	2.35 ± 0.54	5.77 ± 0.98
Franco arenoso	4.61 ± 0.04	1.80 ± 0.16	0.22 ± 0.03	0.10 ± 0.01	2.32 ± 0.21	13.73 ± 0.87

Table 2. Soil characteristics (mean value ± standard error) for Sesnie parcelas depending on soil texture.