Technical report on the second year of the engineering school at ENTPE

KAWSAY EIRL BIOLOGICAL STATION

AVENUE LEON VELARDE N°928 – 170001 PUERTO MALDONADO – PEROU

INTERNSHIP ON THE SELECTIVE LOGGING OF TREES IN THE AMAZON FOREST UNDER THE SUPERVISION OF RAÚL BELLO SANTA CRUZ

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I. INTRODUCTION OF THE HOST ORGANIZATION

a. General introduction

Picture from the website of Kawsay Biological Station

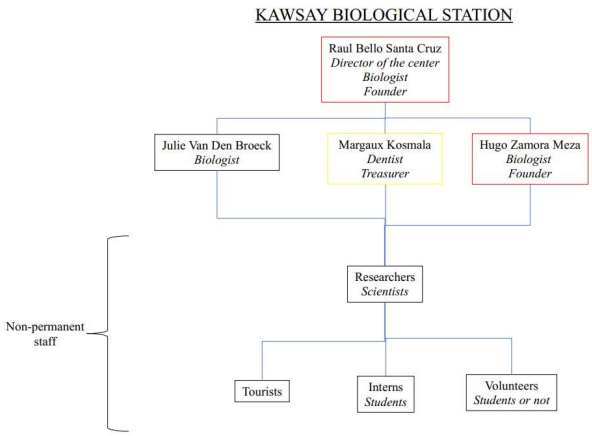
The work placement was carried out at *Kawsay Biological Station* near Puerto Maldonado, Peru.

The center, created in 2018, is located in the Peruvian forest and allows volunteers, students, interns, tourists and researchers to see from the inside how the forest is conserved and studied through various activities and works.

The centre's objectives are to preserve the forest through activities compatible with ecotourism, education and research. The centre also wishes to make science accessible to anyone wishing to discover the Peruvian forest.

They also have a website where all the activities, publications and services offered by the centre are listed (https://www.kawsaycenterperu.org/).

b. Organizational structure



Organizational structure of the host organization

The center was founded by the current director, Raúl Bello Santa Cruz, Hugo Zamora Meza, biologist, and Margaux Kosmala, treasurer.

During my internship, the permanent members of the center were Raúl Bello Santa Cruz and Julie Van Den Broeck, both biologists. The non-permanent members of

the station are the various researchers, tourists, volunteers and trainees. In addition, the centre can accommodate a total of about 15 people.

In addition, the station's activities are quite diverse. *Kawsay Biological Station* offers:

- Perform phenology ;
- Study bats ;
- Collect climate data within the domain ;
- Help collect data for other ongoing scientific projects ;
- Observe birds or mammals to collect data ;
- Analyze photos and videos of cameras in the jungle ;
- Perform maintenance work ;
- Etc.

However, the station focuses more on the study and characterization of the flora with studies of the dynamics of plots as well as on the behavior of the spider monkeys.

The details of the activities can be found in *Appendix 1* of this report.

II. PRESENTATION OF THE SUBJET IN WHICH THE INTERNSHIP TAKES PLACE

a. Context

Over the past ten years or so, forest conservation has become a central issue for policy makers and the world's population. Concerns are focused on tropical forests in the first instance as well as the timber industry. In the mid-1980s, two international initiatives were launched to discuss forest protection: the *Tropical Forest Action Program* (TFAP) and the *International Tropical Timber Organization* (ITTO).

In the more temperate areas, forest cover is stable and/or tends to develop. This is not the case for the rest of the forests. Old-growth forests tend to be replaced by plantations of all kinds that negatively impact the quality of forest cover. Statistics from the *United Nations Food and Agriculture Organization* (FAO) have revealed that deforestation of tropical forests has increased from « 11.3 million hectares in 1980 to 15.4 million hectares in 1990. According to these data, this would mean that the world loses 0.8% of these tropical forests every year. » (Cf. Bibliography 7/).

Deforestation is a social, ecological and economic problem. It impacts each of these domains at different scales which makes it complex and delicate to approach. It is not simple to quantify, although it is clear that it plays a huge role in the loss of biodiversity and land for forest dwellers.

For many years, the Peruvian forest has been the victim of selective deforestation. This term refers to the fact of cutting certain species of trees specifically because they have interesting properties for construction, framing, the construction of parquet houses, or even cabinetmaking for example.

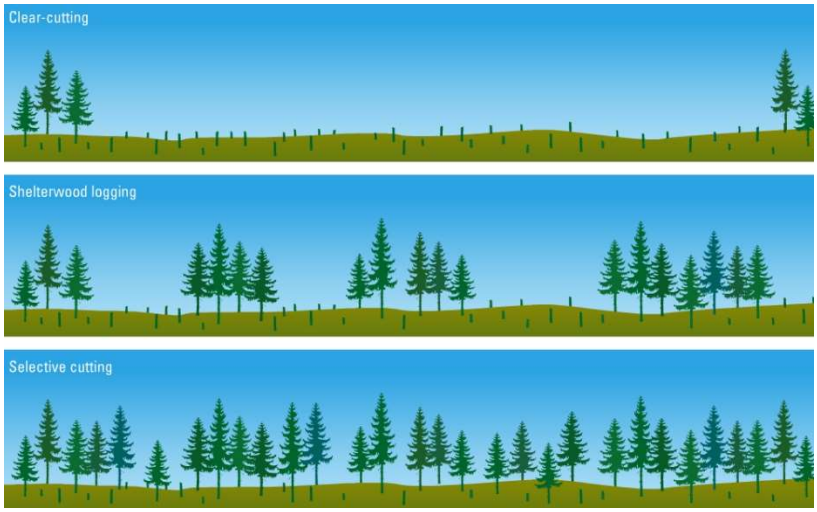
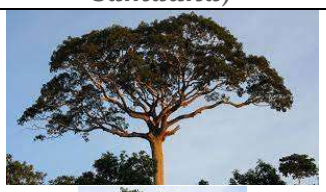


Diagram of understanding the different types of deforestation

This type of deforestation is common throughout the country and severely degrades the rainforest. The average height of the trees on the Kawsay Biological Station is on average 20-25m, while the average height of an «healthy» forest of this type in the scientific literature is rather around 30m.

The two species most affected by this phenomenon are Shihuahuacos (*Dipteryx ferrea*) and Lupunas (*Ceiba pentandra/ Ceiba samauna*).

	Shihuahuaco (*Dipteryx ferrea*)	**Lupuna (*Ceiba pentandra/Ceiba samauna*)**
Photo	  	 
Identification	50-150cm diameter 20-35m high Light brown color Flower: 2.2-3.0cm long with fushia petals Leaf: asymmetrical Hardwood, of very good quality	80-200cm diameter 30-50m high Flower: 6-20cm, hermaphrodite Hardwood and very straight, of very good quality
Use	Victim of the timber trade for construction in general and parquet	Victim of the timber trade for construction in general and triplay

The quality of the wood, the robustness, the beauty, the low rates of appearance of knots on the wood that therefore generate few losses as well as their imposing proportions of these two species make them prime targets for the wood trade.

The creation of the concession in 2018 also aims to reduce the activity of this type of deforestation in order to allow the forest to continue in addition to other activities (*cf. Appendix n°2*).

The problem of the subject of the internship is thus the following: *To what extent is the domain of Kawsay Biological Station on the Madre de Dios impacted by selective logging?*

b. Issues related

The issues identified in this internship topic can be summarized in the following table:

TITLE OF THE ISSUE	EXPLAINATIONS
Understanding of the concept of selective logging	Common activity in Peru Type of deforestation involving only certain tree species selected for their hardwood, sustainable, beautiful, expensive on the market, etc.
Understanding the timber construction market in Peru	Massive use of cut wood for construction, framing, parquet, cabinetmaking, etc.
Understanding of the need for sustainable construction and associated challenges in its implementation	Taking a step back on the use of wood in public works in a country where this activity makes it possible to earn a living
Understanding and satisfaction of the order	Production of results around selective deforestation in order to study the selective cutting of trees in a given territory
Preservation of the biodiversity	Fauna and flora affected by selective deforestation: fewer habitats for animals, fragmentation of the environment, less food, degradation of breeding grounds, etc.

c. Objectifs

The objectives identified at this time are:

- Find trees cut on the Kawsay Biological Station estate;
- Record GPS coordinates of trees cut on the domain;
- Identify trees targeted by selective deforestation on the estate;
- Estimate the timber taken and its price on the market;
- Estimate the impacts of selective deforestation on the forest through different parameters.
- Provide a critical look at the measurements taken and the results obtained.

d. Production expectations of the internship

The expectations of the workshop in terms of production are as follows:

- The creation of a map with trees that are victims of selective deforestation;
- Statistical analysis of various elements related to selective deforestation (EXCEL and/or Rstudio).

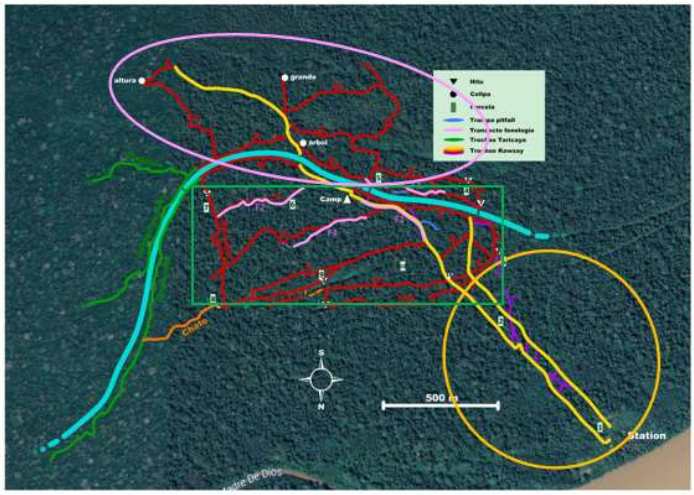
III. CONTENT OF THE INTERNSHIP ASSIGMENT

a. Methodology

At the beginning of the internship, a bibliographic search was carried out to clarify the notions of the subject of the order in which the internship falls.

This research led to the production of a PowerPoint to present the methodology that would be used in the field and then at meetings to clarify the latter.

The estate has therefore been divided into three study areas: a sector around the station and taking into account the beginning of the two main paths (in orange), an area containing the trails of the concession (in green) and finally an area close to the Tambopata reserve after crossing the river (in pink).



The priority sectors to be covered are the first two because a working hypothesis is that selective deforestation is more important in the parts near the Rio Grande River.

The trees cut in priority in Peru are listed in various scientific documents: the two main ones remain Shihuahuaco (*Dipteryx ferrea*) and Lupuna (*Ceiba pentandra*/ *Ceiba samauna*).

The field methodology is as follows:

1. Walk on trails in different areas looking left and right for trees cut ;
2. Walk parallel to trails to look for trees cut when possible OR walk between two trails to canvass the entire area ;
3. Mark cut trees found in the forest with a GPS dot ;
4. Take pictures of the trees and surrounding environment ;
5. Identify the tree cut ;

6. Take measurements (diameter, heights, various space characterization percentages in order to define regeneration after a tree has fallen, the area impacted by the tree's fall or Claro de bosque, etc.) ;

7. Analyze data collected in the field to obtain actionable results in a report.

As for the material used, the detailed list can be studied below:

Picture from the oral presentation made in English at the beginning of the project (16/04/2022)

As for taking measurements on the ground, the methodology is as follows.

Field measurements are therefore the diameter, the height of the trees cut and the Claro de bosque. The first step is to find the cut tree and measure the diameter directly if the trunk is circular. If the trunk has the trace of ramifications, it is necessary to measure the diameter on another part of the tree, an abandoned part of the trunk or the end of the tree just before the branches with the leaves so as not to take into account the ramifications of the base of the tree which then disappear. Height is measured in two ways: commercial height, that is, the height of wood that can be taken for resale on the market and the total height corresponding to the height of the tree with all the branches comprising the leaves and flowers when the tree was still alive. These two measures make it possible to calculate the volume taken and thus to estimate the price of the sale of these trees on the market if the species of tree is identifiable. If either data is not measurable in the field but the tree species is identifiable, it remains possible to estimate either measure with the relationship between diameter (d), height (h) and a factor of 1 to 8 depending on the species of tree considered.

$$\frac{d}{h} = 1 - 8$$

Another field measurement is the Claro de bosque. This is the area impacted by the fall of the tree in the immediate vicinity of the forest. This surface allows sunlight to enter, making the soil drier and impacting the flora and fauna interacting with the tree before it falls. This Claro of bosque closes as the medium regenerates after the fall of the tree. Vegetation cover can therefore be an indicator of the regeneration and/or cutting time of the tree under study. In addition, if no other part of the tree can be seen, the

measurement of the bosque Claro allows to approximate the height of the tree thanks to the measurement of the length of the latter. Also, the air around the cut tree is characterized by different percentages corresponding to the elements encountered on the medium (plants, wood left on site, soil, swamps, etc). Regular measurements of the width of the Claro bosque allow to estimate the area impacted by the fall of the cut tree and thus to estimate the total area of vegetation cover in less according to the years of cutting on the domain.

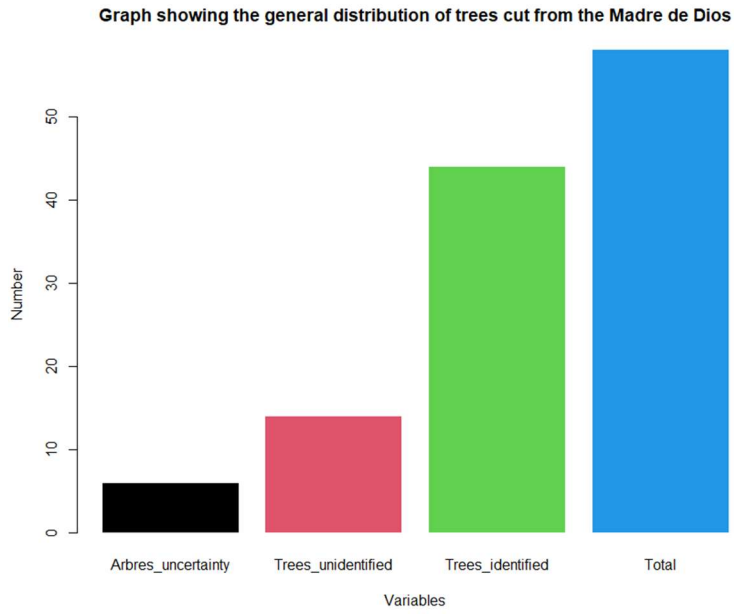
b. Main results

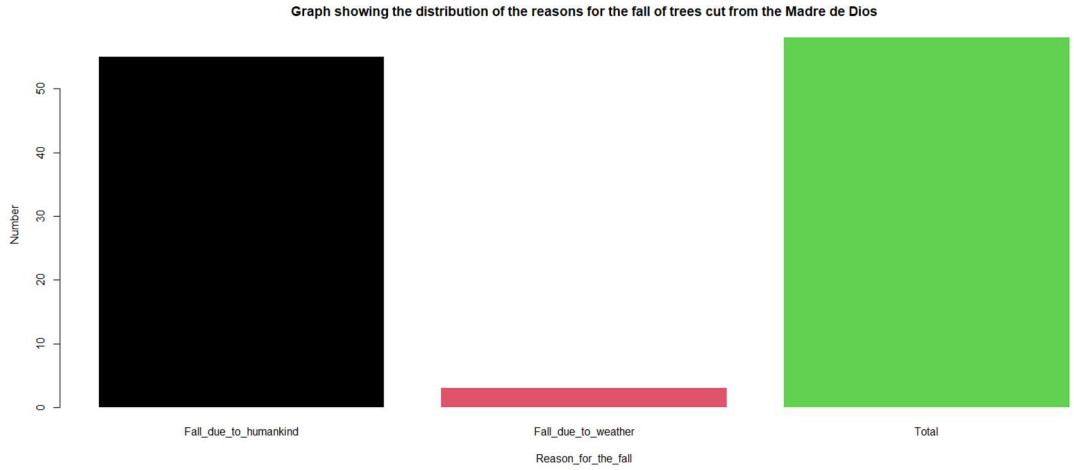
The reader will find in appendix (*cf. Appendix n°3*) the list of trees with the common name and the associated scientific name for a better understanding of the results that will follow.

The objective of creating a QGIS map locating the trees cut on the domain could not be achieved during this period of training.

General results:

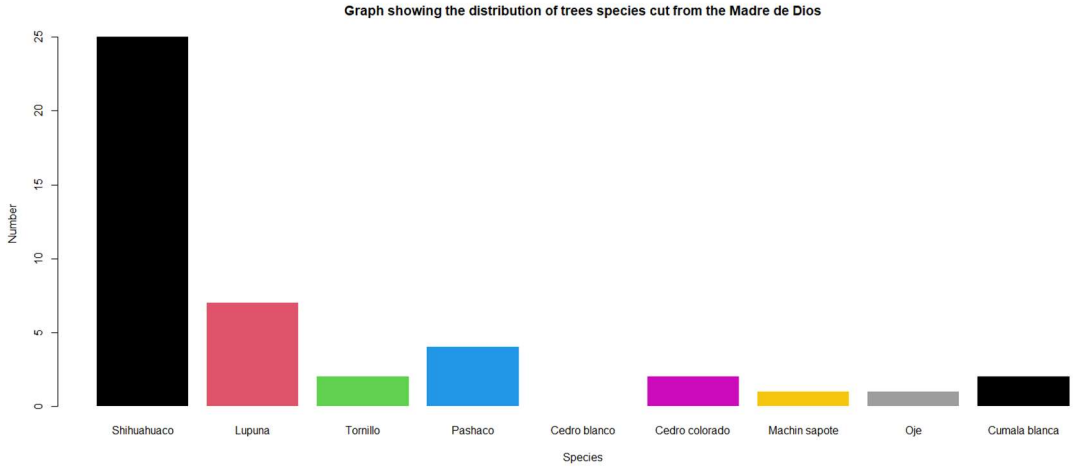
The first results obtained during the placement can be presented with the following graphs:





Out of a total of 58 trees affected by selective deforestation on the estate, 44 have been identified, 6 of which have significant uncertainties regarding their identification and 14 remain unidentifiable.

The main reason for the fall of these trees is indeed selective deforestation: 55 trees were directly selected and cut for their wood while 3 others fell first because of weather conditions (wind, thunderstorms, lightning, floods, etc.) and were cut for their wood.



The majority of trees affected by selective deforestation are Shihuahuacos (*Dipteryx ferrea*) and Lupunas (*Ceiba pentandra/ Ceiba samauna*) on the Madre de Dios estate.

```
    Diametre        Diametre
Min.   :0.5900   Min.   :0.0000
1st Qu.:0.7175   1st Qu.:0.6320
Median :0.7900   Median :0.8950
Mean   :1.0264   Mean   :0.8696
3rd Qu.:0.9650   3rd Qu.:0.9650
Max.   :2.4400   Max.   :1.7100
```

(a) *(b)*

Data for diameters of Lupunas (a) and Shihuahuacos (b)

```
Hauteur_commerciale_prise
Min.    : 5.30
1st Qu.:11.20
Median :12.00
Mean   :14.43
3rd Qu.:18.06
Max.    :25.60
NA's    :2
```

(a)

```
Hauteur_commerciale_prise
Min.    : 0.00
1st Qu.:15.84
Median :18.18
Mean   :16.96
3rd Qu.:22.07
Max.    :35.40
NA's    :3
```

(b)

Data for commercial heights taken for the market of Lupunas (a) and Shihuahuacos (b)

```
Hauteur_totale
Min.    :14.90
1st Qu.:21.20
Median :30.10
Mean   :27.77
3rd Qu.:32.00
Max.    :40.67
NA's    :2
```

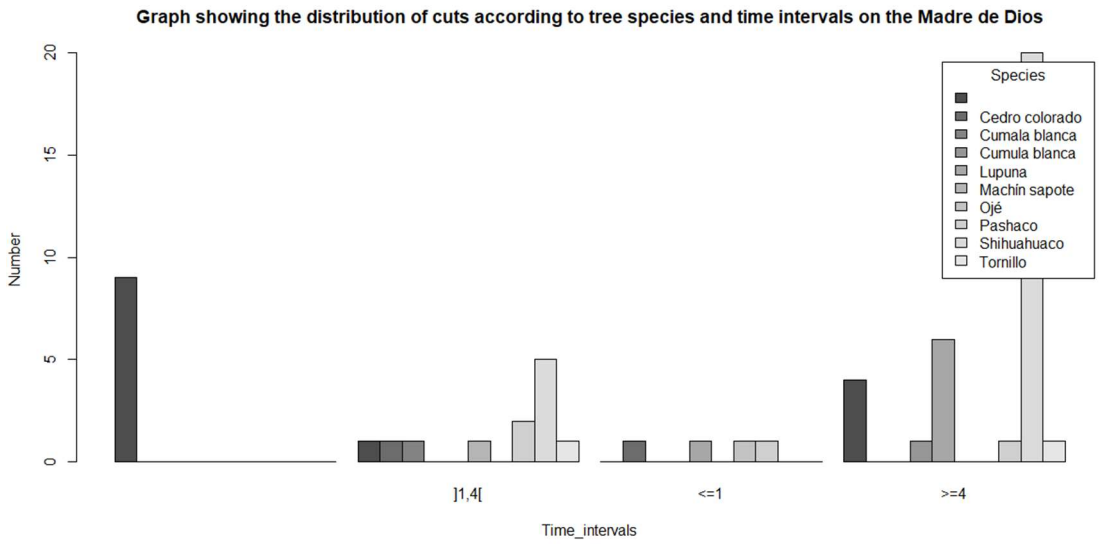
(a)

```
Hauteur_totale
Min.    :23.00
1st Qu.:31.30
Median :32.94
Mean   :34.42
3rd Qu.:37.22
Max.    :52.00
NA's    :7
```

(b)

Data for total heights of Lupunas (a) and Shihuahuacos (b)

With the data above, we can see that these are trees of high height and diameter and whose wood is particularly appreciated for its beauty and robustness.

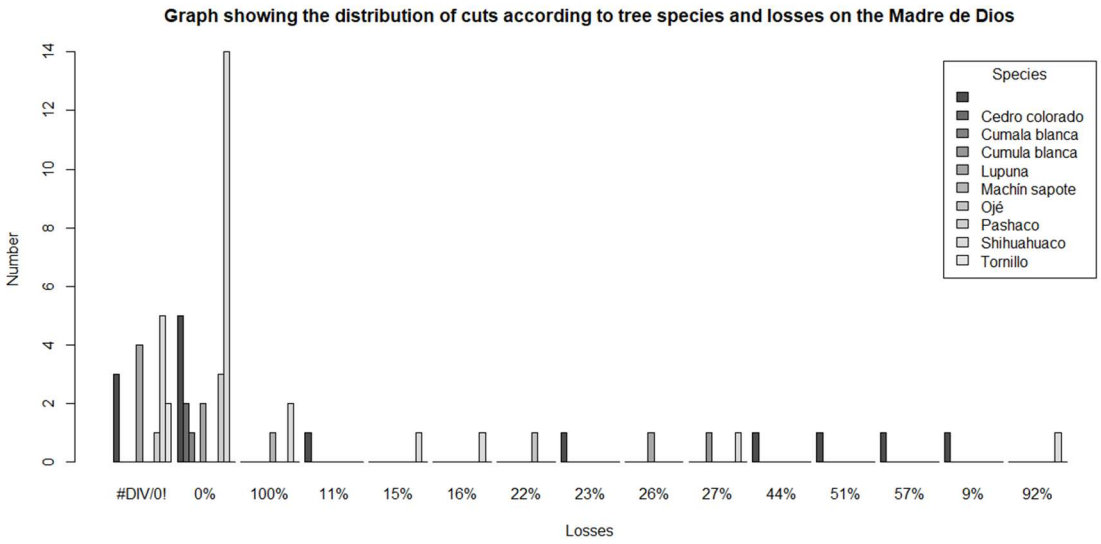


First, we note that the majority of trees were cut four years ago or more. We then observe that selective deforestation seems less active over time: we go from 33 trees cut 4 years ago or more, to 12 trees cut between 1 year and 4 years excluded, then to 4 cut 1 year ago or less. This result could be explained by the creation of the concession and thus by the activities in the forest that would allow the trees to have some protection thanks to the daily presence of Man on the estate.

Again, the trees most affected are Shihuahuacos (Dipteryx ferrea) and Lupunas (Ceiba pentandra/ Ceiba samauna) with respectively 25 and 7 cut individuals.

The annotated data of the legend "(empty)" are the data collected for tree species that are not yet identified.

Study of the losses of the commercial wood:

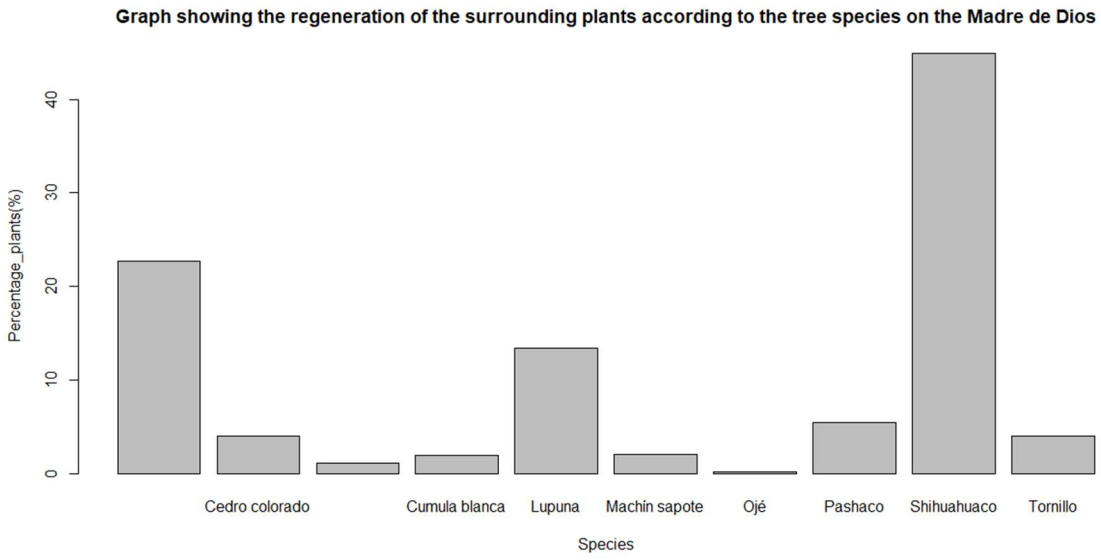


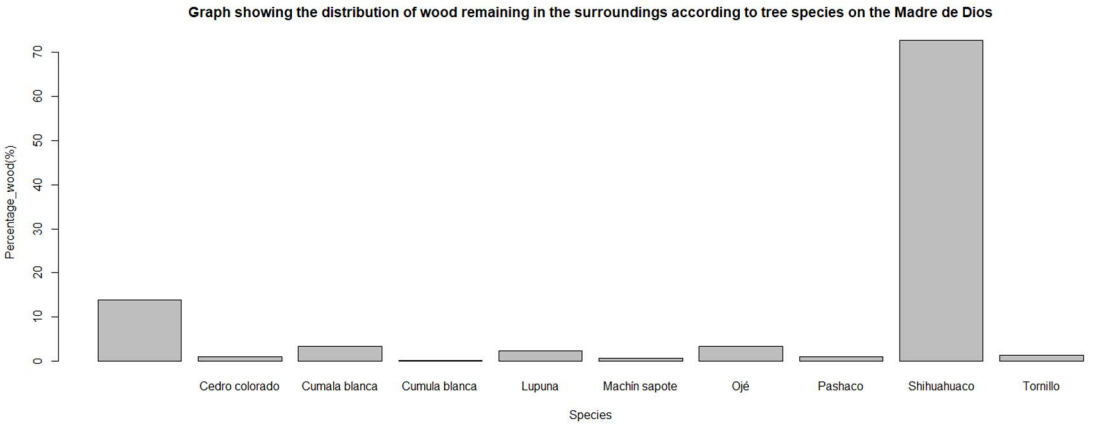
The graph above represents the loss of commercial wood. This is wood left in the forest when it seemed usable.

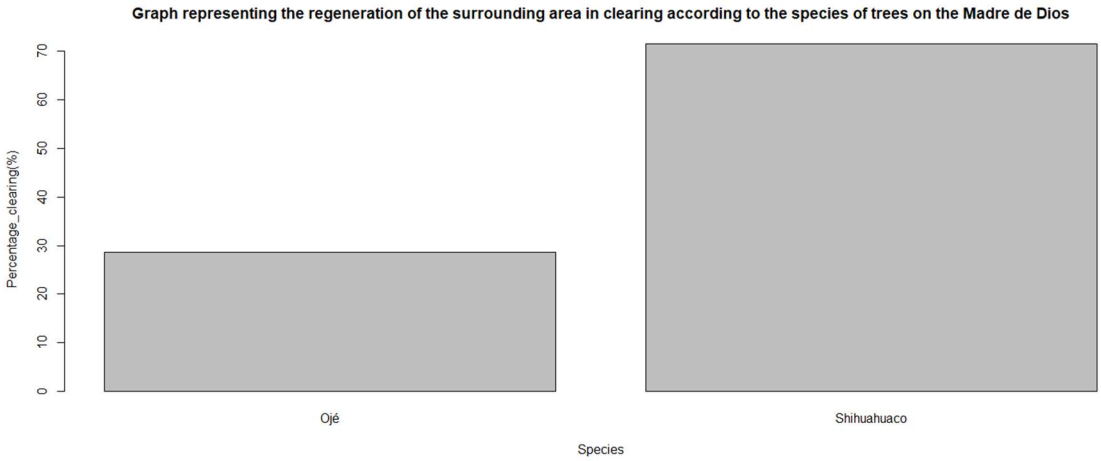
First of all, we note that, overall, very few losses are to be reported. Then, some trees were cut but no wood was removed (cf. graph with a result of 100% loss of wood): this could be a lower quality, a transport problem after the cut or simply an oversight of the tree after the cut. So that wood is lost and is somehow wasted. The loss of commercial timber is not confined to a particular species: it is possible to observe on the graph that it affects Shihuahuacos, Lupunas as well as Pashacos or Ojés, for example.

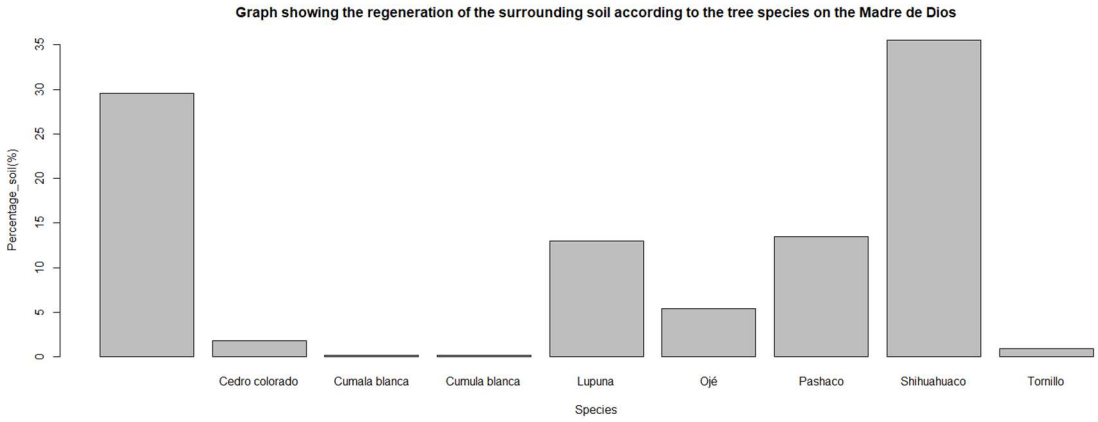
Caracterisation of the environment after cuts of trees on the *Kawsay Biological Station* :

A key to understand the criteria is available in the *Appendix n°4*:


Graph showing the regeneration of the surrounding plants according to the tree species on the Madre de Dios
Percentage_plants(%)
0
10
20
30
40
Cedro colorado
Cumula blanca
Lupuna
Machín sapote
Ojé
Pashaco
Shihuahuaco
Tornillo
Species


Graph showing the distribution of wood remaining in the surroundings according to tree species on the Madre de Dios
Percentage_wood(%)
0
10
20
30
40
50
60
70
Cedro colorado
Cumala blanca
Cumula blanca
Lupuna
Machín sapote
Ojé
Pashaco
Shihuahuaco
Tornillo
Species


Graph representing the regeneration of the surrounding area in clearing according to the species of trees on the Madre de Dios
Percentage_clearing(%)
0
10
20
30
40
50
60
70
Ojé
Shihuahuaco
Species

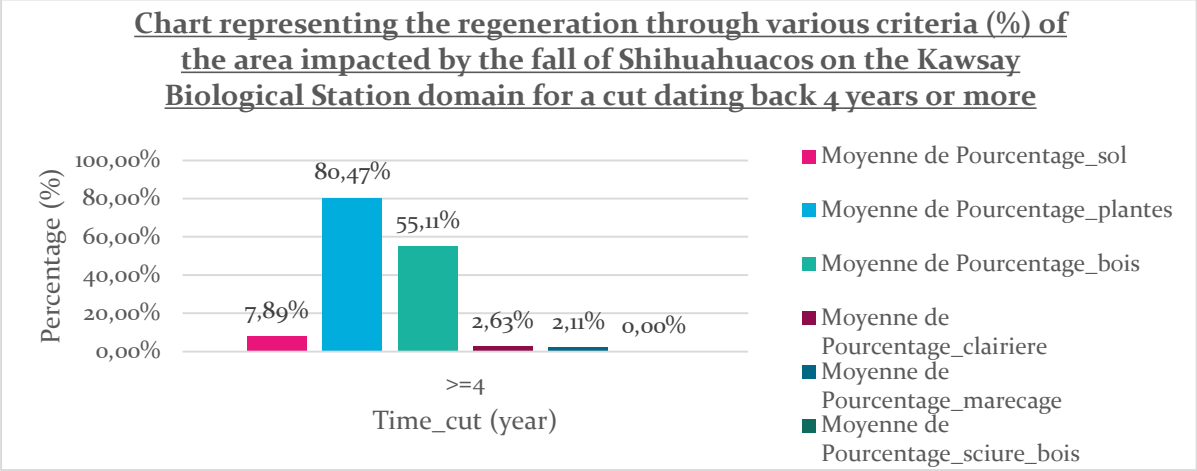


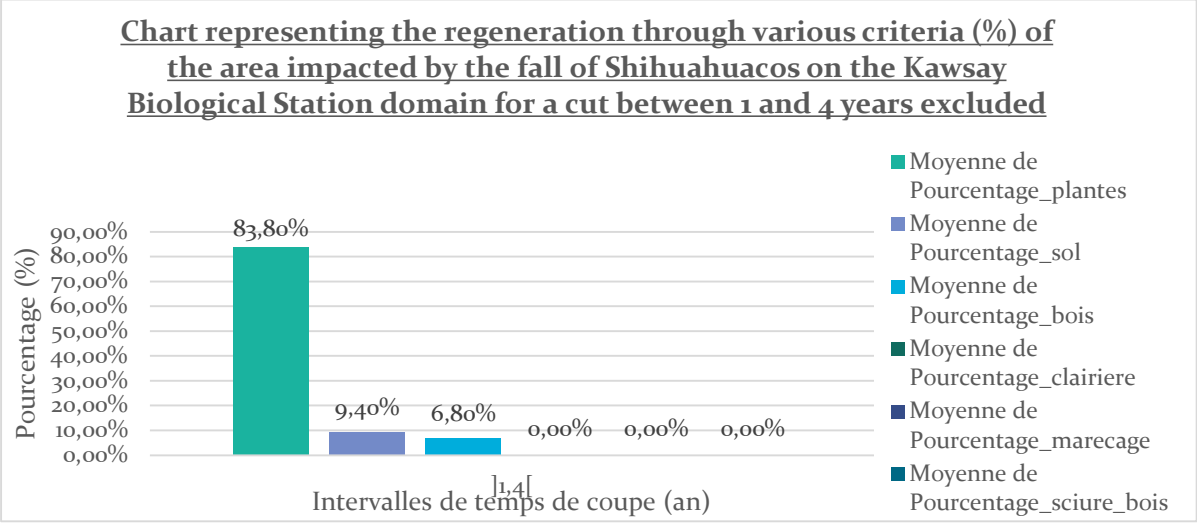
The graphs above show that after the trees cut for wood marketing, the surrounding environment is impacted at different scales. A large percentage of plants of all sizes (regenerative plants, invasive plants, etc.), exposed soil and wood left on site are found regardless of the species of trees taken into account.

With respect to the presence of swamps or clearings around tree cutting, the reader will note that these two categories apply only to Shihuahuacos (*Dipteryx ferrea*).

The histogram with the parameter «(empty)» corresponds to the trees still unidentified. Therefore, the results cannot be used and are therefore not representative of the entire study at this time.

Caracterisation of the environment after the cut of Shihuahuacos (*Dipteryx ferrea*) an Lupunas (*Ceiba pentandra / Ceiba samauna*) depending on the time of the cut:

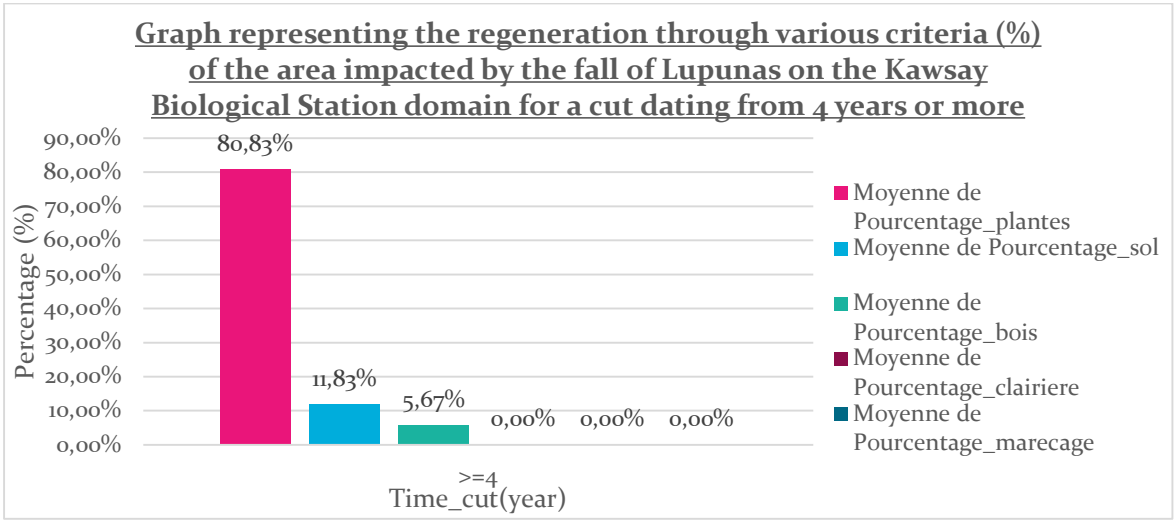


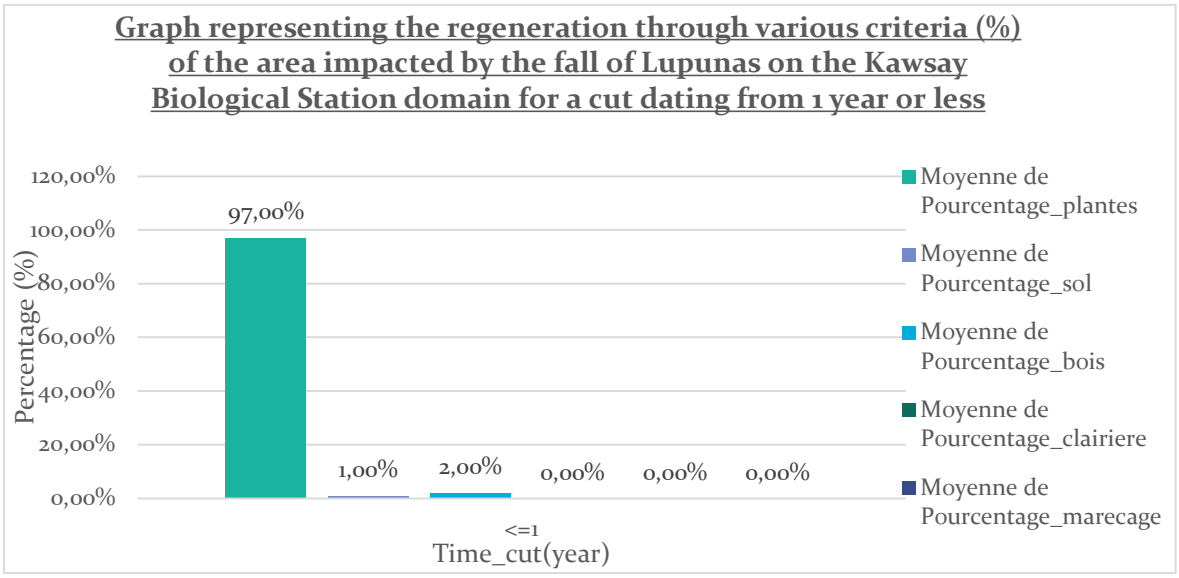


The reader can see on the above graph that the fall of Shihuahuacos follows the trends of the global study of the previous graphs: the percentages of plants, soil and wood remain considerable. In addition, we can notice that for a cut greater than or equal to 4 years, the regeneration of the environment through plants is as important as for a cut between 1 and 4 years excluded: we go from 80.47% to 83.80%. Indeed, the area had time to reclaim space. However, we note that the percentage of wood left on site is higher for these trees cut 4 years ago or more (55.11%>6.80%). At the beginning of the deforestation phase, the virgin forest was home to larger Shihuahuacos and therefore the remnants of branches and the base of the trunk are more important. In more recent times, as trees have not had enough time to regrow and the demand for wood is increasing, the wood left behind is becoming rarer and the ramifications of smaller trees are less important.

The percentage of soil present is also more important for cuts between 1 and 4 years excluded because the area covered by these trees when they fall is as large and the fall is more recent than for the other period: from 7.89% for a cut of 4 years ago or more to 9.40% for a cut between 1 and 4 years excluded.

Pictures taken on the field: cut of a Shihuahuaco 4 years ago or mor (Dipteryx ferrea)





As for the Shihuahuacos, the Lupunas cut represents a significant impact on the surrounding environment. Data in terms of percentages of plants, soil and wood left on the ground characterize the environment after cutting, as for Shihuahuacos. However, we observe that the percentage of plants is more important for a more recent cut than for an older cut while the area has had less time to regenerate: 80.83% for a cut from 4 years ago or more to 97% for a cut of 1 year or less.

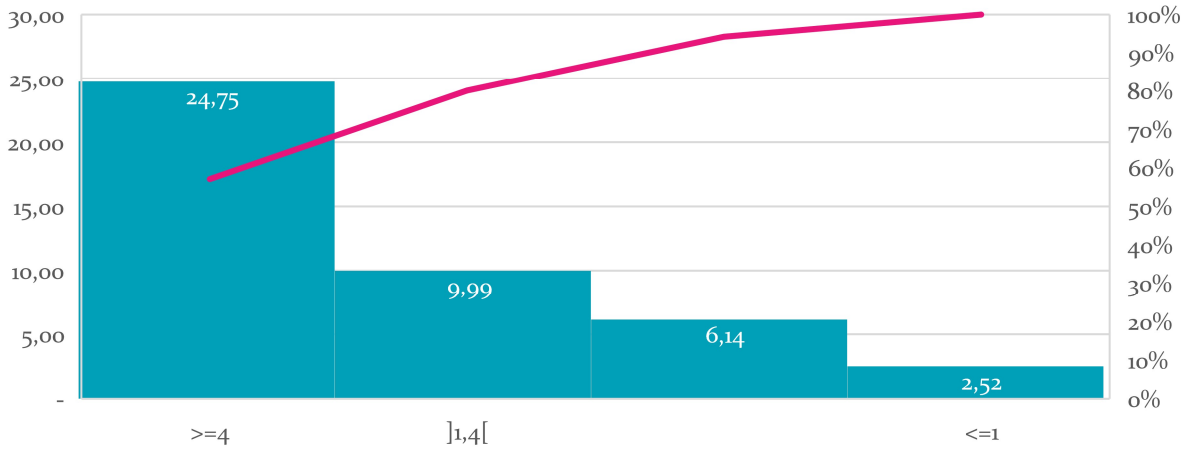
The reader can see that the percentage of wood left on site is less important for Lupuna than for Shihuahuaco. The reason may be due to the fact that Lupuna is a very straight tree, thus causing little loss during cutting. The fact that this percentage of wood is lower for more recent cuts may perhaps be due to the fact that the demand for wood is still so high and that this causes few losses.

However, it should be noted that these graphs were made after identification of only 7 Lupunas so the results may lack precision.

Pictures taken on the field: cut of a Lupuna 4 years ago or more (Ceiba pentandra / Ceiba samauna)

Mathematical relation between the vegetation cover and the cutting time:

Pareto graph representing vegetation cover (%) as a function of cut time intervals (year) for the Kawsay Biological Station domain in a data distribution in DECROISSANT order of frequency



CAUTION: A Pareto diagram traces the distribution of the data in descending order of frequency, with a line cumulated on a secondary axis as a percentage of the total. (*Cf. Appendix n°5*)

The graph above shows the relationship between vegetation cover and cutting time intervals. It is observed that the older the cut, the greater the vegetation cover.

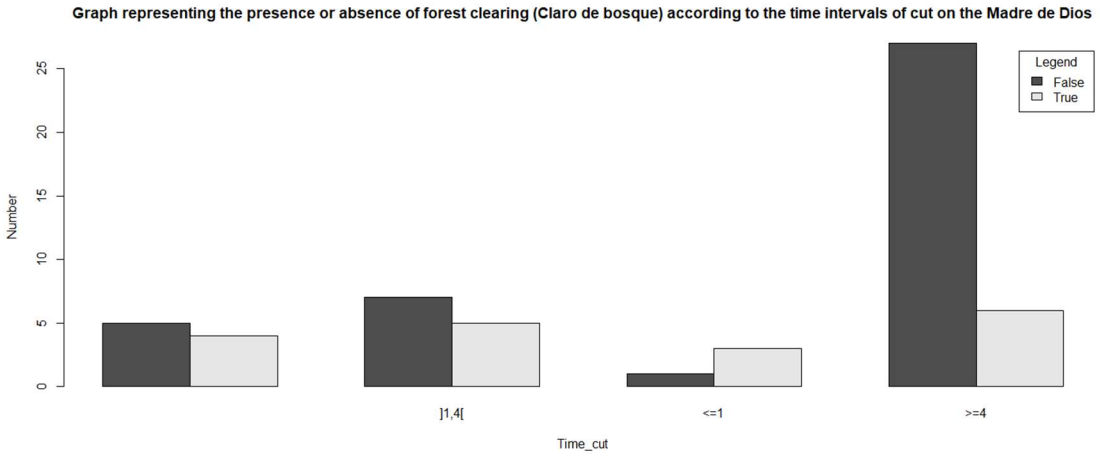
Study of the *Claro de bosque* :

S_claro_totale (m²)	Volume_total (m^3)
2129,7	393,94

Extract of the EXCEL page containing all data

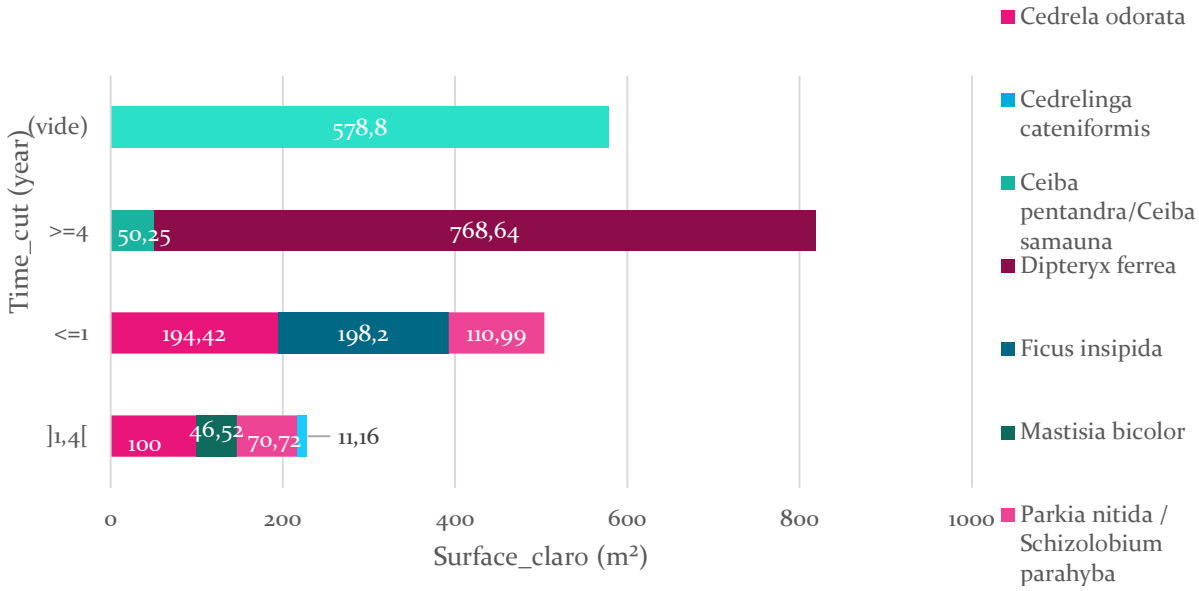
The total area impacted by the fall of the trees cut is 2129.7 m^2, thus representing a volume of wood of 393.94 m^3 for 4 years or more of selective deforestation activity on the domain. More specifically, this number refers to the area currently without forest cover and helps to understand the impact that selective tree cutting can have on the surrounding flora and fauna. There are fewer breeding grounds, fewer nesting grounds, fewer resting and sleeping grounds for some animal species. For example, spider monkeys find fewer trees to sleep on because large trees such as Shihuahuacos (Dipteryx ferrea) and Lupunas (Ceiba pentandra/ Ceiba samauna) are victims of deforestation. They are therefore forced to spend more energy in finding other trees to sleep safely. In another example, aquatic beetles are stressed by falling trees in marshy environments and since many sediments are disturbed at that time, this prevents proper oxygenation of the water and thus prevents these insects from breathing properly under the water. If the stress is too great, it can even kill them. The loss of these aquatic beetles cannot be neglected because they are holders of the history of our planet and of these different ecosystems throughout the ages. As for the flora, the impact consists of the drying of the soil and the appearance of regenerative plants which can prove to be invasive plants whose growth is faster than the others.

Most trees are chosen and cut directly by Man. The study of selective deforestation in the Amazon forest shows however that 3 of them owe their fall to the bad weather (wind, storms, storm, etc.) and were then cut by Man. This type of deforestation may seem to have less impact on the environment because they are already fallen trees but their cutting prevents some animals such as birds, snakes, hornets, bees, ants or spiders from finding refuge and/or breeding grounds.



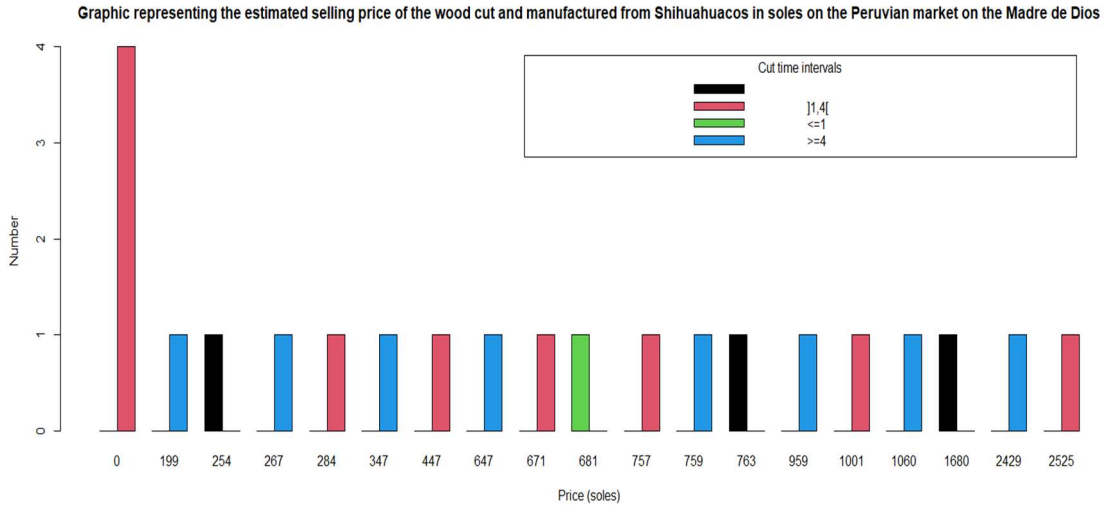
As for the presence or absence of the Bosque Claro, we note that for identified trees, a cut of 4 years or more is generally related with an absence of Bosque Claro. The bosque Claro is absent for 27 individuals for a cut of 4 years or more, while it is absent for 6 and 1 for a cut between 1 and 4 years respectively excluded and equal or less than one year.

Graph representing the area of claro of bosque (m²) impacting the forest after cutting according to tree species and time intervals (year)



Moreover, the area of *Claro de bosque* is more important for trees cut 4 years ago or more. On the one hand, these areas have more time to regenerate so this result seems erroneous but on the other hand, the latter were created by the fall of much larger trees because older and so this result may seem consistent with the study and the previous results stated.

Study of the price of the commercial wood for Shihuahuacos (*Dipteryx ferrea*) :



After conducting a survey of the inhabitants concerned by the timber trade, my internship tutor asked me to estimate the price of wood cut more than 4 years ago so far for the Shihuahuacos (*Dipteryx ferrea*). These data are therefore a high estimate of the real selling prices of wood and do not take into account wood losses as well as certain quality levels for all the criteria presented.

First, it is important to note that, as some data are missing in the field, the estimation of certain sales prices has not been calculated and therefore the result is 0 soles.

Second, this price is the first selling price after cutting the tree, converting the cut wood into 7-ply boards for this species and transporting the manufactured wood to the market. This is the first level of sales in the timber trade chain.

Thirdly, it should be noted that the selling prices vary between 199 soles and 2429 soles for trees cut 4 years ago or more and between 284 soles and 2525 soles for trees cut between 1 and 4 years excluded. Finally, for a tree cut 1 year ago or less, the estimated selling price to the first buyer is 681 soles.

Finally, the reader might think that the illegal activity of selling this wood can be a good way to earn a living in Peru. That is not the case.

Indeed, the gain from cutting these trees is only used to pay for the labour for the next cut and to "survive" within the family of loggers because it is generally all family members who participate in this activity in order to reduce costs. The salary is around ~150 soles for each individual.

Category	Larbour force	Estimated price (soles)	Period
Day of work	Cut Motorisation Help	250 soles/day/pers	Few days / 1 month
Move the tree to the river	Transporting the tree from the forest to the river by plank	300 soles/pers/day	2-5 days

Transportation	Transport on the boat to the city 1 thousand pies per transport	200-500 soles	Few hours
Unloading	Necessity to hire 4-5 people Transport wood from boat to market or company	100 soles/pers	Few hours

These results will have to be clarified in the future because they are only a «high» approximation of the reality on the Peruvian timber market.

c. Puting observations into perspectives with the French situation

To conclude, the area on which *Kawsay Biological Station* on the Madre de Dios has settled is experiencing less and less selective deforestation activities. In just over four years, tree cuts have become increasingly rare on the estate, probably thanks to the daily presence of the members of the centre. The oldest trees are the first targets of the loggers because they offer more wood than the others. The species most affected by the timber trade remain Shihuahuacos (*Dipteryx Ferrea*) and Lupunas (*Ceiba samauna*/ *Ceiba pentandra*). Primary and secondary forests are therefore affected at different scales by this trade: access to the primary forest requires more resources, but traffic between the trees is easier as the space is more open and the largest trees are located in this area. For the secondary forest, the space is denser and the trees smaller but the proximity to the river reduces transport costs. The timber trade is not lucrative for the loggers, being the first links in the chain, this business just allows them to survive until the next cut. In addition, the entire forest ecosystem is impacted by this industry, which degrades forest habitats and biodiversity.

The study conducted on the *Kawsay Biological Station* domain shows the ecological, sociological and economic aspects of this trade in Peru.

In France, forest areas are on the rise: we can schematically distinguish France which, being part of the temperate zones, 5 million hectares a year. This increase is mainly due to the contraction of agricultural space and is to be relativized by the forest losses that agricultural and forestry imports induce in other countries. Indeed, France imports 20% of its food. These include products responsible for deforestation in some countries: imported deforestation. One-third of forest losses are related to logging or forest fires, while the rest are related to agricultural expansion.

France therefore established a national strategy in 2018 (SNDI) and is a member of the Amsterdam Declarations Partnership with the ultimate goal of eradicating deforestation in connection with agricultural and forestry exploitation.

d. Critical analysis of the internship assigment

<u>Possible difficulties encountered:</u>

On paper, these are “simple” measures. However, in the field, it is sometimes difficult to draw a straight path in order to correctly measure a height. The diameter can

also be complicated to measure if the decomposition of the tree is advanced or if a nest of termites has decided to take up residence there. In addition, the GPS has an error of 5 to 8m which can lead to get lost very easily in the jungle. In addition, many ants, spiders or hornets populate the surroundings or directly the tree cut and getting stung is not uncommon. Finally, the weather can also put the project at a disadvantage and lead to lost opportunities to go out into the field.

Potential methodological and measurement improvements:

Laser measurement, not decameter:

• More accurate measurements (+)

• Higher cost (-)

Use of a better GPS:

• More accurate measurements (+)

• Avoid getting lost out of the way (+)

• Higher cost (-)

Using a drone to fly over the domain:

• Reduce GPS coordinate uncertainties (+)

• Time saving (+)

• High cost (-)

• Know how to fly the drone in the jungle (-)

• Pollution (-)

Characterization of the environment around the cut tree with associated regeneration:

• Use plant size, plant type, or even recognized plant species in the field to characterize the regeneration of the medium: gain in accuracy (+) but longer measurement time (-)

• Perform real measurements of the percentages of the components in the medium under regeneration: do not make measurements «with the eye»: gain of precision of the results (+) but longer measurement time (-)

Clean up the environment with a machete:

• More accurate measurements (+)

• Degradation of the regenerating environment (-)

IV. ANNEXES

Appendixe n°1 (website of *Kawsay Biological Station*):

Vegetation study

The aim of this study is understanding better the structure, composition and dynamics of the forest. To investigate this, we installed 10 plots (20x50m) where in we labeled all the all the trees>10 cm diameter. Different parameters are measured like diameter, height, how many trees died etc. Every year we analyze the data. In addition, we have also activities to maintain the plots.

Activity duration: 3h-4h*

Energy required: Low

When: Weekly

Pitfall traps

To investigate the diversity of terrestrial small fauna (arthropods, amphibians, reptiles), we installed 20 pitfall traps divided in two transect of 100m. The buckets will be opened 3 nights in a row and be checked every morning the next day, we go back to determine the different species that fell into the buckets.

Activity duration: 3h-4h

Energy required: Medio

When: Monthly

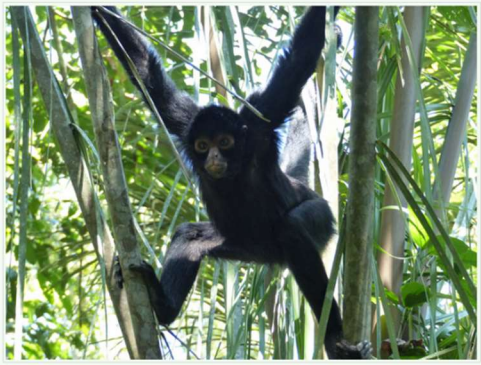
Phenology studies of angiosperms

A standardized method is used to better understand the reproductive stages of plants and trees. The transect in total is 2 km long (4 transects of 500m). You will walk the transect and collect flowers, leaves and fruits in the morning and in the afternoon the determination of the collected material and pictures will find place. We own a library with many books and field guides to help you with the determination. Also, we can always help you finding the family or even species name.

Activity duration: 3h-4h

Energy required: low

When: Every 2 weeks (1km)



Behavioral studies of black spider monkeys

In this long-term study, we investigate the seasonal variation of the behavior of black spider monkeys. We collect data about pattern activities, diet composition and habitat use. This data is used to investigate the ecological requirement of the species and their impact on the ecosystem. You will go to the forest to look for the monkeys and study their behavior. There will be also presentations to give a more theoretical background.

Activity duration: 4h-9h*

Energy required: High

When: Weekly

Mammal transect

A standardized method is used to determine the diversity, abundance and density of local mammals. The transect is 4 km long (4 parallel lines of 1km). You will walk the transect in teams of 2, when the animals are the most active: early in the morning and when the sun goes down. To have more chance to encounter animals, the walking pace is low: 1km/hora. Every time an animal is encountered, the species name, hour, location and distance to the trail will registered.

Activity duration: 3h-4h

Energy required: Low

When: Weekly

Monitoring of climate variables

Different climate variables are measured on daily base to investigate the local climate change over the years and can also be used as another variable in other studies to explain certain patterns. Every day, 3 times a day, the average, minimum and maximum value of the temperature and humidity is noted down. The precipitation is only noted down at the end of day.

Activity duration: 2 min.

Energy required: Low

When: Daily

Data entry

A lot of data is collected in the station (data of the cameras, phenology, temperature, humidity, …) and doing research requires digitalization of the data. Therefore, data has to be transmitted to excel files. This activity is mostly done or rainy days or when you want to do a less physical activity.

Activity duration: 3h

Energy required: Low

When: Weekly

Camera traps

Using camera traps, we monitor continually mineral licks. This allows us to investigate the seasonal use of vertebrates (mammals, birds, reptiles) of these mineral licks. These areas include places where animals come to consume soil where they extract minerals from. Like this we can capture animals that are normally difficult to spot.

Activity duration: 3h-4h

Energy required: medium

When: Every 2 weeks

Bats

To investigate the diversity of bats species, we put once in a while mist nets. This activity find place in the evening and the nets are checked every half an hour. Bats are taken out carefully by a professional biologist and morphologic characteristics and species name are determined.

Activity duration: 3h

Energy required: Low

When: Every season

Machete work & Maintenance

It is necessary to keep our area and our trails neat. Therefore, we will clean around the house, the trails and around our farm with a machete on a regular base. This activity requires a little bit more energy than the other ones, but it can bring a nice variation with the other activities. It is really satisfying to see how fast you can clean something and the juice afterwards will be extra refreshing. Other activities to maintain or improve the station are reparation, painting, cleaning, small constructions, gardening, ...

Activity duration: 1-3h

Energy required: High

When: When

Appendix n°2 (website of *Kawsay Biological Station*):

Surveillance and monitoring of timber species

It is necessary to protect the concession and prevent that people do logging and other illegal activities in the area. To protect our area, we do some surveillance in the concession. During this walk we can also visit the different habitats with aguaje (a local fruit of palmtrees) and brazil nuts trees. These species have a great economical importance.

Activity duration: 3h

Energy required: Medium

Appendix n°3:

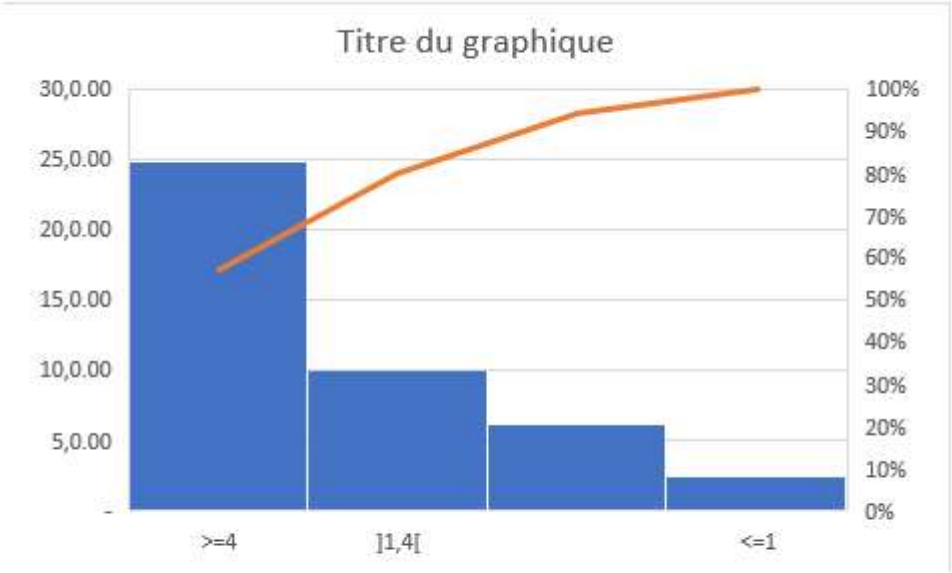
COMMON NAME	SCIENTIFIC NAME	FAMILY
Capirona	*Calycophyllum spruceanum*	RUBIACEAE
Cedro blanco	*Cedrela fissilis*	MELIACEAE
Cedro colorado	*Cedrela odorata*	MELIACEAE
Cumala blanca	*Virola sebifera*	MYRISTICACEAE
Huarni caspi	*Sterculia apetela*	MALVACEAE
Lupuna	*Ceiba pentandra*	MALVACEAE
Lupuna	*Ceiba samauna*	MALVACEAE
Machín sapote	*Masticia bicolor*	MALVACEAE
Ojé	*Ficus insipida*	MORACEAE
Pashaco	*Parkia nitida*	FABACEAE
Pashaco	*Schizolobium parahyba*	FABACEAE
Punga Negra	*Pachira aquatica*	MALVACEAE
Sangre de grado	*Croton lechleri*	EUPHORBIACEAE
Shihuahuaco	*Dipteryx ferrea*	FABACEAE
Tornillo	*Cedrelinga cateniformis*	FABACEAE

Appendix n°4:

Percentage_plants	Percentage on the impacted area of any type of flora: regenerative plants, tall grasses, shrubs, invasive plants, palm trees, etc
Percentage_wood	Percentage on the impacted area of any type of wood left on site: branches of the end of the cut tree, trunk, planks, various pieces, etc.
Percentage_soil	Percentage on the impacted area of soil without flora, possibility of cover by dead leaves or bare earth
Percentage_clearing	Percentage of impacted area with only low grass forming a clearing
Percentage_swamp	Percentage of impacted area encountering swamp, dry or not, as data were collected during the dry season
Percentage_dust	Percentage of the area impacted by wood chips and/or sawdust when cutting the tree before transport

Appendix n°5 :

Pareto



Un diagramme de Pareto trace la distribution des données dans l'ordre décroissant de fréquence, avec une ligne cumulée sur un axe secondaire sous forme de pourcentage du total.

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Legal minimum cutting diameter of different tree species in Peru

2/ 6 Criterios medicion arbol en Pie

Page 34

Factor for the estimated volume: 0.65 → factor de forma

3/ SERFOR 2019 MFC GUIA 04-2019

Page 21

4/ Cartilla Lima enero2016

Price of woods for different criteria and products

Tipo de cambio COMPRA 1us$ = S/3.443 & VENTA 1us$ = S/3.447

25 January 2016 : 1 us$ = S/3.4626

https://www.exchangerates.org.uk/USD-PEN-spot-exchange-rates-history-2016.html

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Pt : pies tablares → 1 m^3 = 424 pt

6/ A-FICHAS-MADERABLES-OSINFOR-2017-final-comp

Identification paper of the different trees species

7/*Certification of forest products – Isues and perspectives*, VM Viana, J Ervin, R Donovan, C Elliott, H Gholz - 1996 - books.google.com

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